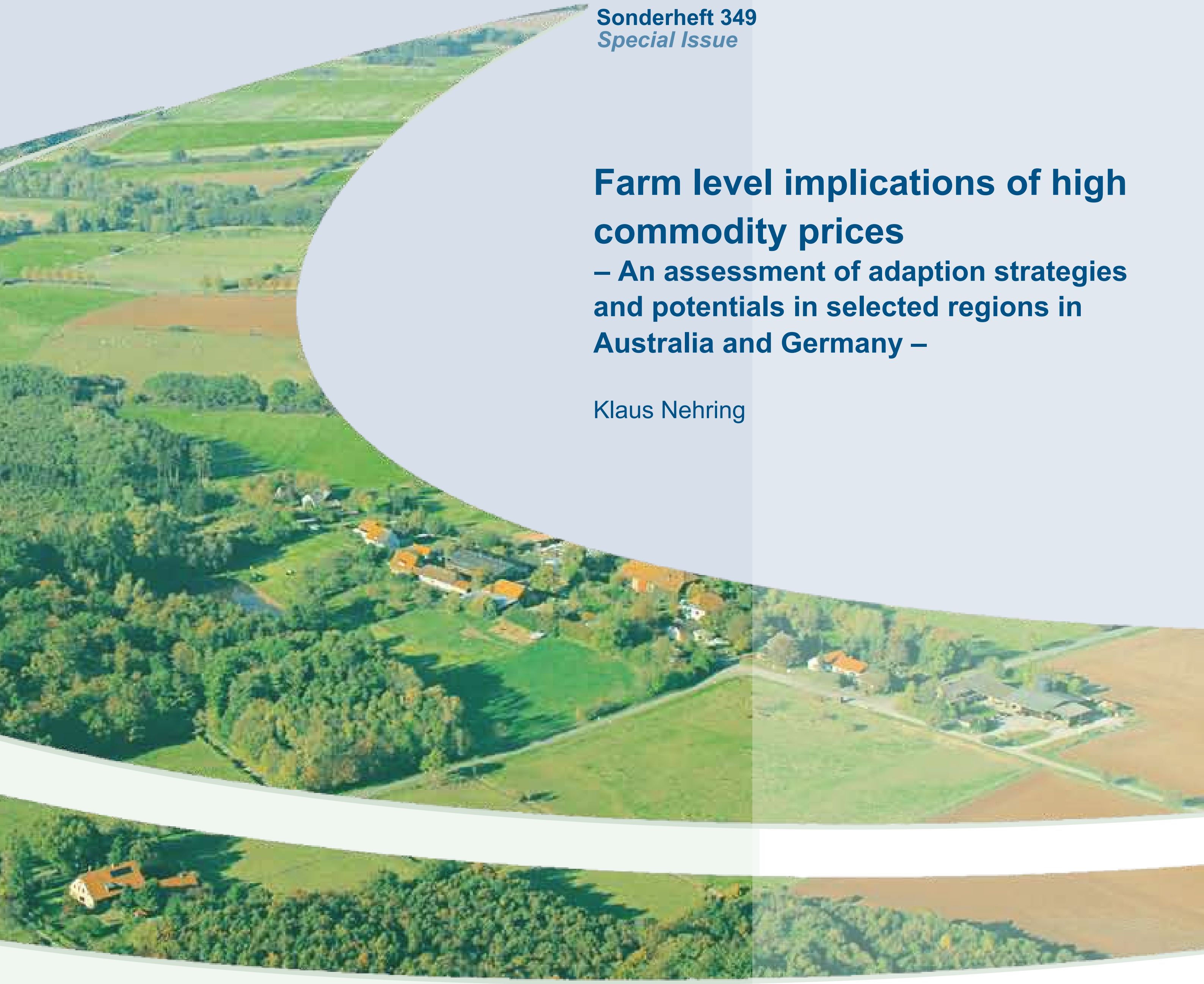
Johann Heinrich von Thünen-Institut

Sonderheft 349
Special Issue

Farm level implications of high commodity prices

– An assessment of adaption strategies and potentials in selected regions in Australia and Germany –

Klaus Nehring



Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz

Bibliographic information published by the German National Library

The German National Library lists this publication in the German National Bibliography; detailed bibliographic data are available in the internet at http://www.d-nb.de/

Bibliografische Information der Deutschen Bibliothek

Die Deutsche Bibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://www.d-nb.de/ abrufbar.

Johann Heinrich von Thünen-Institut

2011

Landbauforschung
vTI Agriculture and Forestry Research

Johann Heinrich von Thünen-Institut
Federal Research Institute for Rural Areas, Forestry and Fisheries,

Johann Heinrich von Thünen-Institut
Bundesforschungsinstitut für
Ländliche Räume, Wald und Fischerei (vTI)

Bundesallee 50, D-38116 Braunschweig, Germany

landbauforschung@vti.bund.de
www.vti.bund.de

Preis / Price 18 €

ISSN 0376-0723
ISBN 978-3-86576-089-0

Landbauforschung
vTI Agriculture and Forestry Research

Sonderheft 349
Special Issue

Farm level implications of high commodity prices

– An assessment of adaption strategies and potentials in selected regions in Australia and Germany –

Klaus Nehring

Johann Heinrich von Thünen-Institut (vTI)
Institute of Farm Economics
Bundesallee 50, 38116 Braunschweig

Content

List of Tables

List of Figures

List of Tables in Appendix

List of Figures in Appendix

Abbreviations

AHL	Ammonium nitrate and urea solution
AR	Argentina
AU	Australia
AUD	Australian Dollar
B	Boron
BBCH	BBCH Code – growth stages of mono and dicotyledonous plants
bbl	barrel
bu	Bushel
B-0	Basis scenario, reference average 2005-2009
CA	Canada
CaO	Calcium oxide
CAP	Common agricultural policy
CBH	Co-operative Bulk Handling Ltd.
CW	Central West NSW
COP	Cost of production
COV	Coefficient of Variation
DAP	Diammonphosphate
DE	Germany (cp. Deutschland)
DSE	Dry Sheep Equivalent
EU	European Union
EUR	Euro
FR	France
gal	Gallon
GPS	Global positioning system
GSR	Growing season rainfall
ha	Hectare
K	Potassium
kg	Kilogram
K-40	Chloride of potash
KZ	Kazakhstan
lbs	pound
LP	Linear programming

MB	Magdeburger Börde
Mg	Magnesium
MAP	Monoammonphosphate
MoP	Muriate of Potash
MRT	Marginal rate of transformation
N	Nitrogen
NSW	New South Wales
P	Phosphorus
RF	Russian Federation
S	Sulphur
S-0	Scenario S-0
S-1	Scenario S-1
S-2	Scenario S-2
SA	Saxony-Anhalt
SB	Sugarbeet
SC	South Coast WA
SOP	Standard operating procedure
SSA	Sulphate of ammonia
t	Tonne
TSP	Triplesuperphosphate
UA	Ukraine
UK	United Kingdom
USA	United States of America
VRT	Variable rate technology (site specific application technology used with seed, fertiliser and chemical distribution)
WA	Western Australia
WB	Wheatbelt of Western Australia
WRa	Winter rapeseed
WTI	Western Texas Intermediate – Cushing
WW	Winter wheat

Nomenclature of the model-farms and conducted panels

DE 1300MB	**De**utschland, **1300ha** farmland, **M**agdeburger **B**örde, Sachsen-Anhalt 7th October 2009 in Osterweddingen, Sachsen-Anhalt, Germany
AU 4500SC	**Au**stralia, **4500ha** farmland, **S**outh **C**oast region of Western Australia 16th March 2010 in Esperance WA, Australia
AU 4000WB	**Au**stralia, **4000ha** farmland, **W**heat**b**elt of Western Australia 1st April 2010 in Tammin WA, Australia
AU 2800CW	**Au**stralia, **2800ha** farmland, **C**entral **W**est region of New South Wales 5th February 2010 in Wellington NSW, Australia

1 Introduction

1.1 Issue

The economic framework conditions for the global agricultural sector have changed radically in the past decade. Trigger of this development is the rising demand for agricultural commodities which is, unlike than in former decades, driven by three factors: firstly by the growth of the world population, secondly by the risen purchasing power of consumers in important developing and threshold countries resulting in rising demand for meat and milk products and thirdly the increased transfer of agrarian raw materials into bioenergy (BANSE et al., 2008a, b).

The supplying sector could initially not keep up with the strong increase in demand in the second half of the last decade. The result were decreasing stocks of agricultural products of some important sectors worldwide over several years; finally resulting in a steep increase of commodity prices in the period of 2007/08. Moreover, weather-dependent production failures in some important growing regions of the world contributed to a further cut back. Then, however, the strong increase of commodity prices combined with weather conditions favouring the harvest in 2008 released an unexpected increase of the total harvest output worldwide. Hence, the global farming sector produced surpluses in 2008 again despite a record consumption of the bioenergy sector and world consumption, prices decreased significantly. Since that, global agriculture has been affected by other shocks, such as the drought in the Russian Federation during the summer of 2010, which caused the country's wheat production and export to fall dramatically and agricultural commodities started to bull market (USDA, 2008; FAO, 2011).

After these tumultuous developments on the agricultural commodity markets a considerable uncertainty about possible future market trends has spread. However, the open questions concern primarily the supply and less the demand side.

For the demand side a strong increase of consumption is generally expected and all three factors (growth in population, increase of purchasing power and further development in the bioenergy sector) play an important role after overcoming the financial and economic crisis. The increase of oil prices which is expected from the US Energy Information Administration but also the increased competitiveness of the bioenergy and the augmented resources deployed in this sector will lead to prices for agricultural commodities above the level prevailing before 2005 (VON BRAUN, 2007; EIA, 2009a; SCHMIDHUBER, 2007).

Different views of opinions exist on how the supply side can possibly adapt to this development. One viewpoint is that world farming already reached its limit and, provided further increase in production is generally possible, expansion can only be realised on the expense of sustainability (IAASTD, 2008).

Another opinion is that world farming still has the potential for expansion and that even a growing bioenergy sector would lead to a rather moderate increase of soft commodity prices (BBE, 2009).

The agricultural economic research faces several unsolved questions including how strongly the global farming sector can expand to cope with high demand and high prices and which results would be connected with it. The classic agricultural commodity market models can deliver only limited contributions, in particular when the scenarios to be examined deviate strongly from the situations observed up to now (CARTER and GARDINER, 1988).

Therefore it seems appropriate to supplement market model results by the development of "bottom-up" - research concepts to investigate available resources, production systems and potential adaptations in major regions worldwide. Respective results can then eventually be processed to higher aggregated conclusions (SCHONEY, 1992).

With the methodical design of such "bottom-up" concepts two central issues become evident which require different approaches of investigation:

(1) To what extent, constraints and cost can **currently unused potential arable land** be brought into production?

(2) What are the options to increase productivity on the **already existing farm land**, how can global agriculture adjust production and which expenses or side effects are connected with it?

While there has been some progress regarding the first question during the past years (OECD/FAO, 2009) there are currently no usable systematic results available to answer the second question on a global scale. This might be due to the fact that this question can only be answered from case to case on a small-scale level and up to now this has only been done for very few regions. Hence, a systematic approach for world farming can not be derived from attempts answering the second question.

In a long term perspective this problem could be solved if one succeeded in using the infrastructure of the *agri benchmark* network, which is in principle worldwide straightened, for assessing adaptation strategies and estimating yield increase potentials of global farming systems. A first attempt in that regard is undertaken in the doctoral thesis in hand.

For this explorative approach the first step is to carry out a strict containment for the regions to be investigated. In the core of the *agri benchmark* concept stands the collaboration with regional expert teams (so-called panels) in which the production-economic know-how is concentrated for individual regions.

The regions for this thesis are chosen in such a way that the results of the research may contribute to generate hypotheses regarding the dependency between location factors, intensity level of production and yield increase potentials.

The questions addressed in this thesis are (a) important for the understanding of the agricultural adaptation reactions in the global context and (b) currently considered to be unanswered:

– How do expected adaptations strategies differ between high-input and low-input production systems?
– Which influence does the coexistence of arable and pastoral agriculture have on the adaptive behaviour?
– Which role do climate risks take up with the definition of farm adaptation strategies?

Fully aware of these questions and the global agricultural diversity the focus is fixed on arable production on a total of four different panels, three are carried out in Australia, one in Germany. By doing so, particular emphasis is placed on being able to illustrate different intensity levels along a gradient.

1.2 Thesis objectives

The main objectives of this thesis are to examine within the scope of the global *agri benchmark* network how arable farms might adapt to prospectively rising commodity prices and what growth in production can potentially be discharged in selected regions.

With regard to content the further objective is aspired to obtain a first estimation about the relation between location factors and yield increase potentials.

In methodical regard the aim is pursued to develop a concept which can be transferred with minor modifications to other locations represented within the *agri benchmark* network.

1.3 Procedure

The global *agri benchmark* network provides a research infrastructure which can in principle be utilised for investigating the research question.

The research approach of *agri benchmark* is based on a central element, termed ‘typical farms’. Typical farms represent the dominating type of farms in relevant regions for agricultural production; although they do not exist in reality. While having the influence of individual specific features reduced to a great extent on the one hand, there is still the possibility to address the production procedures in a sophisticated manner. On the other hand, a remaining disadvantage of the concept is limited representativeness (HEMME, 2000).

agri benchmark Cash Crop is a branch of the *agri benchmark* global network project focussed on arable production systems. The concept, development and perspectives are outlined further after a brief introduction to the theoretical background for this thesis in Chapter 2. Up until now the typical farms approach is intensively used for ex-post production cost comparisons, hardly for ex-ante analyses to investigate adaptation processes of typical farms.

First experiences with regard to the latter objective show that estimates with linear programming (LP) are not sufficient enough. To be able to estimate farm adaptation strategies close to reality, great expenses would have to be pursued to quantify all adaptation options in such a way that they become generally applicable in LP. Further doubts remain whether certain considerations which are important for the decision makers can generally be implicated in a LP. Symptomatic for the weakness of LP modelling is that it has not asserted itself in practical planning of arable farms as well as in consulting services (EBMEYER, 2008).

For this reason it is decided to not take LP as a model. Instead, a concept is designed which is closer to actual actions and preferences of agricultural entrepreneurs and managers of leading arable farms. Therefore (a) group discussions and (b) an easy accessible quantification tool is put in the focus of the approach planned here to unlock local arable engineering expertise in the selected regions.

In each region a typical farm is established in a panel discussion. The purpose of panels is to develop possible adaptation strategies and to estimate potentials for the typical farm. Since ZIMMER and DEBLITZ (2005) as well as EBMEYER (2008) defined remaining uncertainty with the existing panel practice, the discussions are carried out under application of new methodological findings with focus groups. Further details are found in Section 2.3 of this thesis.

The panels in all four locations are supplied with a carefully prepared analysis of the initial situation of the respective typical farm. This economical and agronomical benchmark is backed upon average values from five single years (harvest 2005 – harvest 2009). To be able to prepare and conduct an efficient discussion about the potential adjustments with the panel it is necessary to have an efficient farm calculation and comparison tool. For this purpose the model TYPICROP is developed in the course of this study.

Given this reference situation it is then discussed how the typical farm will presumably react to a high price scenario disregarding the temporal component (comparative-static). The price scenario is developed by assuming the conversion ability of agrarian commodities to biofuels. They can substitute crude oil-based fuels to a certain extend and thus a minimum ceiling-price can be derived from the price of crude oil for grains and oil seeds (so-called bushel barrel correlation). On the other hand, crude oil prices also determine directly the price of agricultural inputs rich in energy, most of all nitrogen fertiliser and fuel. This systematic approach is chosen to identify the opportunities to adjust land use systems and estimate the production output potential of the locations.

The conceptual issues identified with the panel approach and the scenario derivation is addressed in Section 2.4 where the research design for this study is consolidated.

Taking the hypothesis into account that adaptation strategies and yield increase potentials differ explicitly under the influence of rising soft commodity and energy prices between relevant agriculture regions, this approach is applied to three selected regions in Australia and one region in Germany. The national key characteristics and framework conditions of the regions used in this study are outlined in Chapter 3.

With the determination of these locations, essential characteristics of world-wide land use systems such as differentiating production systems along a gradient of intensity, the coexistence of arable and pastoral agriculture with broadacre livestock farming and different geographical conditions, farming environments and production uncertainty are illustrated.

Participants of the group discussion are asked to develop concrete adaptation options for the model farm and to evaluate the effect on yields. To support this, an iterative trial is initiated which is expected to deliver the following results:

- Quantitative data of production systems and configuration of typical farms
- Qualitative estimation and evaluation of farm’s current challenges, adaptation strategies and yield potentials
- Interaction data of participants for an assessment of the research approach

During the discussion trial the responses of participants are recorded in a written protocol. This protocol supports strategy synthesis during the meeting and contains valuable insights for the descriptive presentation and interpretation of results in Chapter 4. For an assessment of the effectiveness of the panels as well as for the explanatory power of the potential estimation this chapter does also include a structured review of the engineering data and profitability of single measures on the basis of regional-specific agronomy trials (tillage trials, nutrient increase trials, crop rotation trials etc.) and the literature.

Conclusions about farm level implications of high commodity prices, related production output potentials and the application of the focus group methodology in the *agri benchmark* farmer panel concept are drawn and presented in Chapter 5.

A summary of the doctoral research thesis in hand is provided in Chapter 6.

2 Design and development of the research concept

In the thesis, broadacre land use systems, their possible production and adaptation potential under the influence of rising prices are examined. In this chapter the research concept enabling a systematic analysis is outlined and described.

Section 2.1 explains the relevant production-economic background firstly by focussing on utilisation of production inputs according to the marginal returns theory and on characterisation of production systems with joined production. Thirdly a definition of production risk is presented in this section.

Since this investigation stands in the context of the international network *agri benchmark* Cash Crop, Section 2.2 provides an overview about concept, development and perspectives. It includes a critical evaluation of the methodical approaches of *agri benchmark* particularly with regards to farmer panels and their utilisation for this study.

Section 2.3 presents scientific findings about focus group discussion with regard to the application in the panel methodology.

In Section 2.4 the final research concept is consolidated considering the raised methodological requirements. Therefore, besides developing the farm calculation model TYPICROP this section also outlines the derivation of the price scenario.

2.1 Economic principles of crop production adjustments

2.1.1 Production theory

The neoclassical economic theory of production considers an agricultural business to be a system which uses inputs or given production factors for a specific production process to generate a certain output. The central question is thus, what principles are in place to determine how these inputs and production factors are combined optimally and which products are to be produced to achieve an optimal organisation of the business and maximise profit as a price taker (DABBERT and BRAUN, 2006).

Thereby production theory adumbrates the monetary quantification of biologic-technical relations between inputs and outputs by respective prices. Underlying assumption in this thesis are changing prices for agricultural inputs and outputs. It is thus expected that the optimal organisation of the investigation farms changes. This suggests the question whether economic theory can provide indications for potential changes in the production program.

The **intensity** level of production is determined by technical factor-product relations and its prices. The relation assumed in neoclassical production theory is a production function with diminishing growth in yields. Optimal specific intensity is thus achieved, when marginal cost of an output unit equals its marginal revenue (DABBERT and BRAUN, 2006).

Accordingly, farms in the investigation regions are expected to have a certain level of intensity established in presence of their local farming environment and the prevailing price level for inputs and outputs. If output prices increase differentiating from factor prices as assumed in this thesis, an adjustment of the production along the marginal cost curve is expected since an adaptation can increase the profit. In the long run production needs to be adjusted to the point where minimal average cost per unit of output are achieved. The force to obtain the optimal specific intensity increases with rising product prices.

Expected measures are adjustments of direct crop inputs such as fertilisation level, plant protection strategy, genetic potential (crop varieties) and operational intensity (e.g. tillage). However, if intensification of direct inputs is an appropriate measure at a certain location increasing cost per hectare are expected (GANDORFER et al., 2006).

Agricultural commodities are produced worldwide predominantly in production systems with several products (**joint production**). In particular grain and oilseeds are predominantly produced by businesses which produce more than one product.

Beside the previously discussed optimal intensity of production this suggests the question how single enterprises (crops, livestock) are combined to maximise profit. This is determined by dependencies between enterprises in a multi product farm. According to DABBERT and BRAUN (2006) these dependencies adumbrate assuming a short term fixed farm configuration:

– **Parallel production**: In this case the production of a single product, does entirely not interfere the production of another product. Each enterprise can be extended or increased without affecting the others requirements. However, this relation is relatively rare in agriculture and not existing in the selected investigation regions of this study.
– **Coupled production**: This relation is found when the production of a certain output is associated with the occurrence of by-products. Coupled production is more common in agriculture and found for instance in arable production (wheat and straw) or livestock farming (dairy: milk and meat or sheep: meat and wool). In the planning of enterprises the main product and its by-product is commonly considered as one since the ratio is more or less fixed.

- **Competitive production** commonly characterises production systems in which two or more products are competing for a limited resource. Most prominent example is given farmland which can be utilised by a combination of enterprises and the increase of acreage dedicated to a certain product goes consequently to the detriment of other(s).

The dependency of enterprises in competitive production is the most relevant for discussing adaptation strategies of existing farm configurations in the course of this investigation.

The optimal production configuration (product-product relation) at given production factors is determined by individual transformation conditions, measured by the marginal transformation rate (MRT). Commonly, the MRT of single enterprises in arable production systems is increasing due to the fact, that an extension of a given crop forces disproportionate decline of the disappearing crop (DABBERT and BRAUN, 2006).

In reality this economic principle is considered with the design of cropping portfolio and crop rotations. The range of agricultural products incorporates crops which are self-intolerant (e.g. rapeseed, sugarbeet, legumes etc.), show substantial yield decline due to higher pest and disease pressure (e.g. wheat) or have specific requirements regarding factor input and timing (seeding or harvesting period). An extension of these crops within the rotation would lead to a decreasing overall yield level which must potentially be offset by an additional decline of the forfeiting crop. Furthermore, in joined production systems enterprises compete for scare production factors (land, work and capital).

This implies agronomic-technical constraints for the share of single enterprises in the production portfolio which are expected to vary significantly between the selected locations. On the other hand, the on-farm competitiveness of single enterprises under changing price relations might force the entrepreneurial agriculture to re-evaluate potential negative effects for the total profitability of the farming system.

Because in this thesis farms are analysed whose output is not only cash crops but also wool and meat, agronomic-technical interdependencies of the farming systems (crop rotation effects, land use systems), on-farm competition of individual enterprises and further motivations and constraints are in the focus.

A potential method for the optimisation of the production programme is linear programming (LP). Linear programming is a mathematical planning technique based on linear relations to find an optimisation solution under simultaneous consideration of a number of variables and limitations. Thereby the optimisation problem is defined in a system of linear equations and computed according to the best possible utilisation of resources short in supply. Linear programming is an established planning method in agricultural economics with various applications (STEINHAUSER et al., 1992).

However, based on the experiences gained by EBMEYER[1] and related recommendations, LP is not considered for the conceptual approach in this thesis. With regard to the complexity of farming systems analysed in this study, trend reversals and technological progress it is assumed that LP can not deliver comprehensive results and is assessed inexpedient for this kind of analysis.

2.1.2 Production uncertainty and risk

An important property of the neoclassical theory is the complete predictability of results implied by entrepreneurial decisions. This interferes with the reality for the following reasons (DABBERT and BRAUN, 2006):

(1) Agricultural production is exposed to environmental conditions, pests, diseases and other natural influences which cause **fluctuations in production output**.

(2) Agriculture operates on markets for inputs, production factors and outputs which are subject to volatility. Especially output **price fluctuations** affect agricultural production due to the considerably long processing times.

(3) Uncertainty in supply with factors, services and capital due to long term investment decisions.

(4) Institutional uncertainties resulting from changes in policy and regulations that affect agriculture.

(5) Human or personal risk.

Production uncertainty and price fluctuations are of central importance since the selected locations show substantial differences in that regard. They are explicitly chosen to depict a gradient. Production and price uncertainty are assumed to be determinants for the latitude of farm level adjustments and the individual assessment might change in the presence of high commodity prices. The following section provides a brief overview about the interpretation of ‘uncertainty’ and ‘risk’ as well as expected management measures.

[1] Cp. Section 2.2.3.

HARWOOD et al. (1999) provide a definition for uncertainty and risk which is also underlying for its interpretation in this study:

"Risk is uncertainty that affects an individual's welfare and is often associated with adversity and loss (financial loss, harm to human health, repercussions that effect resources). Uncertainty is a situation in which a person does not know what will happen. Uncertainty is necessary for risk to occur but need not lead to risky situations."

The handling of uncertainty and the willingness to take financial risk is an essential part of entrepreneurial operation. The expected outcome of the business refers to **potential conditions of the farming environment** and **applicable courses of action**. On the other hand, the **entrepreneurial personality** of the risk-taker is of importance for the business outcome. In many cases their individual experience from the past is extrapolated and forms the decision framework for the future (DABBERT and BRAUN, 2006).

To estimate the influence of uncertainty under which production takes place, the abovementioned properties are accumulated as follows:

- Potential farming environment conditions are estimated by the occurrence of extreme events in the past. Therefore precipitation patterns, yield development and price development are examined during the five-year-investigation period from 2005 to 2009. It is assumed that the evolution of these patterns a) shows significant differences between the regions and is thus appropriate for a qualitative categorisation and b) is crucial for the decision making process on farms with regard to the objective of this study.
- The applicable course of action is determined by the current production system and upcoming technological developments. It is expected that the production systems and its prospects vary significantly between the selected regions and thus the latitude of potential adjustments.
- The entrepreneurial personality and its willingness to take risk is considered in the investigation since the data sourcing process integrates local farmers who combine production engineering experience and subjective assessment of their business risk.

Given these preconditions, first qualitative conclusions about the influence of production uncertainty on farm level adjustments to cope with high commodity prices can be drawn on the basis of advanced expectation values from local entrepreneurs.

However, a clear disadvantage of this approach is the limited representativeness and transferability of the defined categories to other locations. A stochastic approach to estimate the probability of occurrence of extreme situation statistically is not carried out due to the explorative character of the study and the limited suitability of the expected data outcome.

With regard to differentiating production and price uncertainties, risk management strategies are expected to be applied in the investigated land use systems at present or in the prospect of high energy prices.

Risk management strategies a) reduce risk within the farm's operation (such as diversification) b) transfer risk outside the farm (such as contracted production) or c) build the farm's capacity to bear risk (such as maintaining liquid assets). For an individual farming enterprise, risk management involves finding the preferred combination of activities with uncertain outcomes and varying levels of expected return (HARWOOD et al., 1999).

2.2 *agri benchmark* Cash Crop – A scientific network to provide results and information about international agriculture

The background of this thesis is provided by the international *agri benchmark* Cash Crop network. For a better understanding of its objective it is thus prerequisite to lay out the concept, development and future perspectives of *agri benchmark*. The following brief overview is extracted from related publications tracing the development of *agri benchmark* until present such as the annual *agri benchmark* Cash Crop Reports by ZIMMER et al. (2007-2010), ZIMMER and NEHRING (2008), EBMEYER (2008), ZIMMER et al. (2009a) and the *agri benchmark* website.[2]

2.2.1 Development

The *agri benchmark* network is the result of long time research work and experience in economic analysis of international agriculture. Motivation for this is to draw conclusions about how market liberalisation in a globalised world economy triggers competitiveness of farming systems and its products in important production regions and how dynamic farming environments (e.g. retreating political measures, technology developments etc.) affect the development of farming systems. Global agriculture has changed substantially during the past decades and will further be subject to dynamic restructuring (ZIMMER et al., 2009a).

The necessity to provide information in this area is identified by ISERMEYER (1988) and DEBLITZ (1993) who conducted international comparisons of production systems and the economics of dairy and beef production. The studies use existing data from individual national sources for cost calculations and identify weaknesses regarding comparability,

[2] http://www.agribenchmark.org.

calculation methodology and accessibility. Both authors recommend the establishment of an own database to overcome these deficiencies.

In the following, attempts to establish a sustainable data source and organisation for scientific exchange were successfully undertaken with the setup of a European network of dairy farmers[3] before the predecessor of *agri benchmark*[4] was founded in 1997 at the Institute of Farm Economics (FAL) in Braunschweig, Germany as a worldwide research platform for agricultural scientists, advisors and farmers. First experiences of operating such a network were gained with dairy production and later applied to similar organisations for beef and arable production. In 2006 the network was restructured and the *agri benchmark* Cash Crop network, in which the thesis in hand is embedded, was launched. Considering this development, *agri benchmark* gained institutional experience in the area of integrated research in the field of competitiveness of international agriculture and organisation of scientific networks for over 15 years (PARKHOMENKO, 2004; EBMEYER, 2008).

agri benchmark is a joint project of the German Agricultural Society (Deutsche Landwirtschaftsgesellschaft, DLG) and the Institute of Farm Economics at Johann Heinrich von Thünen-Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries. Since the foundation of *agri benchmark* Cash Crop, the network showed continuous growth. By 2011, it merges experience from 32 partnering scientific organisations in 26 countries.

2.2.2 Concept of "typical farms" and panel approach

This section provides a brief overview of the conceptual approaches of *agri benchmark* Cash Crop which are relevant for the thesis in hand. General descriptions of *agri benchmark* concept and methods can be found in HEMME (2000), HEMME et al. (1997, 1999) as well as DEBLITZ et al. (1998).

Research within *agri benchmark* Cash Crop is focussed on arable farming systems and its economics, framework conditions and perspectives at an international scale. Integrative element of *agri benchmark* Cash Crop is a grid of **typical farms** in major production regions worldwide. The typical farms form the primary database and the reference marker for cost and productivity analysis.

---

3 European Dairy Farmers (EDF), http://www.dairyfarmers.net.

4 International Farm Comparison Network (IFCN).

A typical farm represents the predominating type of farm in a certain region or country. It includes a) structural data for size and land use, b) engineering data for production systems of certain crops c) configuration data for labour, machinery and building as well as d) whole farm data about finance and overheads. Although they can in principle be based on a single farm, typical farms are model farms and do not exist in reality.

The general denotation of the farms follows the *agri benchmark* standard. It can be explained by using the example AU 4500SC:

AU	=	**Au**stralia (Country abbreviation, ISO 2-letter country code)
4500	=	**4500** ha (total farm size in hectare)
SC	=	**S**outh **C**oast of Western Australia (abbreviation of the local region)

For the purpose of defining typical farms a standard operating procedure (SOP) is developed to ensure the same approach and working steps in all participating countries. The SOP contains four steps. In the first step, important regions for the production of the commodity are identified. Commonly, this is carried out by means of regional statistics showing the spatial distribution of production. Once the region is identified, the relevant farm population, farm type and production system is determined with the help of local advisors or farmers. During this process the degree of specialisation and intensity, the capital and labour structure, yield levels, cropping patterns and technology and further indicators are elaborated and a draft for the typical farm is established (pre-panel). In the third step this draft is discussed, adjusted and approved by a group of local farmers (panel) to ensure the dataset reflects the typical farm situation. In the final phase, the data is computed and results returned to the panel for cross-checking. In the course of *agri benchmark* activities, this process is carried out for each farm every three years, while yield and price data is updated every year (ZIMMER and DEBLITZ, 2005).

In the core of the *agri benchmark* data sourcing concept stands the work with regional expert teams (so-called panels) in which the production-economic know-how is bundled up for an important production region in each case. The regional panels are commonly conducted by the national partners of *agri benchmark* in their respective countries. Results are then transferred to *agri benchmark* centre and analysed centrally. With this procedure a harmonised efficient method to collect first hand production and economic data from farmers is established and the disadvantage of sourcing data from inhomogeneous national sources is overcome principally.

However, while ZIMMER and DEBLITZ (2005) took great effort to improve the identification of the important production regions and thus the locations of the typical farms, a considerable methodological uncertainty about the course of an investigation involving groups and the discussion process itself within the panel is experienced with the application of the SOP. They involve the following points of criticism:

- Selection and recruitment of participating farmers
- Validity and reproducibility of discussion process
- Individual influence of the researcher on the results

Given that the prevailing uncertainties bear also limitations for the output generated from *agri benchmark*, a profound application of a group discussion method involving widely standardised elements could not only improve the confidence of the individual researcher running the panel discussions but likewise the validity of results. An attempt to consolidate the *agri benchmark* method in this regard is undertaken with the thesis in hand.

For calculations of the farm data within *agri benchmark* a computer based calculation tool termed 'TYPICAL' is used so far. This program is designed to calculate static economic indicators as well as their projections for various agricultural enterprises and products such as dairy, beef and cash crops and is used by the three branches of *agri benchmark*. A comprehensive documentation of TIPICAL is found in HEMME (2000).

However, with the planning of this investigation it is experienced that TYPICAL shows substantial deficiencies. They are identified with regards to this investigation but also to the potential development of the cash crop branch of *agri benchmark*:

- TYPICAL is not able to display and calculate cash crop production systems in greater detail under consideration of physical inputs and performance data.
- The model structure of TYPICAL requires considerable user skills and does principally not allow sporadically involved partners to generate immediate results for their typical farm to enhance data quality.
- The TYPICAL platform and interface can practically not be used directly in panel discussions with farmers to gain immediate response from participants about the economic performance of the typical farm and assessments of potential farm adjustments.

In particular the latter case restricts a more effective application of the typical farm approach since sourced panel-data has to be calculated externally and reissued with the participants in a second meeting. This additional effort does not only extend the investigation time but also shrinks the acceptance of the farmers to participate in the project.

Hence, the technical appliances of the data collection and calculation process can be assessed as potential subject for improvement and is considered with the conceptual design of this thesis.

2.2.3 Perspectives

The *agri benchmark* network has generated substantial knowledge about production systems, production structures and international cost comparison and the corresponding international infrastructure of the network has successfully been used for calculation and ex-post production cost analysis of major agricultural commodities in relevant production regions worldwide. Results from *agri benchmark* Cash Crop in that regard are found in the respective Cash Crop Reports from 2005 to 2010.

The conceptual approach focuses on the comparison and assessment of competitiveness of production in major production regions under changing framework conditions. This development has so far been driven by ongoing liberalisation and international trade. Since the increase in global demand for agricultural commodities is outpacing supply and world market prices started to run bullish, the perspective on competitiveness may change. In the future, competitiveness estimations may not only be focussed on production cost advantages but be seen as the availability of the different agricultural products to compete for the scare resources available for production. *agri benchmark* research may further focus on how agricultural entrepreneurs react on price shifts in presence of their individual farming environment, how production systems will adjust to these conditions and where substantial productivity gains might come from in the future (EBMEYER, 2008).

In that regard several case studies are conducted such as an investigation on the economics of tillage systems (ZIMMER et al., 2007), triggers of crop production in individual countries such as Russia, China, Australia and Malaysia, the challenge of exchange rate fluctuations, perspectives for further yield growth (ZIMMER et al., 2009b), perspectives in grain marketing or the economics of high land rents (ZIMMER et al., 2009c).

A doctoral research study using the *agri benchmark* Cash Crop infrastructure to generate ex-ante results about prospective entrepreneurial response is undertaken by EBMEYER (2008). The research concept is designed to predict and validate changes of the crop portfolio of typical farms with output from linear programming (LP) assuming a shift of output price ratios of single competing cash crops on four typical farms in Canada and Germany.

Crop rotations are found to be relatively firm according to the respective regional conditions and intensity of production. In less intensive production systems only marginal changes in the crop portfolio are to be expected compared to more cropping flexibility with high input systems (EBMEYER, 2008).

From a methodological perspective the panel discussions with farmers conducted within *agri benchmark* are principally suitable for this type of investigation but bear limitations as already outlined. However, the outcome of the panels can only marginally be substituted with outputs from LP which are obtained with far more complexity. In respect to the latter, the extended panel approach has only been executed on one out of the four locations (EBMEYER, 2008).

Acknowledging the experience and the status quo of *agri benchmark* Cash Crop, the concept appears to be suitable to analyse ex-ante adaptation strategies and estimate yield increase potentials of global cash crop farming systems. A respective attempt is undertaken in this thesis.

However, the *agri benchmark* concept bears methodological vulnerabilities which have to be considered and responded to before implying the procedure into the research design. This will be carried out in the following Section 2.3.

2.3 Advancement of *agri benchmark* methodology for analysing farm level implications

With regard to the objectives of this thesis and the conclusions deducted from the discussion above, two methodical vulnerabilities are identified within the current *agri benchmark* Cash Crop concept. These exist

a) In the procedure of panel discussions and in the sound generation of farm data thereof and

b) In the systematic analysis of the typical farms. This involves the calculation of economical indicators and the explanation of the underlying production systems.

The following sections outline possible solutions of how to overcome these methodical vulnerabilities. The first Section 2.3.1 incorporates a literature review of empirical methods involving groups.

The second part 2.3.2 discusses a methodical approach for the planning and realisation of panel discussions compiled on the basis of social-scientific findings and a possible contribution for the generation of raw data for the investigation farms is also discussed.

2.3.1 Literature review of empirical methods involving groups

The development of the methodical estimate of investigations involving groups justifies itself upon results of the research from other scientific disciplines. In the relevant literature different forms of accessing the group-shaped, communicative interaction by scientists are described. Thereby, the institutional availability of a group can have quite different meanings. According to LOOS and SCHÄFER (2001) it is distinguished between the following:

- **Group survey**

  The group survey or group interview can take place in different specifications. Very often standardised questionnaires are answered in a group situation in presence of a researcher or an open questionnaire is worked through (ATTESLANDER, 1991). In many cases, these forms are merely a time-economic variation of the single questioning because the group is not conceived methodically as an object of the investigation. A discussion with the survey participants is not intended with the group survey.

- **Group conversation**

  The group conversation is geared to naturally start conversations between individuals since people certainly talk to each other even if not requested by researchers. Therefore, group conversations are of specific interest for the analysis of conversation structures. Their attention is rather focussed on their occasion; typical forms, activity patterns and contents are irrelevant.

- **Group discussion**

  The group discussion differs from the group conversation because their formation is externally initiated. The group gathers to discuss a subject given by the discussion management. In contrast to the group survey it is not only about straight collecting opinions of individuals as time effectively as possible but also about the challenge to initiate an intensive exchange and discussion of subject-related arguments within in the group. At best, the group discussion resembles a ‚normal' discussion as if the management would not be present.

The group discussion distinguishes itself in comparison to the other introduced procedures per se by the combination of an oriented discussion towards results and high interaction possibilities between the participants of the group.

According to LOOS and SCHÄFER (2001) it can be distinguished between two basic orientations of the group discussion:

1. The traditional and by far the most widespread area of application of the group discussion is marketing and consumption research. In English-speaking nations this procedure is used since the end of the 1940s to retrieve explorative information from consumers. Since the group discussion is focused predominantly on certain content and results (in this context), this method is called **focus group**.
2. Besides that in social and education-scientific research questions reveal in connection with collective phenomena or collectively interfered orientation patterns for example the investigation of biographic orientation of teenagers, the area of the

media reception research or the gender investigation. In this context the **group discussion method** is designed to investigate and interpret the role behaviour of individuals in a group.

With regard to the inclusion of expert's knowledge to generate raw data for the establishment of typical farms and the analysis of adaptation strategies a result-oriented approach is chosen. Hence, the procedure of focus groups is chosen for the panel discussion.

2.3.2 Focus groups

2.3.2.1 Introduction and characteristics

A focus group discussion is a moderated group discussion focused on a certain content. It is a combination of the methodical instruments group discussion (see above) and the focused interview in which an interviewer questions a participant according to guidelines focussing on a specific subject (DÜRRENBERGER and BEHRINGER, 1999).

According to KRUEGER (1988), focus groups can be distinguished by the following characteristics, for example size of the groups, constellation of participants, discussion process, their position in the research context and validity. Each of these characteristics will be explained in more detail in the following section.

Size of the group

In the cited literature the recommended number of participants in focus groups varies from seven to ten people. However, specific groups can also amount from three to twelve people. The effective size of a focus group is influenced by two factors;

(1) The group has to be small enough to allow every participant the possibility to describe their own views without hesitation.

(2) The group has to be large enough to contain a sufficient variety of individual perceptions on a certain subject.

If a number of twelve participants is exceeded the danger exists, that the group splits up into smaller groups. Although the participants want to confide in the discussion, they do not receive the opportunity to take part by the number of requests to speak, but begin talking with the people in their immediate surrounding.

Smaller groups with three to five participants are recommended if the participants have a big interest in the subject, know a lot about the subject or show a strong emotional dismay. Moreover, they have the logistic advantage that they can be easily held in locations in which the amount of space is limited[5] (DÜRRENBERGER and BEHRINGER, 1999).

Constellation of participants – Homogeneity and Anonymity

Focus groups consist of people who are similar in a prominent characteristic. This characteristic is determined by the purpose of the study and pre-defined by the number of possible application of focus groups. This homogeneity regarding a certain investigation object also forms the basis for the recruitment of participants.

The literature disagrees about the significance of the homogeneity of the participants on the success of the focus group. KRUEGER (1988) examines the fact that focus groups in the ideal case consist of participants which are absolutely foreign among each other and only brought together for this occasion **(random groups)**. However, at the same time he argues that this can often not be realised in thematically or spatially limited investigation fields. There are several reasons for this position:

– People who deal with each other regularly can show a dependent behaviour in discussions by experiences, events or discussions of the past.
– An existing group dynamic, i.e. sports club, youth group can suppress opinions of single participants.
– Integration of the participants in social or economic dependence, i.e. father vs. son, manager vs. worker can affect the attendance in discussions negatively.
– For a successful discussion role behaviour in the group or private talks of single participants can become a problem.

A discussion can also be conducted with a group in which the participants already know each other at the beginning and they share an experience basis. DÜRRENBERGER and BEHRINGER (1999) as well as LOOS and SCHÄFFER (2001) describe this group work with so-called **real groups**. The authors argue that real groups should be considered more because:

– Real groups already have an existing group dynamic. Thus, the participants don't have to become acquainted at the beginning of the meeting and a lively discussion can develop quickly.
– During the discussion process a collectively shared experience basis can be accessed, since this is generally the common characteristic on which the groups have initially been established.

---

5 Refer to mini focus groups in Section 2.3.2.3.

- The selection of real groups enables to reach people who would not take part in a focus group existing of „strangers”.
- Real groups can be mobilised quicker and with less expenses than artificially combined groups.

From the comparison of the group concepts it arises, that the anonymity of the participants is of great importance for the course and the success of the discussion. How the discussion with a focus group shall be arranged in harmony with the described arguments is discussed in the following Section 2.3.2.2. The meaning of the anonymity of the group participants for the research in this thesis is explained at the end of this chapter together with the development of own methodical approaches (Section 2.4).

Discussion process

The discussion with focus groups is based on open questions.[6] As a result, the participants decide independently about the direction and the type of the answer under the consideration of own experiences as well as under the observations of the other participants. A discussion atmosphere originates when a single participant influences the others but is also influenced by the rest of the group. This internal controlling mechanism is an explicitly initiated essential feature of focus groups.

An exclusive feature of the discussion with focus groups is that the moderator is not under a considerable strain to produce a consensus with the group. Instead, the attention is focussed on the understanding of the consideration process if the group argues about a subject.

Strength of focus groups is to register positions, opinions and motives of the participants by comparing products, services or options for action. Focus groups differ from other interactions with groups carried out for the purpose of finding consensus on a conflict, to result in action, recommendations or to make concrete decisions.

Focus groups in the conflict between qualitative and quantitative research

In general, empirical research can be qualitative or quantitative. Qualitative research concentrates upon facts and observations to describe situations. In contrast, the quantitative approach arises of the academic tradition to answer scientific questions with figures.

Qualitative research is criticised to be subjective and to be influenced by the arbitrariness, because data is not raised by using a uniform pattern. However, the view is that new research objects can not be explored with quantitative methods since the reversal of

---

[6] This type of question and the application is defined in detail at a later stage in this chapter.

trends can not be extrapolated. Quantitative methods always assume and test hypotheses which are the result of qualitative methods.

However, research has identified advantages from the combination of both approaches for a broader methodical variety to improve research designs (WARD et al., 1991). Focus groups can deliver qualitative data by generating positions, opinions and motives in regards to different questions and investigation topics. The following paragraph will explain how focus groups can complement quantitative research methods.

- **Focus groups can be arranged ahead of quantitative investigations.** In this way the researcher can approach the research topic exploratively to get samples of decisions of the target group. In addition, focus groups can already give an indication about problems which possibly appear during the quantitative phase of the investigation.
- **Focus groups can proceed at the same time as quantitative investigations.** In this case the focus group offers the possibility to check intermediate results for consistency or to complement the initial method.
- **Focus groups can follow quantitative investigations** and add a valuable supplement to the interpretation of the results. In addition, focus groups can turn out to be helpful if problems arise by quantitative methods (e.g. demand analyses) for which solutions can be developed.

It can be concluded that the application of focus groups in connection with quantitative methods are of advantage. Which methodical approach is preferable depends on the research questions and is decided in detail in the planning stage of the study.

Validity and reproducibility of results

As an instrument of qualitative social research, data derived from focus groups bear limitations concerning validity and ability of reproduction. These limitations are caused by the fact that the discussion process is influenced by preconditions which are often unknown. Some of these preconditions can be

- Selection of participants
- Influence of dominating participants
- Management by the moderator
- Appearance of a group subculture
- Group dynamics
- Differences in material status
- Social background or tension
- Clash of interest

Nevertheless, it is not the aim of focus group discussions to initiate an infertile discussion in which these factors are ignored. The results from it would be of little value. Hence, it is important to estimate by which factors the discussion is influenced in each individual case (DÜRRENBERGER and BEHRINGER, 1999).

Quantitative data can not be generalised categorically to statistically representative statements and generalisations from outcomes of focus groups are not allowed. Nevertheless, KRUEGER (1988) refers to investigations in which the results generated by focus groups agree astonishingly well with quantitatively raised results.

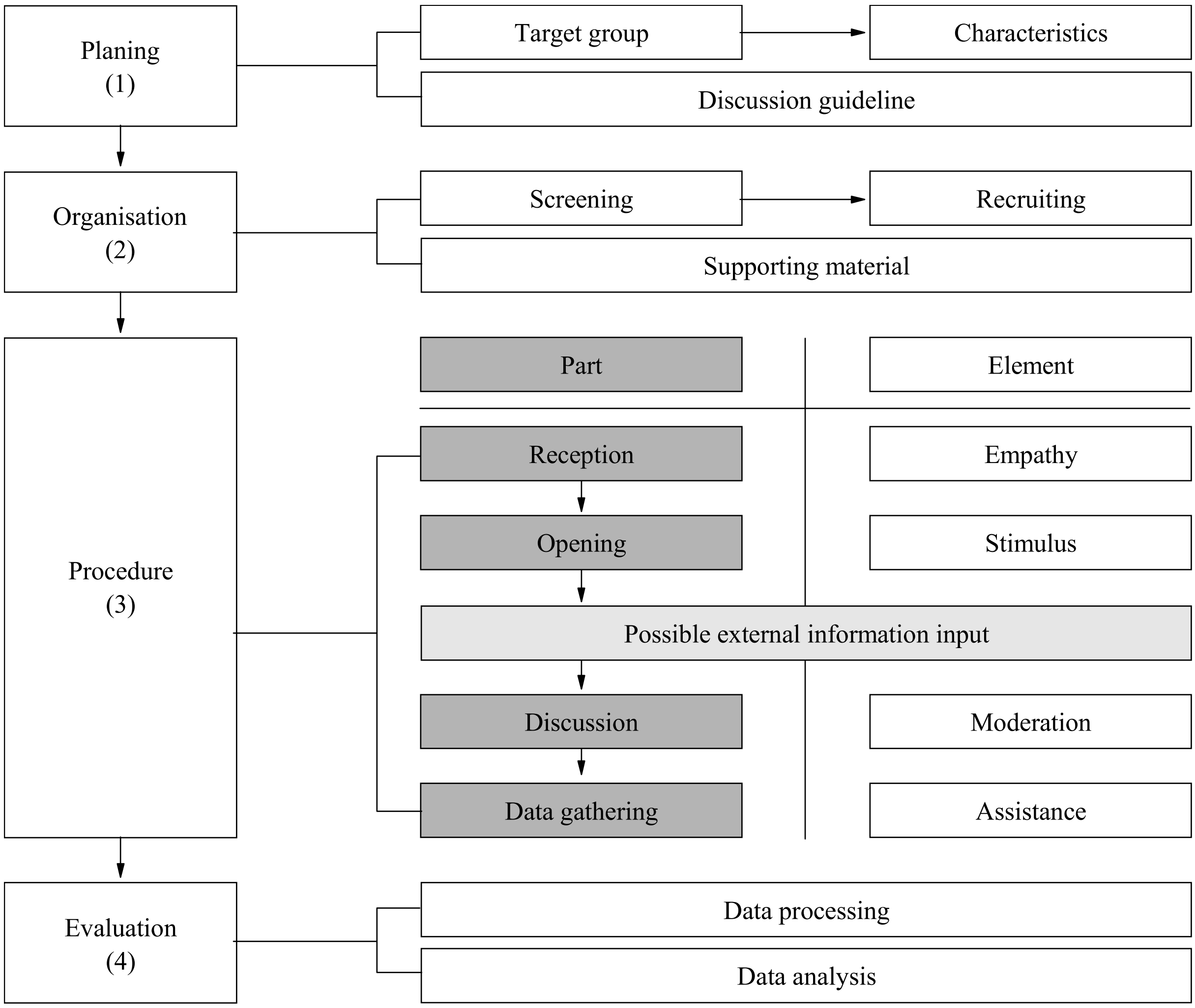
The discussion with focus groups has been established as an independent method in the empiric research. However, it can also be applied together with other methods to reveal valuable additional knowledge.

The extent to how focus groups can be integrated into the methodical approach of this thesis will be discussed after the sequence of investigations and special forms are explored in the following section.

2.3.2.2 Sequence of investigations with focus groups

According by DÜRRENBERGER and BEHRINGER (1999) an investigation with focus groups consists of four stages (Figure 2.1).

Figure 2.1: Stages of an investigation with focus groups



Source: Dürrenberger & Behringer (1999), own illustration.

(1) Planning of the investigation

Once it has been decided to use focus groups to answer a scientific research question the planning begins with the choice of the **target group**. The target group can be so small that all people can be included in the investigation or so large that a random sample has to be selected (DÜRRENBERGER and BEHRINGER, 1999).

With the choice of a random sample no statistical randomisation procedure has to be used. In many cases this is rather theory-guided. One searches extreme cases: the typical case or the most productive case. Selection criteria are time, money, knowledge or methodical aspects (such as homogeneity of a group) (PATTON, 1990).

After the definition of the target group the **characteristics**[7] (see Figure 2.1) of the consequential focus group are to be defined, such as homogeneity (similarity of the participants regarding a prominent characteristic) or anonymity (random groups versus real groups).

According to the guidelines derived from theory, the following characteristics have been defined for the panels in this study:

– Homogeneity: Farmers or entrepreneurs running top-managed agricultural businesses in the selected regions. Major part of the farm revenue must be generated with the cash crop enterprise
– Anonymity: Real groups are chosen especially in rural areas of Australia, since farmers potentially know each other. Farmers can, but must not necessarily be organised in local farm advisory groups.

The selection of the participants depends on the anonymity of the group. With random groups the selection procedure can be complex. According to the criteria and available filter possibilities the quoting or random procedure is applied. Far less laborious is the choice of real groups. In particular if a contact person of the enquired institution grants active support (DÜRRENBERGER and BEHRINGER, 1999).

A criterion for the **number of sessions** to be carried out is the so-called „theoretical saturation". Carefully and professionally organised focus groups are carried out on a subject until no new important insights can be revealed by additional groups (GLASER and STRAUSS, 1967).

Usually, standard focus groups incorporate one session. Further meetings are necessary when the subject can not be discussed adequately due to the limiting extent of one session, if specialist knowledge should be provided or a report has to be produced.[8]

Guided by this general finding, it is assumed in the course of this study that theoretical saturation is achieved about the farm level adjustments per typical farm by conduction one panel per region.

---

7 Cp. Section 2.3.2.2.

8 Refer to Section 2.3.2.3 (Special forms of focus groups) for more details.

The **discussion guideline** is *the* central instrument of the group discussion. It structures the sequence and forms the basis of the evaluation. According to DÜRRENBERGER and BEHRINGER (1999) the construction of the guideline might follow some basic rules such as

(1) Begin the discussion with general questions and finish the discussion with specific questions.

(2) Asking clear and exact questions regarding the content with enable efficient data analysis.

(3) Usage of understandable and unequivocal formulations.

(4) Usage of references to unlock the thematic background and knowledge of the participants.

(5) Usage of positive questions (What do you prefer …?), avoidance of negative questions (What disturbs you …?).

(6) General utilisation of open ended questions requesting explicatory answers, not to be answered by „yes“ or „no“.

The flexibility of a discussion guideline depends on subject, question, target group and time. Questions are normally formulated identically in all focus groups to allow comparisons between the focus groups.

Nevertheless, with explorative investigations sometimes it might be necessary to deviate from this principle. The guideline is the „screenplay“ for the discussion and at the same time material application. Moderation techniques, activities and breaks can be noted (DÜRRENBERGER and BEHRINGER, 1999).

Based on the findings from the pre-panel investigations the discussion guideline procedure is modified from the introduced method: Instead of formulating a plain questionnaire with open end questions, a two-part guideline is developed:

(1) A handout that contains 12 tables and figures describing the reference scenario of the respective typical farm is developed. It contains the relevant data for the typical farm in order of their relevance for the topic (from general to special) and their specific grade of sensitivity (from low to high).

(2) A further document is edited containing individual figures of the high price scenario of the world market and farm gate level.

(2) Preparation and Organisation

When recruiting the participants the selection process should guarantee that the intended composition of the focus group is achieved. Therefore it must be clarified that the contacted person consents to participate in the discussion group. An efficient way to contact people is a guided telephone conversation (DÜRRENBERGER and BEHRINGER, 1999).

- The telephone conservation should start by explaining the purpose of the phone call in *very personal manner*.
- Further information on the group discussion, place and date, length, content of the discussion, clients and whether compensation is available should be discussed.
- The consent of the potential participant should be sought.
- It should be identified that the potential participant is suitable with regard to the objectives for the group composition.
- Additionally, potential participants are informed that an invitation letter with programme is send and that all information are kept confidential.

From the perspective of the contacted person the selection process is absolutely meaningless. Therefore it is crucial to deliver the necessary information and decide whether the participation in the event is feasible or not.

Some authors find that the willingness of people to take part in focus groups is astonishingly high (KRUEGER, 1988; DAMMER and SZYMKOWIAK, 1998; DÜRRENBERGER and BEHRINGER, 1999). Possible reasons why people are interested in participating in the discussions are interest in the subject, personal dismay, the possibility to meet other people or curiosity.

However, it should also be noticed that there are aspects which can disfavour participation. These can include for example date, place and duration of the event, mistrust in the organiser or the feeling one could possibly be overstrained by the discussion. Hence, organisers can help themselves with a professional recruitment process which contains the following incentives to encourage people to participate in the survey (DÜRRENBERGER and BEHRINGER, 1999):

- The contact should follow through an organisation, such as a club, political party, industry representative office or lobby groups the person belongs to.
- The conversation is carried out by a competent and trustworthy person from a research or interviewing institute with a very personal way of speaking.
- The topic is close to everyday life.
- The discussion should take place at a central place and at a favourable time with several dates being offered to the candidates.
- Additionally, a financial compensation can be offered.

The first contact is usually followed up by sending a letter with a registration form to the interested people. The letter should inform about the aim of the investigation, clients, supporting organisations, place and time of the discussions, content, confidentiality/data security and compensation. The registration form may also contain specifications to bank details in case compensation will be paid directly to the participants.

The registration form can also provide planning security. Candidates who do not send back their registration form are phoned again. One day before the event participants should be phoned to ascertain their attendance to keep absences as low as possible. Nevertheless, to guarantee the intended group size, overrecruiting should be aimed for (EDMUNDS, 2000). The period between the first inquiry and the beginning of the event should not be longer than four weeks (DÜRRENBERGER and BEHRINGER, 1999).

Acknowledging the theoretical considerations, the recruitment of participants for this study is carried out by means of the following four steps:

1. Farmers and consultants are approached as potential participants. The initial contacts from the pre-panel investigations act as contact persons. It is planned that this person is present at the panel discussion.
2. Four weeks prior to the meeting participants are contacted by telephone. Purpose of the study, explanation of the framework, clarification of the willingness to participate, clarification of the general suitability according to the objectives for the group composition and commitment to further steps are discussed.
3. A personal invitation letter and submission of relevant information is send out ten days prior to the meeting.
4. One day prior to the meeting a personal telephone conversation follows to confirm participation.

The possibility to employ a professional recruitment process is kept in mind in case personal recruiting proofs unsuccessful. Financial compensation for participants is not planned, because participants are provided with exclusive access to results from this study and from *agri benchmark* Cash Crop. The proposed registration form will not be used in this study because the survey is of rather casual nature.

The phase of the preparation and organisation of the focus group also includes the **production of supporting material**. Two major methodical elements become evident at this stage.

The objective of the **stimulus** is to assign the participants' priorities for the topic to be discussed and to stimulate the discussion at the beginning of the meeting. It delivers a common content and emotional reference point to the group. Therefore a short presentation, report, text and pictures may be helpful. In marketing applications prototypes of the products, packaging or advertising are often used as a stimulus. The effect of the stimulus should be tested in advance in a trialled discussion. The test should reveal whether the discussion is really stimulating or if the stimulus starts debates that have only little in common with the planned focus of the discussion (DÜRRENBERGER and BEHRINGER, 1999).

In case the discussion covers complicated subjects **additional information** material can be introduced to the group. This could happen independently and apart from the stimulus. DÜRRENBERGER and BEHRINGER (1999) suggest options for providing information including

– **Documents** – Briefly and concisely written material. For the immediate success the time of the delivery is vital. If the documents are sent out prior to the session, the participants can step into the discussion pre-informed.

– **Expert's presentation and discussion** – Usually first hand information is very valuable. However, precondition is a good presentation which orientates itself towards the knowledge and demands of the audience: brief, not too complicated, as little jargon as possible. Expert's knowledge can also prevent discussions. Hence, ideal case is a short impulse contribution with extensive discussion.

– **Computer models** – To meet specific questions, computer simulations are also used. Nevertheless, it is to be proceeded very carefully since an immediate content and graphic information depth may have a negative effect on the participants which can lead to uncertainties. It is important that concept, explanatory power and limitations of the introduced model are present. Another factor is the time requirement: Most models are not applicable in small groups in less than one hour. Hence, their application should be checked critically.

Considering the value of additional information for the focus group discussion stated in the literature, a written handout (document) is send to the participants upfront and the discussion itself is supported by an efficient farm calculation tool (computer model).

(3) Procedure focus group discussions

The conduction of focus groups starts with a **personal reception** of the participants. In the literature it is argued that the first minutes of contact decide whether the following discussion is carried out in a constructive and open atmosphere or in a rather defensive and close manner (LOOS and SCHÄFER, 2001; DÜRRENBERGER and BEHRINGER, 1999).

The organizer or the moderator should act as the host of the discussion group and create a friendly, comfortable atmosphere. Empathy and ability to 'small talk' can be essential. However, the main topics of the discussion must remain untouched during this phase because the participants commonly express their opinion only once during such a meeting. If this already happens in the early informal stage it can happen that they are repeated in the following discussion only hesitantly and might get lost for the analysis. In addition, it is recommended to use the personal introduction and bilateral conversations for the acquisition of the participant's perspective (KRUEGER, 1988).

The following **official opening** is the critical phase for the success of the focus group discussion. The presenter must create an attentive, tolerant atmosphere in very short time, introduce the subject and encourage the discussion simultaneously.

The opening begins with a suitable short introduction speech which can enclose the following aspects: welcoming, short overview of the aim and structure of the event as well as a round of introductions if the participants do not know each other. The stimulus follows and delivers a common reference point for the group (KRUEGER, 1988). The phase after the official introduction offers an ideal opportunity for the explanation of additional information about the subject of the discussion.

The introduction of information should take about 15 to 20 minutes at the most. This information should not be presented by the same person who conducts the discussion (DÜRRENBERGER and BEHRINGER, 1999).

Up to this point only organisational information is provided to the group. Therefore it is not relevant whether the group is randomly composed or the participants already know themselves. With the subsequent discussion phase the anonymity of the participants comes to the fore. In **random groups** a natural phase on the participants becoming acquainted with each other follows. This phase is crucial to the success of the focus group. If an existing consternation or mistrust is not cleared the discussion dynamic can be influenced negatively and with it the quality of the results.

It is worthwhile to address this aspect openly. In case during the opening not everybody has the chance to speak, the first question must function as an „ice breaker" to encourage every single participant to contribute to the discussion (KRUEGER, 1988).

This can have three practical consequences:

1. The first statement reveals the similarity of the participants regarding a specific topic which is theoretically only known by the moderator of the session up to now.[9] Now all participants realise that they have a common basis to share information among each other (= trust).
2. After a participant has said something it is encouraging to contribute again.
3. The opening statement can serve to approach to the participants by specific questions and/or to restrict the discussion course at a later stage.

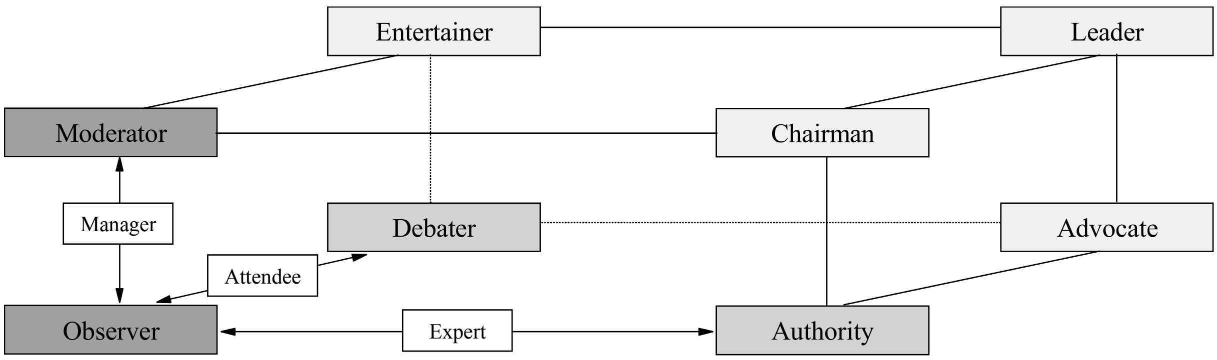
[9] Cp. Section 2.3.2.2.

By deploying **real groups** for focus group investigations one can neglect the above outlined procedure since the participants already know themselves. In some cases a personal contact connects the organizer of the focus group with the participants. Such a connection at the session further supports the internal confidence (DÜRRENBERGER and BEHRINGER, 1999).

In the herewith introduced investigation, the course is oriented at a group discussion with real groups. It is placed particular emphasis on knowing the participants personally before the meeting with regards to sharing confident information. However, the beginning of the meetings is used to provide lunch and refreshments which enables an informal introduction of participants before starting the formal discussion.

After the complex early stage of a focus group discussion the **moderator** takes over a defined role concerning the group. He introduces information to the group, listens, observes and has the possibility to analyse more thoroughly or to double-check the gained information. It can be distinguished between three active basic roles: the role of the expert, the role of an attendee in the discussion and the role of the discussion manager (Figure 2.2).

Figure 2.2: Requested and unrequested roles of moderators



Source: DÜRRENBERGER and BEHRINGER (1999), own illustration.

In the ideal case the presenting person switches between observing and moderating the discussion. Once successfully initiated this person can step back into the passive position of the observer recording generated findings until the group needs further guidance. The person must then act immediately as a proactive moderator raising questions, managing conversation interactions and shaping social processes within the group.

By introducing expert knowledge to the group, the presenting person appears as an authority, which is undesirable because it can dominate the discussion in regards to the contents or socially. In case competence in a specific subject is indispensable for the discussion, external experts should be consulted (see above).

The role of an attendee in the discussion is also undesirable for the moderator. In this case the presenting person takes part in the discussion and argues a personal opinion. The discussion can hardly be guided objectively.

The influence of all other possible functions, such as entertainer, leader, chairman and advocate upon the group can be negatively assessed in regards to the success of the focus group. Therefore moderator must avoid taking up one of these roles.

In execution of the intended role the moderator applies **moderation techniques**. These different techniques are control measures to guide the course of conversation. Moderation techniques are learnable and therefore immediately based on the abilities of the presenter.

The following section includes a literature review to reflect the three most important presentation technologies for the successful outcome of focus groups (DÜRRENBERGER and BEHRINGER, 1999; KRUEGER, 1988; DAMMER and SZYMKOWIAK, 1998).

Interview techniques address the focused problem in the discussion:

– Questions for focus groups are usually open, i.e. they request explicatory answers and are not to be answered by „yes“ or „no“
– Generally participants are not questioned directly
– If vague or unclear answers are given it is the assignment of the moderator to sharpen the picture or to reach the necessary depth dimension. To audit the outcome of focus groups the following methods are suitable:

  5-second-break – after a comment of a participant is formulated an artificial break of 5 seconds is kept which produces approval/rejection or complementary arguments.

  Listening & body language – mindful listening of the presenter without any signs of evaluation is essential for the development of the discussion. For example, frequent affirming nod of the presenter can be a sign of (unintentional) approval, shaking of the head can signal an aversion to the participants in regards to the proposed arguments saying that further input is not useful, not welcome or wrong.

  Short verbal statements – colloquially common, short verbal reactions like „OK“, „yes“, „but”, „maybe”, „hmm”, etc. can be understood as an implied evaluation. They conceal the danger that not only the professional suitability but also the manner of contribution of the participant is valued. Moderators are recommended to use value-free gestures and comments.

Specific inquiries – specifically targeted, structured inquiries can lead to more precise answers (justify, describe, give examples). However, such inquiries can cause time delay especially if it concerns minor issues.

Methodical naivety – A proven method of the critical analysis of arguments for the moderator is to be objective and without understanding concerning the offered stories. One pursues a systematic break with everyday self-evidences or usual technical consensus.

In addition, the methodical naivety is also a controlling function for the moderator. With a strong professional connection with the discussed topic, presenters can be inclined soon to understand too much. Accordingly, the danger may occur that statements are left unevaluated.

Stretching – The stretching aims to firm establishment. The moderator initiates step by step descriptions of processes or products in her embedded situation. By interpretation of outcome qualities, decisive factors and personally preferences can be exposed during the discussion. The stretching phase works like a slow motion.

Exaggeration – exaggeration pursues the goal to productively break up especially pertinacious arguments of ostensible importance. Common means are extremes and levelling.

Application of extremes means the exchange of a commonly known, apparently unavoidable course of action by an extreme example or the abstraction of the question by an extreme thought experiment.

With the analytical levelling the most evident reason is cancelled for a certain choice and the participants are put once more to the decision with all alternatives.

Analytical techniques are used to understand perception or assessment dimensions of the participants to guarantee the traceability of the discussion. A standard procedure is scaling of alternatives in one or several categories. The categories can be given, e.g. guideline or spontaneously chosen and discussed. To secure traceability of the discussion the participants are asked to confirm important tentative conclusions termed "communicative validation".

Controlling techniques are essential to control unfavourable group dynamics and to neutralise extreme influence of individuals. Because focus groups are usually composed differently, every meeting can potentially bear an unpredictable combination of characters and with it unpredictable problems for the moderator. The following four special personalities are explained; the expert, the dominant narrator, the reserved participant and excessive narrators (DÜRRENBERGER and BEHRINGER, 1999).

- Experts can be a problem for a discussion. Their way of expressing themselves can have a negative influence on the other participants. To avoid these problems all chosen participant may be experts or situations in which experts can obviously be identified in the group should be avoided by specific questions in the early stage of the discussion phase.
- Dominant narrators often consider themselves as experts, however they often do not realise their effect on other participants and try to shift the discussion on their opinions. If the moderator is aware of such participants, they should be placed close to him to influence them through the body language. If this is not possible, dominant narrators are questioned face-to-face or asked to be remain quiet unless asked.
- Reserved participants tend to contribute little to the discussion. Therefore, the moderator must have an additional influence on them to share their opinions with the group. These participants should be seated close to the moderator to be able to have eye contact. In many cases direct eye contact encourages the requests to speak.
- Excessive narrators are time-costly. They use many words to express their opinion and often they do not come to the point at all. In addition they feel obliged to contribute to every topic. Eye contact with the excessive narrator should be avoided. The moderator should also be prepared to put another question to the group immediately to break up the excessive narrator's comment.

Basic presentation technologies can be learnt by an introduction programme consisting of a literature study, discussion protocols and consultation of focus group discussions. Moderator training is recommended for a consolidation of the presentation abilities.

To accomplish the discussion teamwork is recommended. By doing so, a division of the workload is advisable between moderator and the rest of the team workers: The moderator concentrates upon the direction of the discussion, maintains a lively discussion flow and takes only minimum notes to identify further questions. An assistant should record the session in a detailed protocol. If necessary a tape recorder should be used. The assistant can also look after the environment of the group, manage unexpected interruptions and can be helpful to evaluate the discussion (DÜRRENBERGER and BEHRINGER, 1999).

Acknowledging the complexity of conducting a multilateral focus group discussion, professional moderation training has been accomplished by the author of this thesis prior to the data collection phase. Furthermore, the sessions are chaired by a team of the moderator (author himself) and one or two assistants.

Instruments for compiling data of focus groups can be versatile. In Table 2.1 the most important instruments are listed with their respective advantages and disadvantages (DÜRRENBERGER and BEHRINGER, 1999).

Table 2.1: Instruments for compiling data of focus groups

Criteria	Advantages	Disadvantages
Video recording	Completeness (verbal and non-verbal)	Cost (equipment) Complex Time-consuming analysis
Audio recording	Completeness (verbal) Cost (equipment)	Voice recognition
Protocol	Overview of important arguments	Selective perception Revision required
Abstract	Length Comparability Time-saving analysis	Selective perception Verifiability
Questionnaire	Comparability (interpersonal, intertemporal)	Acceptance of participants Time requirement
Collage	Symbolic and emotional moments	Interpretation Comparability Time requirement
Report	Authenticity Validity Comparability	Time requirement Organisation of the writing Interpretation
Bullet points	Authenticity Validity Comparability	Interpretation

Source: DÜRRENBERGER and BEHRINGER (1999), own illustration.

Audio or video recordings are a standard instrument for the data collection in focus groups. The tapes serve as a raw data carrier for the production of written documents.

Protocols complement or substitute audio or video recording. Taking notes is carried out by another (non-presenting) person. The assistant documents the course of the discussion. Therefore in thematically oriented focus groups not single statements, but primarily discussion passages are fixed and commented. If the discussion follows a guideline, single protocol cards can be prepared for every single question.

Summaries are prepared by the moderator and the assistant immediately after the meeting, which are based on the conversation following the discussion (see below).

The questionnaire is not a standard instrument for focus groups. Nevertheless, questionnaires can be useful for documenting the change of individual opinions, for comparing individual opinions with group opinions or for the evaluation of the discussion. Generally, they should be very short and be applied only in addition to the discussion.

A collage, report and bullet points are mixtures of instruments and data material. The visual construction of collages can support the imagination and creativity of the participants. Furthermore, it provides a basis for informal contacts which can support the group dynamic positively.

Written documents such as a report can be written or dismissed by the participants. Nevertheless, writing is no group activity but an individual activity which can influence the group dynamic negatively and be very time consuming.

A list of bullet points contains important arguments, opinions or decisions made by the participants during the discussion. Bullet points are constructed during the discussion mostly on a flipchart. Bullet points can be good raw material for the writing of result reports.

With regards to the customs in farmers meetings and the cost effectiveness only a few instruments for compiling data are applicable: audio recording is going to be used for **data gathering** if the participants agree. A protocol is written by an assistant while the moderator takes notes in form of bullet points. Furthermore, a computer model is used with continuously updated datasets for a reference scenario and adaptation strategies. It is operated by the researcher.

(4) Evaluation

The evaluation of the focus group discussion by the moderator and the assistance begins immediately after the participants have left. This allows the recording and commenting of fresh impressions and the comparisons of expectations and actual results. This recapture of results is helpful to evaluate the method (DÜRRENBERGER and BEHRINGER, 1999).

Challenges

The evaluation of focus groups can be challenging because of the **amount and depth of data**. Collected data can be grouped in three categories:

(1) **Individual data** include personal opinions expressed individually by participants in the discussion.

(2) **Group data** are expressed collective opinions in the form of collages, reports or votes. They can not be seen as accumulated individual opinions, but originated in an opinion-educating process or by arrangement of the participants.

(3) **Interaction data** describe the behaviour of the participants.

Generally, not all three data categories are of interest at the same time. Therefore, a clear structure of data collection is essential for an efficient data management. The basis of the structure is put in place with the establishment of the discussion guideline.

Another challenge concerns the **dynamic of opinions**. During the discussion participants may change their opinions. This occurs because of uncovering alternative views, persuasive arguments, social adaptation to the group majority or uncertainty of a participant.

The investigation of the position dynamic is a complex issue which can be an aspect to be investigated individually or within the evaluation of a focus group. However, it should carefully be considered in all cases.

Evaluation principles

The most important evaluation principle is a **systematic procedure** which begins with the development of the discussion guideline. The formulation and order of questions should be the same for all groups. Questions should be clear and exact to enable efficient data analysis. General questions can be difficult to interpret (DENZIN and LINCOLN, 1994).

Another evaluation principle is **traceability**. To be able to trace results for interpretations these need to be recorded systematically. According to DÜRRENBERGER and BEHRINGER (1999) it should be checked whether:

– Single findings stand in a general connection with regard to the content (argumentative validation),
– Results are supported by several focus groups,
– Results are generated by evaluation from more than one researcher,
– There are external indications to the soundness of the results (e.g. combination with quantitative methods).

Thematic evaluation

The thematic evaluation combines **data processing** and **data analysis** (see Figure 2.1). The following steps describe data processing.

– **Data backup** – involves maintaining and checking of all generated material, examining the quality of recordings, reworking handwritten protocols.
– **Transcription –** involve copies of tape recorders. With thematic transcripts only the answer to the respective question is recorded. All insignificant arguments or dialogues are not recorded. The collections of such selective transcripts require a lot of understanding of the discussion and they should be made only by the moderator or the assisting person.

The data analysis is the second part of the thematic evaluation. DÜRRENBERGER and BEHRINGER (1999) distinguish between three types of analysis.

- **Descriptive analysis** – The purpose of the descriptive analysis is to describe what has been said by participants, in particular to the systematic description of the opinion spectrum.

  The descriptive analysis is not about quantification of arguments. It is rather a qualitative interpretation of the arguments based on how frequently these are said by participants. The system of the descriptive analysis follows questions, subjects or groups: What opinions were expressed? How often was what opinion expressed? By which participants? With what intensity? What opinions were argumentative? Did participant change their opinion?
- **Analysis conducted by hypothesis** – The hypothesis-conducted analysis is basically also descriptive, however, only those statements are considered for the analysis that refer to the content of the hypothesis.
- **Explorative Analysis** – The explorative analysis stands in contrast to the targeted analysis of a supposition and involves an intuitive investigation of a subject to generate hypotheses. Ideally, the explorative approach is not only limited to the evaluation but it also includes data compilation.

  Therefore an iterative approach can be used involving hypotheses to be developed which are then reviewed, refined and evaluated in further focus group discussion(s). The enhanced understanding of a topic is considered with the planning of additional discussions. As soon as no more essential findings can be generated the process can be finished.

The evaluation concludes the methodical conducted procedure of a focus group discussion. However, the standard procedure can be adjusted to match demands of particular research questions which will be explained in the following section.

In due consideration of the evaluation principles of focus groups, analysis in this study is conducted according to the concept of *positive theory* applied in agricultural economics (GIERSCH, 1960; HENRICHSMEYER and WITZKE, 1991). It involves a systematic investigation of the typical farm's environment, asset configuration, production systems and profitability. These leads to hypotheses regarding farm-level implications of higher commodity prices on which the influence of intensity levels, production uncertainty and coexistence of arable and pastoral farming is assessed.

2.3.2.3 Special forms of focus groups

In the previous sections, the method of standard focus group discussions is described in detail. However this procedure does not entirely match the requirements of the research objectives of the thesis. Therefore, this section introduces special forms of focus groups.

The relevant literature (cf. DÜRRENBERGER and BEHRINGER, 1999; KRUEGER and CASEY, 2000; EDMUNDS et al., 2000) differentiates between two special forms of focus groups:

- Serial focus groups
- Mini focus groups

Serial focus group

The methodology outlined in the previous sections refers to one singular focus group discussion or standard focus group. In order to discuss more complex topics or to stimulate the necessary experience of the participants a further type of focus groups has been established also called serial focus group (DÜRRENBERGER and BEHRINGER, 1999).

Serial focus groups can be distinguished from standard focus groups through three characteristic criteria:

- Usually three to five sessions are held with the same group. This can secure that the group is able to get involved with the topic in more detail.
- Further consecutive meetings offer the possibility to procure expert knowledge to be combined with the individual experience of the participants. Nevertheless, the preparation of the information is an extensive process and should not be underestimated.
- The third criterion is the focus on results. While standard focus group discussions are initiated with the help of a stimulus, participants in serial focus groups are confronted with the research objectives to generate particular results.

These adjustments to focus groups should allow a comprehensive assessment of complicated question by the people involved.

Mini focus groups

Mini focus groups differ only slightly from a standard focus group. Rather than including eight to ten participants in a group, this methodology typically includes only five or six participants. These groups are conducted like standard groups are, e. g. in a conference room setting with a moderator and data compiling appliances (DÜRRENBERGER and BEHRINGER, 1999).

Conducting mini focus groups can offer some benefits:

- Focus groups with fewer participants allow a more detailed discussion of the topic. It also allows greater detail with more application of moderation techniques.
- Smaller groups permit greater observational opportunities and an unrevealed view on the position dynamic because participants have less time to observe others and copy themselves.
- With fewer participants the recruiting efforts and co-op fees are usually less intensive.

These benefits are similar to those related to many other groups. However the even smaller group size usually increases the benefits. A special form of mini focus groups are also called **triads**. As their name suggests, triads consist of three participants making them smaller than standard focus groups. With only three participants it is easier to discuss comments in more detail. With triads there is also less opportunity for group-think. Thus, the moderator must not entirely control the social processes but can obtain more input and unbiased details from participants.

Smaller groups allow better testing opportunities. It is easier for example to test a new software program with only three people in a group setting. There is more time to work with a group and discuss their opinions of the product then with a group of eight participants where a large portion of the group time would have to be devoted to answering questions and getting them set up with the program.

There are, however, a number of disadvantages associated with the mini focus group methodology:

- More groups need to be conducted to obtain enough information for data analysis in order to cover the topic adequately and reach some general conclusions.
- Smaller groups can be more uncomfortable for participants because they may feel obliged to participate more vigorously by compared to larger focus groups. The participants have to speak more often and answer questions in greater detail. Hence, smaller groups require a strong moderator to minimise participant's discomfort.

While mini focus groups do provide some level of group discussion, the variety of opinions offered is obviously limited by the small group size. The trade-off is the depth of information obtained from the participants.

It is advisable to conduct at least enough mini focus group discussion within each targeted segment to equal one standard focus group (EDMUNDS, 2000).

2.3.2.4 Summary

In the previous sections the methodology of focus group discussions and two special forms are described in detail. It can be concluded that focus groups are an accepted method in empirical social sciences containing a range of innovative conceptual issues.

So far, the panel process conducted within *agri benchmark* contains references to requirements and problems as identified above which can hypothetically be overcome by the implementation of the focus group. In conclusion, the use of the focus group methodology can be considered as a fundamental advancement of the existing *agri benchmark* panel procedure and is seen as valuable for the research concept of this thesis.

The results generated by using this research design reflect typical farm situations which are examples in relation to the regional farm population. This is secured by focussing on regional benchmarking data and the selection of participants for the panel discussions.

However, this approach has some disadvantages since results are restricted in terms of representativeness for spatial and aggregated conclusions and do not represent the situation of the whole production sector for the selected countries or regions.

2.4 Consolidation of the research design

2.4.1 Course of investigation

In consideration of the introduced focus group methodology to advance the *agri benchmark* panel procedure the following steps are carried out in the course of investigation:

1. Identification and selection of production regions

The identification of the regions to be investigated is carried out using basic principles of the *agri benchmark* standard operating procedure to define typical farms (SOP). This procedure is applied to four different production areas to fulfil the conceptual requirements of this study (intensity levels, production risk, coexistence of cash crop production and livestock). The derivation of the investigation regions is discussed in Chapter 3.

2. Establishment of typical farms

The *agri benchmark* standard operating procedure defines typical farms and envisages the establishment of three different types of farms per region[10] to illustrate cost advantages of scale and the influence of management skills.

In this study the concept SOP is used as the starting point but modified to meet the requirements of the investigation. One **top managed larger size farm** will be established in each the following regions:

– Magdeburger Börde in Saxony-Anhalt, Germany
– South Coast of Western Australia
– Wheatbelt of Western Australia
– Central West of New South Wales, Australia

The regional containment is an important objective of this study using a **bottom up approach** to investigate the influence of high input and output prices for typical farm situations. Furthermore it is assumed that specialised top management farms are most likely to adapt to a changing farming environment more quickly.

The typical farms are established by using expert interviews and informal mini-focus groups in the respective regions. Survey participants are farmers and farm consulting groups personally acquisitioned by the researcher.

3. Establishing a farm gate input and output price scenario

For each region a farm gate input and output price scenario has been established representing a high level of agricultural commodity prices derived from the EIA high crude oil price scenario. Selected method: Bushel-Barrel-Correlation (see Section 2.4.3).

This study aims to uncover total production potentials. Time period determinations are not necessary. Furthermore, time differentiations between on farm buying and selling are not considered. Therefore a comparative static approach has been selected.

4. Evaluation of the reference situation, adjustment of farm gate prices and exploitation of possible farm adaptation strategies (pre-panel status)

The expert interviews and mini-focus groups in the establishment phase (step 2) is used to investigate the characteristics of the typical farms, such as the

[10] Top management larger farm, average management larger farm, average management average size.

– Reference situation of a typical farm organisation, production details as well as input and output prices. The influence of yearly weather conditions, crop performance and price volatility is eliminated by presenting 5-year-average physical and monetary figures. Therefore individual typical farm data is sourced for five individual harvest years[11] from 2005 until 2009 using TYPICROP (see Section 2.4.2).
– Refinement of the price scenario and necessary adjustments to break down world price scenario to farm gate prices for individual typical farms.
– Initial investigation of possible farm adaptation strategies.

During this process the quality of data and the classification of the farm (top management) is assured by using available statistics, farm accounting results and existing farm budgets from the aspired panel participants (if feasible due to confidentiality). However, the results of the fourth step must be interpreted with caution. The final evaluation of the data is carried out exclusively during the panel discussion.

5. Organisation and processing of the panel discussions with focus groups

This step is considered to be the core part of the practical investigation. The following parameters are defined:

– Target group characteristics: homogeneity (**farmers or entrepreneurs running top-managed specialised cash crop farms in the selected regions**) anonymity (**real groups**)
– The panel meeting is planned as a single focus group discussion with **one meeting per region** to achieve theoretical saturation about the farm level adjustments.
– The number of participants is limited to **six local experts** (farmers) in addition to the moderator and the assistant moderator(s).
– The meetings are **chaired by the moderator** (researcher) and the contact person. The use of a computer model operated by the researcher is planned.
– **Data gathering:** Audio recording if approved by participants, records written by assistant (s), respective TYPICROP Frontends, bullet points by moderator
– The meetings take place in **central located facilities** and start at 1 pm in the afternoon, considering some participants may come together from a radius of up to 200 km.
– Duration of the meeting: **four hours**.

[11] Harvest year = result year. All revenues from one harvest are opposed to the actual expenses to produce it. This approach enables comparability between farms operating in different seasonality or taxation periods.

The course of the panel investigation consists of the following individual operations carried out simultaneously for each location using the focus group methodology discussed in the previous section.

Planning of the panel discussion (approximately eight weeks prior to the meeting)

The planning of the panel discussion involves the screening of the local farm population according to the defined target group characteristics. Potential participants are acquired proactively on recommendation from initial contacts from the pre-panel investigation. It is intended that the initial contact is also present at the panel discussion.

The pre-panel data for the typical farm is refined, typified and used for the preparation of the handout for the participants, which also functions as the discussion guideline. It contains the following information:

– **Farm and land use [whole farm]:** country, region, size, legal form, infrastructure, land utilisation, land purchase prices and annual rent cost, other farm enterprises
– **Machinery and buildings [single assets]:** configuration, depreciation and repair details
– **Cropping system [per ha]:** crop rotations of the farm, acreage, yields and prices; physical and monetary inputs, single operations with assignment of machines, working hours, diesel, seeds, fertiliser, pesticides and irrigation
– **Input prices and overheads [whole farm]:** labour, finance, energy, overhead costs
– **Profit and loss account [individual enterprises]**

An example of the handout is found in Figure A30 in the Appendix.

Preparation of the panel discussion

The organisation phase involves the recruiting of the participants and the submission of relevant documents:

– Guided telephone conversation (purpose of the study, explanation of the framework, clarification of the willingness to participate, clarification of the general suitability)

  Timing: Four weeks prior to the meeting.
– Submission of invitation letter (Figure A28 in the Appendix) including information about the appointment, objectives, participants, schedule of activities and the discussion guideline (Figure A30 in the Appendix).

  Timing: Ten days prior to the meeting, if possible in combination with personal appointment.
– Personal telephone conversation to confirm participation.

  Timing: One day prior to the meeting.

To secure the minimum attendance, the number of participants is **over-recruited by two participants**. The information provided to the participants has the purpose to explain the topic and give participants the chance to arrive pre-informed to the meeting.

Conduction of the panel discussion

The panel discussion is carried out by following a particular procedure. This procedure includes a personal reception with an official opening:

1. **Personal reception**.
2. **Official opening** and presentation of the stimulus part 1 (Figure A29 in the Appendix).
3. **Evaluation of pre-panel typical farm results** in reference scenario according to discussion guideline. The data will be entered into TYPICROP Frontend.
4. Participants will have a 20 minutes **coffee break.** Recalculation of new reference scenarios and the influence of price scenarios.
5. After the break discussion continues with the **introduction of price scenario** (second part of the discussion guideline see Figure A31 in the Appendix).
6. **Generating and assessment** of comparative static[12] adaptation strategies in response to new pricing framework and profitability of single operations until saturation.
7. **Estimation** of crop yield and production output potentials in consideration of adjustments defined in step 6.
8. The panel discussion ends with the data gathering.

Analysis and Evaluation

The panel in each location delivers results on the existing situation and adaptation strategies on farm level and allow comparisons between the selected regions. The expected outcome is structured in four levels as shown in Table 2.2.

---

[12] No targeted time period, no time differentiation between buying and selling on farm.

Table 2.2: Overview of reference and scenario configurations

Abbreviation	Name	Scenario assumptions and adjustment details			
		Farm configuration	Production system	Yield data	Price data
B-0	Basis Scenario	Average 2005-2009	Average 2005-2009	Average 2005-2009	Average 2005-2009
		Typical farm data	Typical farm data	Typical farm data	Typical farm data
S-0	Scenario S-0	Average 2005-2009	Average 2005-2009	Average 2005-2009	High price scenario
		Change nothing	Change nothing	Change nothing	(Farm gate)
S-1	Scenario S-1	Average 2005-2009	Production system adaptations	Potential yields	High price scenario
		Change nothing	Panel estimates	Panel estimates	(Farm gate)
S-2	Scenario S-2	Investments or structural adjustments	Production system adaptations	Potential yields	High price scenario
		Panel estimates	Panel estimates	Panel estimates	(Farm gate)

Source: Own illustration.

2.4.2 The single farm calculation tool TYPICROP

At beginning of this chapter two necessary advancements of the *agri benchmark* methodology are defined. The previous sections introduce the focus group methodology and derive a research design in consideration of new methodological findings.

For this research group discussions are used to establish and enhance datasets of typical cash crop farms. To ensure an efficient procedure during the meetings it is necessary to have a capable quantification tool considering the limitations of the calculation model that has been used by *agri benchmark* Cash Crop so far.

Although databank systems are used to manage data in various fields of application and technical solutions, the individual design follows conceptual and technical standards of databank programming which are extensively discussed in the relevant literature (SAAKE et al., 2008). Consequently, the databank developed in this research follows such standards.

However, this section merely discusses how the data sourcing process and the analysis of cash crop farming systems can be supported technically. A general derivation of the databank theory goes beyond the focus of this thesis.

Nevertheless, the findings outlined in the following section are summarised from STEUBER (2006) and SAAKE et al. (2008) whose publications provide detailed information on this topic.

2.4.2.1 Model requirements

This thesis aims to develop a quantification tool for single-farm adaptation strategies which can be integrated into an international network. The following model requirements are considered necessary for the model:

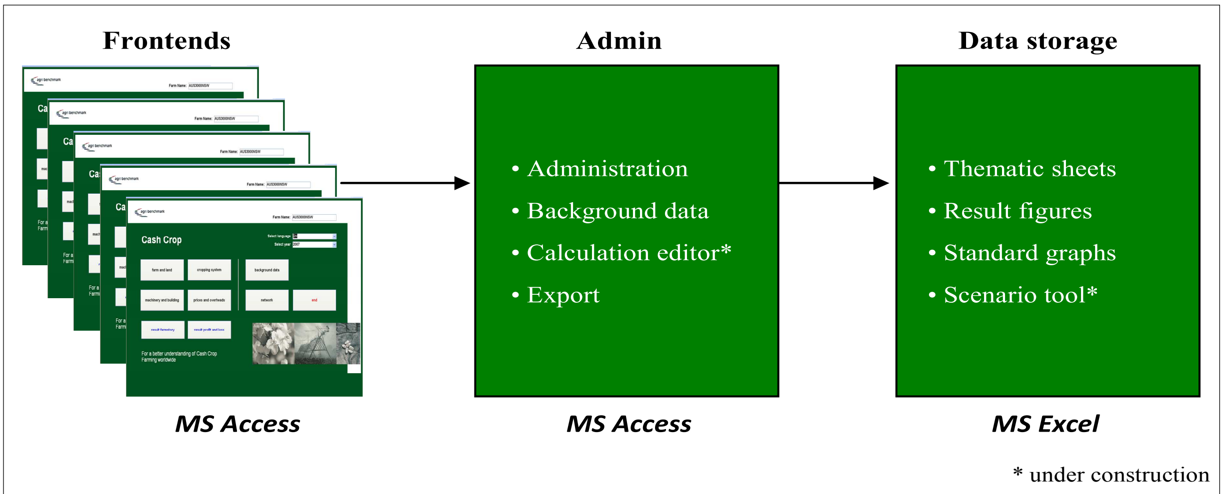
1. The discussion process of a panel meeting with farmers is supported by an attractive model interface, short calculation times and model outputs with great explanatory power.
2. Regarding the international application, the external access of country specific formats (languages, currencies, dimensions, units etc.) is mandatory.
3. The model must be able to register and calculate the current status and prospective adaptations of typical cash crop farms and their production systems in greater detail according to economic standards. Therefore, a set of analytical tools for benchmarking (cost and return, profitability indicators) must be available.

Based on these findings, the single farm calculation tool TYPICROP is developed.

2.4.2.2 Model configurations

TYPICROP[13] is a computer assisted databank program using the software platforms Microsoft (MS) Access and MS Excel. The databank is made up of three components; individual **Frontends**, central **Admin** and **Data storage** as shown in Figure 2.3.

Figure 2.3: Components of TYPICROP



Source: Own illustration.

13 The specifications of TYPICROP regarding intellectual property, software requirements and program versions are found in Table A1 in the Appendix.

The purpose of **Frontends** of the database is to feed the raw data into the model (model input). Every single Frontend contains the data for one typical farm. The data is scaled into four sections:

– **Farm and land use [whole farm]:** country, region, size, legal form, infrastructure, land utilisation, land purchase prices and annual rent cost, other farm enterprises
– **Machinery and buildings [single assets]:** configuration, depreciation and repair details
– **Cropping system [per ha]:** crop rotations of the farm, acreage, yields and prices; physical and monetary inputs, single operations with assignment of machines, working hours, diesel, seeds, fertiliser, pesticides and irrigation
– **Input prices and overheads [whole farm]:** labour, finance, energy, overhead costs

According to this categorisation, the menu structure of the Frontend is designed to lead to the respective data input sheets.

To address the first major model requirement, emphasis is placed on an attractive, self-explanatory design of data input sheets. Frontends are not only used by the researcher but potentially also as a software questionnaire to be send to local experts prior to the investigation or to be used within group sessions. For group discussions the Frontend would be projected on a large screen to allow participants to follow the data input.

Further, data input procedures carried out by first time users or non-scientific people have to be self explanatory and user friendly. For many intended users the interface of a TYPICROP Frontend is the first contact with the project.

Therefore, the Frontend is designed complying with the following issues in mind:

– In order to avoid software incompatibility at the individual user PC, standard software platforms are used: no additional installations, no complex procedures, protection against data loss, centralised administration and international programming codes.
– Extensive self explanatory structures are used to secure user acceptance towards the data input initiative.
– Other features of TYPICROP include transparency. User must be able to follow up on inputs and calculation principles to increase confidence about handling of sensitive figures.
– Editable background data set (e.g. crops, machinery, operations, fertilisers and seed) and copy-paste functions to enable an efficient data input.
– Familiar production patterns and terms are used to ease information transfer (e.g. commonly used single field operation records).
– Attractive and uniform layout to increase recognition and motivate the user.

The following section outlines briefly how these requirements are transferred to practice. Figure 2.4 shows a TYPICROP input sheet for land use and natural conditions.

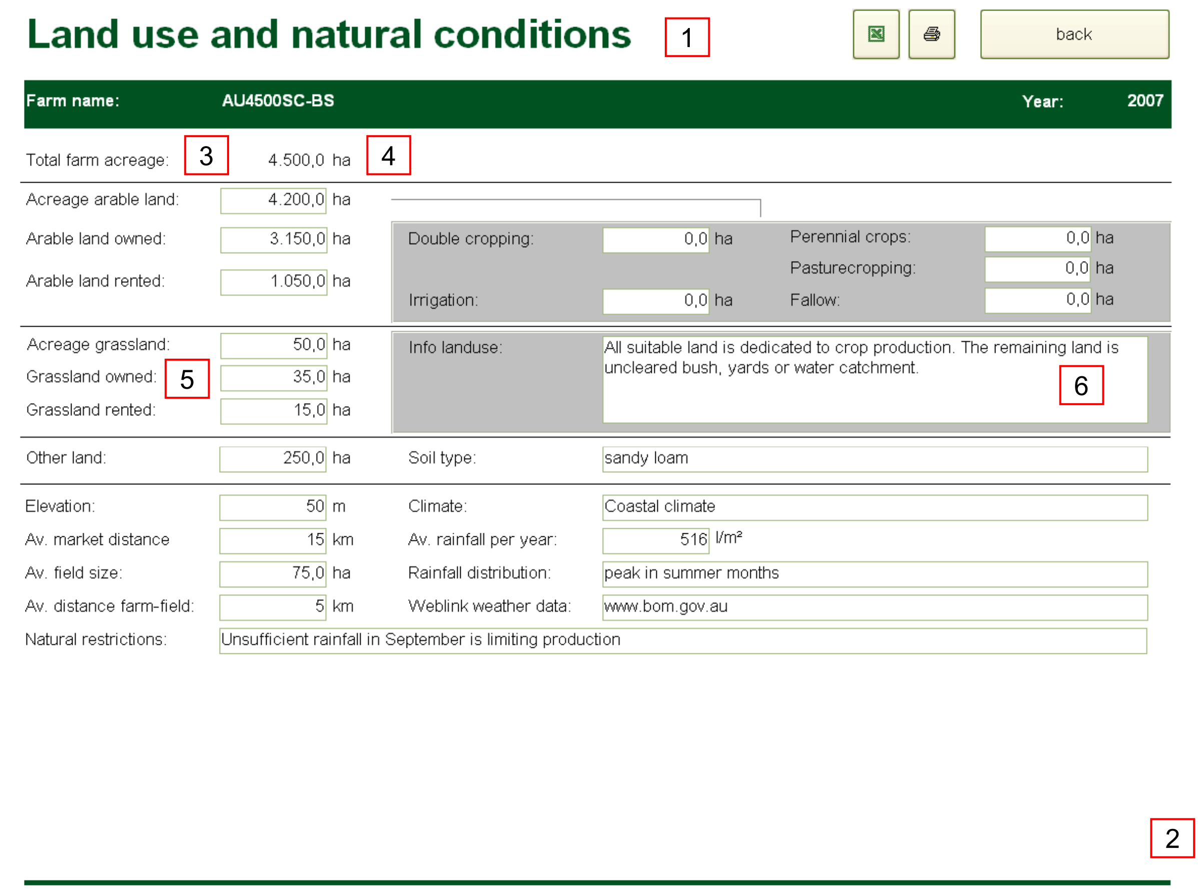
1. Harmonised header design is used for all forms containing individual headlines, control buttons, farm name and result year.
2. Data input fields are clearly arranged in coherence with the topic. A spreadsheet atmosphere with extreme scrolling is avoided.
3. Self descriptive labels for data fields in national languages are used.
4. Pre-selected units and currencies according to national measure system are in place also acknowledging the second model requirement.
5. Internal control functions are put in place to avoid input errors (e.g. total acreage must coincide with subtotals of owned and rented land, otherwise label turns red or user dialog opens to indicate major error).
6. Adequate space is allowed to record additional information systematically. This function might not be necessary to calculate cost of production but useful to compare, and interpret results and identify differences.

Figure 2.4 shows one example of a respective data input sheet. For the purpose of this thesis a complete description is not included as this is beyond the scope of this study.

A complete description of the TYPICROP Frontend can be found in the handbook by NEHRING et al. (2010). This publication contains a detailed description of the model structures and handling as well as single input fields and the required data.

Besides data input, the TYPICROP Frontend also has the function of a data review. This allows reports to be generated at any stage of the input procedure. Such reports can contain facts about the nation and region in which the farm is located (farm story), profit and loss account of single crops and a performance calculation for the whole farm. In regard to the intended application in regional panel discussions, the profit and loss account is constructed in national units and national currencies. For concept and design demonstration purposes, an exemplary three-page profit and loss report is found in Figure A1 in the Appendix.

Figure 2.4: TYPICROP land use data input sheet



Note: Respective numbers are explained in the text.
Source: TYPICROP Frontend screenshot, own illustration.

The Frontend is primarily constructed to contain specific farm data from individual years. All revenues from one harvest are opposed to the actual expenses of producing it. This approach enables comparability between farms operating in different regions seasons or taxation periods. The analysed result year coincides with the harvest year. Stocks are not considered and all monetary inputs are VAT exclusive. However, there is also the possibility to register average values for several years which is of importance for calculations within this thesis.

To secure version conformity regarding background data and calculation principles, the Frontends of all model farms need to be administrated centrally. This is especially important when applying TYPICROP to an international network as it is intended at a later stage in this thesis. Therefore the **Admin**[14] part of the databank is established which contains several functional units such as:

[14] Cp. Figure 2.3.

- Generating new Frontends and version update of existing model farms
- Importing Frontends of individual typical farms
- Formula command to carry out calculations
- Export of individual results into data storage files to generate analysis files
- Storage and service of background data for all model farms (countries, currencies, exchange rates, national units, languages, crops, operations and other enterprises)

The calculation itself is carried out by means of a procedure closely following total cost accounting principles with inclusion of directly allocatable special costs (e.g. seed, fertiliser and chemicals), operating costs (labour, machinery, fuel and finance), land costs (cash lease expenses, opportunity cost estimate for own country) and overhead costs (building, general expenses).

Conclusions on the profitability of production systems of single crops and income situations of companies can be met by including the performance such as yield, output prices and subsidies. The calculation principles are exclusively derived and outlined in the following Section 2.4.2.3.

The formula codes within TYPICROP Admin are managed with the help of a calculation editor. The editor enables editing existing calculation routines and to establish new indicators for the analysis downstream as future analysis may require additional results. The flexibility for additional developments is essential for the proposed utilisation of TYPICROP.

The **Data storage**[15] component of TYPICROP is designed to hold and merge the results from the individual model farms. Results are segmented into thematic sheets and then transformed into standard graphs which can be used in continuative publications.

For this study, the Data storage is extended by an additional sensitivity application. The sensitivity tool confronts the calculated status-quo results of model farms with the influence of scenario prices. Therefore input prices such as seeds, fertiliser, chemicals, fuel, wages and land and output prices can be varied in terms of percentage. This sensitivity analysis can be used in focus group discussions to develop adaptation strategies.

[15] Cp. Figure 2.3.

2.4.2.3 Calculation principles

The measurement of total costs of agricultural production per unit basis for the output is a complex issue. Major uncertainties are found in the assessment of opportunity cost in particular land, labour and capital and how to allocate overhead cost fairly according to the involved input. During the last decades many practical approaches have been discussed in the relevant literature on how to measure production cost in multi-product farms (EIDMAN, 1992; STEINHÄUSER et al., 1992; ZEDDIES and REISCH, 1992; DABBERT and BRAUN, 2006). However, there is no existing economic theory which gives a profound solution for this problem.

Therefore, several methods have been applied within *agri benchmark* and the conducted research in international cost comparison contributed further knowledge. Different methods, their accuracy and quality of the results has been discussed by ISERMEYER (1988), DEBLITZ (1993), RIEDEL (1997), HEMME et al. (1997), RIEDEL and MÖLLER (1999), HEMME (2000), ISERMEYER and DEBLITZ (2005), ZIMMER et al. (2006) and EBMEYER (2008). The methods applied are evaluated in terms of resources needed, their scientific appropriateness and their feasibility. The TYPICROP calculation principles outlined in the following section are developed considering these findings and the requirements described at the beginning of Section 2.4.2.1.

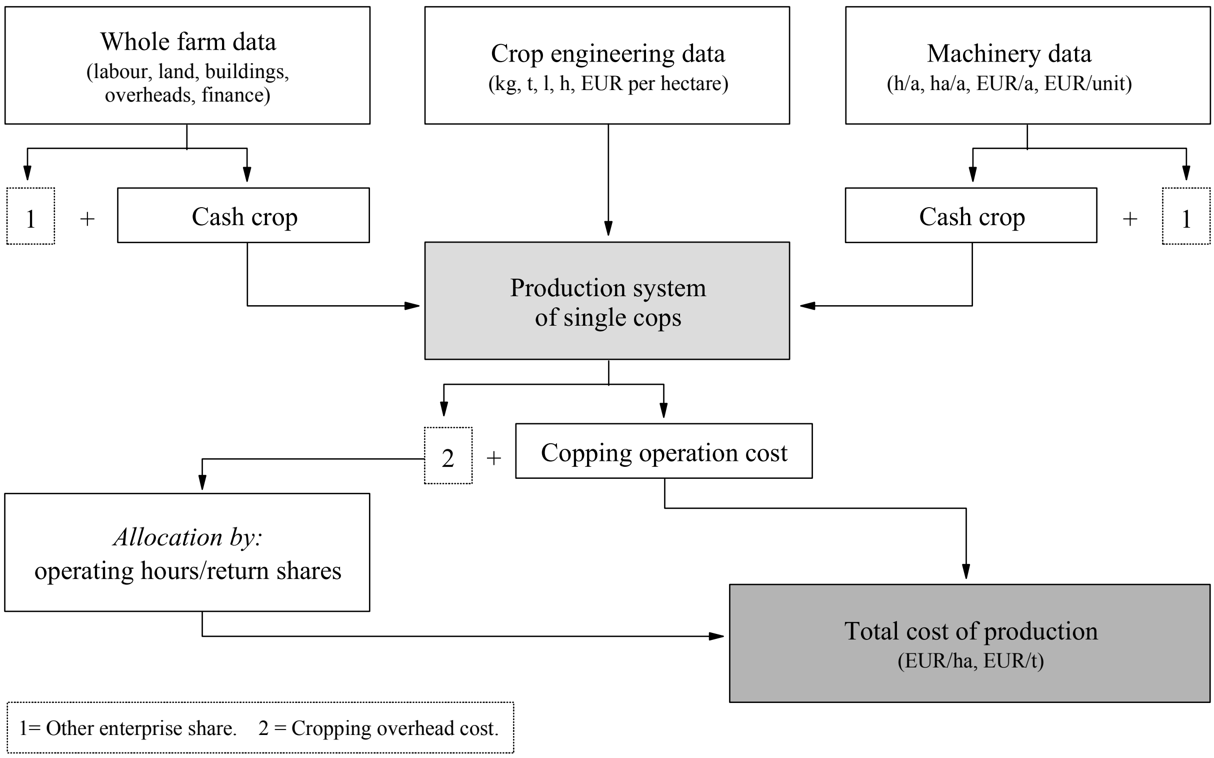
The TYPICROP model is specifically developed to register and calculate physical and economical indicators of arable land use systems. This is in contrast to the approach pursued by TIPI-CAL to reproduce the full range of farming enterprises.

On the on hand, this specialisation is considered important as the majority of typical farms in the *agri benchmark* Cash Crop network are highly specialised cash crop farms. Therefore whole farm costs, revenue and profitability are focussed on the cash crop enterprise. In case any other farm enterprises exist, their figures are considered primarily to identify non-cash crop costs if production factors are used jointly.

On the other hand, research projects like this study require a more detailed analysis of the agronomical context in the respective regions. Therefore TYPICROP enables the allocation of physical inputs and respective costs not only to the production of single crops but to **single fieldwork operations** with the help of the innovative production system feature.

This core part of TYPICROP allows economical analysis of different cropping strategies in greater detail such as general mechanisation, tillage, seed, fertiliser and plant protection and a more sophisticated allocation of overhead costs according to the inputs is possible as described in Figure 2.5.

Figure 2.5: Cost calculation and allocation scheme of TYPICROP



Source: Own illustration.

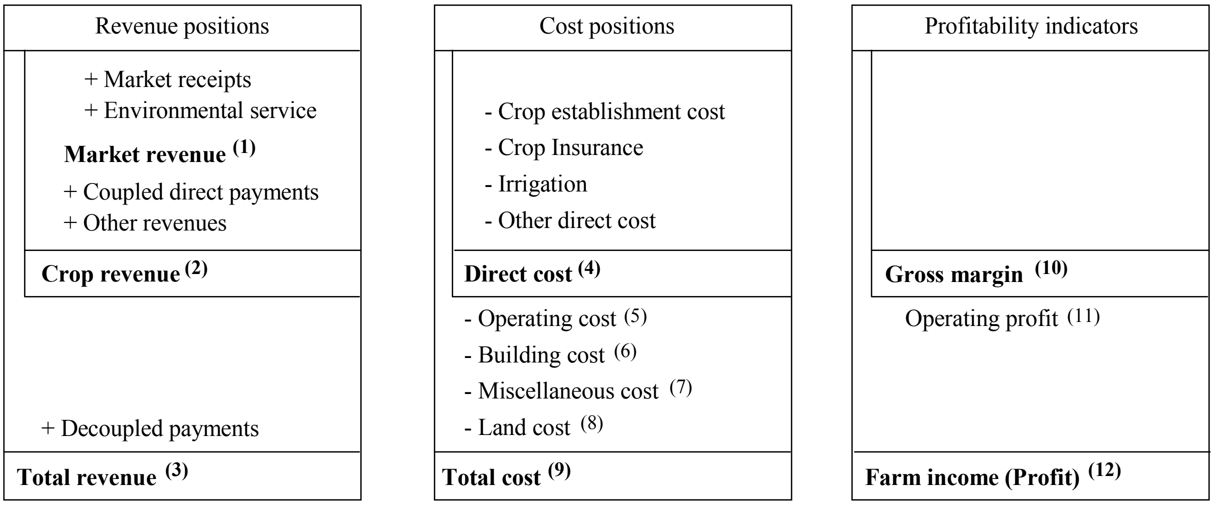
Typical farm data from three sources is computed in the model: whole farm data, crop engineering data and machinery data.

Whole farm data (whole farm level) and **machinery data** (per unit) are computed into the cash crop share and the minor other enterprise share (1) by general return shares of other enterprises (if any). The cash crop share of the farm costs is exclusively allocated to single fieldwork operations, single crops or whole cropping enterprise. **Crop engineering data** (per hectare) is directly allocated to the production system of single crops.

The **production system of single crops** (disaggregated to single fieldwork passes) merges costs allocated directly due to physical input (seed, fertiliser, chemicals and irrigation) or based on performance (fuel input and hourly performance per hectare with single operations) to the cropping operation costs. The remaining cropping overhead costs (2) are the *delta* between cropping operation costs and whole farm costs and are then allocated by operating hours or return shares of single crops according to causality. Both are computed to the total costs of production. A detailed description of each cost position is found in the following where single cost positions are discussed.

Since fieldwork data includes performance data such as ha/h, the share of cropping operation cost in the total cost of production also indicates productivity and operating grade of single production factors such as labour and machinery. Based on these allocation routines the general calculation scheme used in the model is constituted as shown in Figure 2.6.

Figure 2.6: General calculation scheme for revenues, cost and profitability indicators in TYPICROP



Source: Own illustration.

The figure is supplemented with the following descriptions of positions as numerically marked in brackets. The primary reference unit for all revenue and cost calculations within TYPICROP is **per hectare** separately for each **single crop** with the option to differentiate further by affiliation to individual crop rotations, preceding crop and/or tillage system. All crops are handled as individual enterprises. Hence, set aside or fallow is also considered being a "crop".

TYPICROP computes the following **revenue positions:**

(1) Market revenue

Market revenues include all market receipts of main products (e.g. wheat), by-products (e.g. straw) and possible environmental records (e.g. carbon sequestration) generated by the cropping enterprise.

(2) Crop revenue

Crop revenues contain all market revenues and crop related revenues not sourced by market performance such as **coupled direct payments** linked to the production of a specific crop.

(3) Total revenue

Total revenues include all crop revenues and decoupled direct payments. Decoupled direct payments are commonly defined as subsidies paid directly to businesses on a per hectare basis or per farm basis and are **not linked** to the production of specific crops.

The different **cost positions** are characterised and computed within TYPICROP as follows:

(4) Direct cost

The direct cost calculation principles are set out in Figure 2.7. Direct costs are principally calculated per hectare of single crops.

Figure 2.7: Calculation scheme for direct costs in TYPICROP

+ Seed cost
+ Fertiliser cost
+ Pesticide cost
= Crop establishment cost
+ Drying energy cost
+ Irrigation cost (var.)
+ Crop insurance cost
+ Other direct cost
= Direct cost (./. finance)
+ Finance cost field inventory
= Direct cost

Source: Own illustration.

A characteristic segment of direct costs are **crop establishment costs**. Crop establishment costs represent cash expenses for seed, fertiliser and pesticides.

– **Seed costs** result from the physical input of seeds for the respective crop and the pure seed price. Additional costs are seed treatment costs and technology fees. Seed information is directly allocated to the seeding pass.

– **Fertiliser cost** calculation is developed in accordance to common broadacre fertilising practice. Therefore respective information such as type of fertiliser, origin (mineral/organic) and nutrient composition is evaluated with the respective fertilising pass. Prices for single nutrients are calculated on a per kg element basis.[16] This

[16] Nutrients in oxide form are also converted into elementary form to allow establishment of an international standard.

enables to generate fertiliser costs depending on macro nutrient (N, P, K, Mg, S and CaO) and micro nutrient (Fe, Mn, Zn, Cu, Mo, Cl, and Bo) content directly allocated to the single fertilisation passes.

– **Pesticide costs** are differentiated depending on the active substance group (herbicides, fungicides, insecticides or other) and allocated to the respective plant protection pass. With regards to the definition of plant protection, herbicides can be an exception because herbicides are often applied before seeding and therefore form a part of the tillage strategy.

In conclusion, all fieldwork passes for individual crops account for the respective total crop establishment costs.

Direct costs (excluding finances) are calculated based on the previously outlined crop establishment costs as well as drying energy costs, variable irrigation costs and crop insurance costs.

– **Drying energy costs** contain cash energy expenses such as heating oil and gas for drying of the harvested product (most commonly grains and oilseeds) before they leave the farm. They are allocated to the individual crop and averaged by means of the percentage to the dried and harvested product. Costs of drying facilities are registered with buildings.
– **Variable irrigation costs** cover expenses to run irrigation systems. Irrigation costs are allocated to single irrigation intervals recorded as a fieldwork pass within the production system. Irrigation devices are incorporated in the machinery section.
– **Crop insurance costs** cover net insurance expenses for individual crops. Insurance grants can also be included.

Total **direct costs** are based on the previous subtotal and add on a finance cost allowance for field inventory (cf. current assets). Generally, finance costs consist of two compartments calculated taking individual information about the financial situation of the farm[17]:

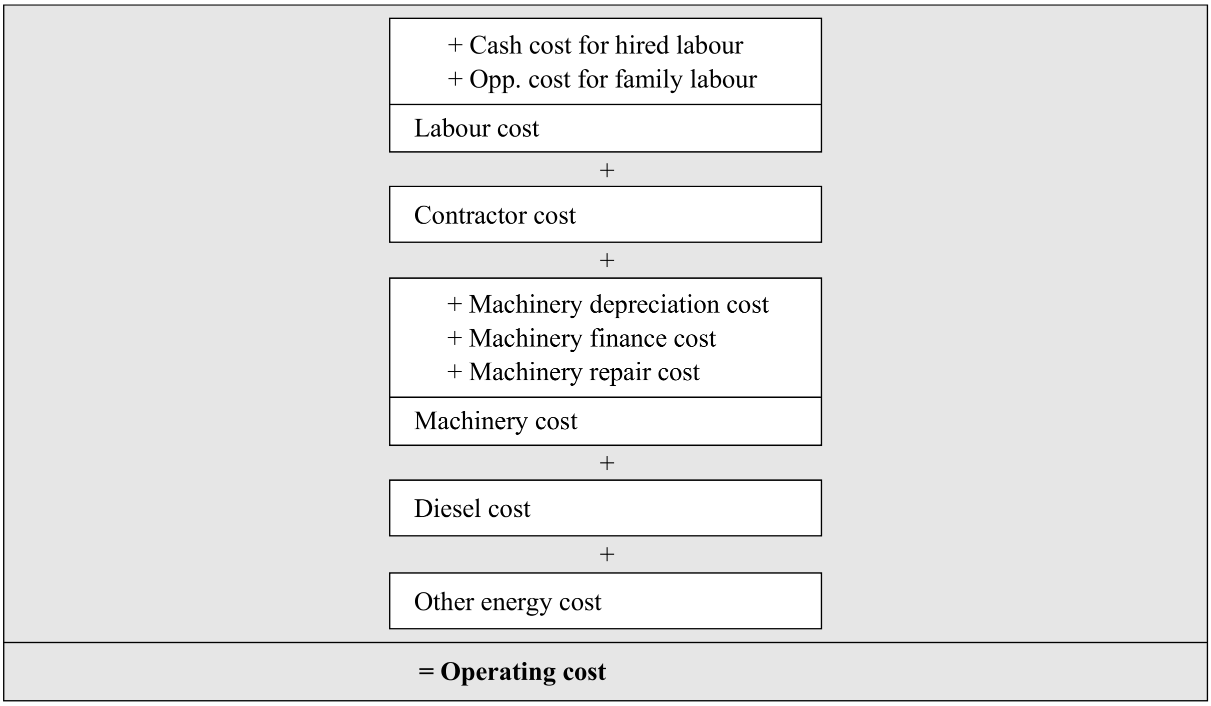
– **Cash finance cost for debt in current assets** are computed in due consideration of the debt share in current assets and the typical interest rate for operating loans borrowed for a time period of up to one year.
– **Opportunity finance cost for equity in current assets** are computed taking equity share in current assets and the potentially received interest rate for short term deposits for a time period of up to one year into account.

[17] For formula details see Figure A2 in the Appendix.

(5) Operating costs

The operating cost calculation is described in Figure 2.8. Within TYPICROP operating costs are calculated including labour costs, contractor costs, machinery costs, diesel costs and other energy costs.

Figure 2.8: Calculation scheme for operating costs in TYPICROP



Source: Own illustration.

Labour costs include all expenditures related to labour. Calculation of these costs requires two different approaches depending on the availability of labour resources.

– **Cash costs for hired labour** equal the expenses paid for off farm hired labour. Therefore, single workers are classified by their qualification and characterised by the annual gross wages including social insurances, tax and annual working hours.

– **Opportunity costs for family labour** refer to calculated costs for the labour input of farm managers with ownership and/or family members. Usually these costs refer to alternative positions in the local industry according to the individual qualification of the respective person. In case there is no adequate position available for example in very remote areas, the basic salary of a hired worker (e.g. hired farm manager) will be taken into account.

Single categories such as labour input is allocated directly to machinery utilisation with single fieldwork passes and labour costs are calculated by individual hourly rates (worked by a farm manager, full time worker or seasonal worker). Remaining labour cost overheads are then assigned to single crops according to the hourly input for the respective crop.

Contractor costs for off-farm services such as machinery services can be divided into three different categories: single fieldwork operations, allocation to individual crops and allocation to the cropping enterprise.

Machinery costs are a collective term for interval-fixed costs related to the investment in machinery. The most important aspect of machinery costs are depreciation costs followed by finance and repair costs.

– **Depreciation costs** within TYPICROP are linear calculated with non-cash costs for depreciation of the machinery. This is carried out using two different approaches. The first one used for example for single machines includes the original purchase price reduced by salvage value. The second calculation is based on the current repurchase value reduced by the current salvage value. Both approaches refer to the utilisation period of the respective farm machinery as depreciation duration.[18] The first approach refers to the nominal depreciation costs of the existing machinery pool which can be of advantage for ex-post analysis however it may lead to paper profits (underestimate depreciation) and can distort comparisons between countries with different inflation levels. Therefore the second approach allows the consideration of current prices to eliminate inflation effects (cf. RIEDEL and MÖLLER, 1999). NEHRING et al. (2010) suggest data input options addressing this issue.
– **Machinery finance costs** account for interest costs which include average fixed capital of the machinery pool. Therefore cash and opportunity costs are calculated from **cash finance costs for debts in fixed assets** and the effective interest rate for long term loans borrowed for an average time period longer than one year. **Opportunity finance costs for equity in current assets** are calculated by taking equity shares in fixed assets and the potentially received interest rate for long term deposits for a duration exceeding one year.[19]
– **Machinery repair costs** account for all cash expenses dedicated to the repair and maintenance of the machinery pool. Repair costs can be allocated annually to single machines or to the whole machinery pool.

All outlined machinery cost positions are calculated as single cost positions per input unit for an individual machine and are allocated to single fieldwork passes. Therefore the annual performance of single machines is recorded for example the total engine hours of single tractors and the total acreage performed of towed and self-propelled machines.

[18] For formula details see Figure A3 in the Appendix.

[19] For formula details see Figure A2 in the Appendix.

Possible remaining overheads are allocated to single crops according to the relative operational input for the respective crop.

Diesel costs account for cash expenses for fuel used mainly in farm machinery. Fuel cost analyses are an important subject within production economics because fuel prices became more volatile in recent years. Therefore, within TYPICROP fuel input per hectare whilst considering the fuel price, is calculated based on consumption of individual fieldwork operations.

Other energy costs refer to potential other sources of energy such as petrol, gas and electricity used for production. They are allocated to single crops according to the crop's share in total crop return.

(6) Building costs

The building cost calculation is outlined in Figure 2.9. Within TYPICROP, building costs include building depreciation costs, finance costs and repair costs. Basic calculation approaches, in particular depreciation and finance, are similar to the above described machinery costs.

Figure 2.9: Calculation scheme for building costs in TYPICROP

+ Building depreciation cost
+ Building finance cost
+ Building repair cost

= Building cost

Source: Own illustration.

However, since buildings are rarely used exclusively for individual crops except for drying facilities, costs are allocated to single crops according to the crop's share in the total crop return.

(7) Miscellaneous costs

Miscellaneous costs are a collective term for cash expenses mainly to facilitate farm management and administration. A summary of these costs is given in Figure 2.10.

Figure 2.10: Calculation scheme for miscellaneous costs in TYPICROP

+ Overhead water cost + Farm tax (related to inventory) + Farm insurance cost + Farm advisory cost + Farm accounting cost + Farm office cost + Other farm cost
= Miscellaneous cost

Source: Own illustration.

Overhead water costs refer to potential overhead water costs which are not already considered within irrigation or chemical application costs.

Farm tax expenses relate to farm inventory such as ground tax and vehicle registration, but do not include income tax.

Farm insurance costs cover inventory related insurances and personal insurances for the farm owner.

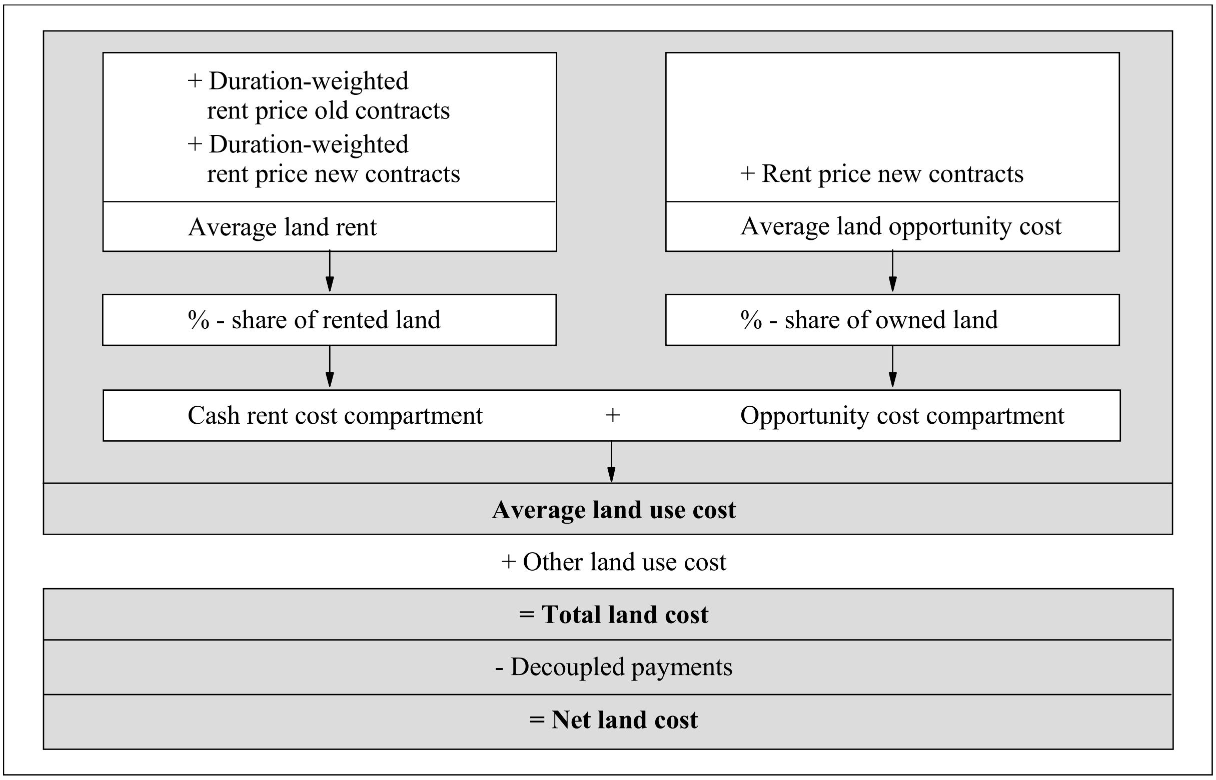
Farm advisory costs include cash expenditures for off-farm advisory services. **Farm accounting costs** cover off-farm accounting services such as bookkeeping and tax accounting whereas **farm office costs** include expenses for an on-farm office including office material, computer and communication systems.

Other farm costs included all other costs which originate on the farm and can not be allocated directly or specified in greater detail. Due to the general nature of all miscellaneous cost positions they are allocated to single crops considering the respective crop’s share in the total crop return.

(8) Land costs

According to the previous assessment of production factors such as labour and capital, land cost calculation within TYPICROP is carried out with the distinction between cash and opportunity costs. Figure 2.11 provides an overview about the calculation of land costs within TYPICROP.

Figure 2.11: Calculation scheme for land cost in TYPICROP



Source: Own illustration.

Average land rent (cash) for leased land is calculated considering possible shifts in rent prices during the duration of rent contracts. The current rent price is set in relation to the remaining old contract price level. The weighting factor relates to the duration of a rent contract.

Average land opportunity costs for owned land are set by current rent price as negotiated with new contracts. This refers to the theoretical possibility that all owned land can potentially be leased out at current rent prices for a production period (assuming that all other factors are variable and any path dependencies are neglected).

Average land rent and average land opportunity costs are then calculated with the percentage share of rented owned land in total land which results in cash and an opportunity costs. The **average land use costs** are made up of cash and opportunity costs.[20]

Total land costs also include **other land costs** which cover for example drainage expenses and are allocated to single crops due to their individual acreage.

[20] For formula details see Figure A4 in the Appendix.

A subject to intensive methodological discussion within *agri benchmark* is how to measure **land cost in the presence of decoupled payments** that are given per hectare of land regardless of the type of production carried out on that land. Hence, an increasing share of the payments are transmitted to the land owner via (high) rent prices (ISERMEYER and DEBLITZ, 2005).

From these considerations it is concluded that in presence of decoupled payments, the rent price can not be used as a proxy for land cost. Total land costs are thus used only as a starting point for further calculations that account for the level of direct payments. A simple and rather accurate approach is to calculate and compare **net land cost** (ISERMEYER and DEBLITZ, 2005). This concept is in particular pursued in this study since Germany and Australia show significant differences in their agricultural subsidy system.

(9) Total costs

Total cost of production is calculated considering the previously described cost positions (Figure 2.6). As many cost positions as possible are treated as variable and output related in order to reduce any bias in total cost figures. Furthermore, production factors such as land, labour, capital and their origin are registered and allocated to the different enterprises as described above.

The default calculation method within TYPICROP generates several **profitability indicators**, such as gross margin, operating profit and farm income, which are outlined in Figure 2.6.

(10) Gross margin: Net return of crop revenue (2) over direct cost (4)

(11) Operating profit: Net return of crop revenue (2) over direct and operating cost (5)

(12) Farm income (Profit): Total revenue (3) reduced by total cost (9)

All revenue positions, cost positions and productivity indicators introduced in this chapter are generated using the following reference units:

- **per hectare (ha) of single crop**

  The per hectare reference system is commonly used by farmers for providing information about their own production system in regards to physical and monetary inputs and outputs. Single operation figures on a per hectare basis are useful to asses the intensity of the production system and agronomical strategies.

- **per tonne (t) of single crop output**

  Referring to per tonne of a single crop output as a base unit allows drawing conclusions about competitiveness of the production system and market performance of a product.

– **per single crop**

  The per single crop reference unit allows comparing total figures between individual crops on farms.

– **per farm**

  The per farm reference unit allows comparing total figures of the individual farm.

– **per hectare (ha) cropping acreage**

  The average input and output figures for a whole model farm are based on the annual total cropping acreage of all crops. This enables an interpretation of cropping systems in which the annual cropped land may exceed the arable land.

– **per hectare (ha) arable land**

  Average input and output figures for the whole model farm are based on the available arable land. This reference system allows an interpretation of the performance of the available acreage.

  Furthermore, the per hectare arable land reference is useful for indicators describing the general capital and organisational structure of single farms. This is of importance for studies like the thesis in hand to understand farming situations in which adaptation strategies are applied. The individual introduced indicators are described in more detail in Section 4.1.

Currency exchange rates

Currency exchange calculations are of importance when comparing economics of land use systems and international competitiveness based on total cost of production. For *agri benchmark* calculations **average annual currency exchange rates** are accounted to national currencies. Main output currencies are Euro (EUR, €) and US-Dollar (USD, US$). TYPICROP contains a currency exchange rate module which is suitable to maintain and administrate average annual exchange rates.

Single year figures in this study are calculated into EUR using the respective exchange rate. The reference situation (B-0) and all scenario calculations (S-0, S-1, S-2) are calculated in 2007 exchange rates, since the high price scenario refers to this year. An overview of currency exchange rates from Australian Dollar (AUD) to Euro used for this study is found in Table A48 in the Appendix.

Acknowledging the discussed methodological considerations with the development of TYPICROP, the calculation tool is applied to the research design of this study.

2.4.3 Scenario derivation for input and output prices

The final step of the consolidation of the research design is the derivation of a consistent price scenario for input and output prices to be adapted to the typical farms. This is carried out in the following Section 2.4.3.

Fossil fuels are becoming limited in supply. Even though current oil prices have decreased since record highs in 2008, they are unlikely to remain low in the long term. A recovery of the world economy leads to an increase in demand which results in higher oil prices. According to the US Energy Information Administration (EIA) price levels of US$ 150 to 200 per barrel may become a realistic scenario in the next 10 to 20 years (EIA, 2009a).

Once driven by high price situations and policy influence the technical advance in processing agricultural commodities to biofuels took off and created a new industry. Nowadays it is feasible and already profitable in the case of sugarcane to convert products from large scale arable production into ethanol and biodiesel to compete and to substitute petroleum products on an industrial level. This technological link also termed **Bushel-Barrel-Correlation** awards a ceiling function and connects agricultural commodities with the oil price. Furthermore, the oil price has a direct influence on the price of agricultural inputs such as fertilisers, chemicals and diesel. This will have a direct effect on the current and future globalised agricultural sector and constitutes the background for this study.

The objective of Section 2.4.3 is to determine a consistent scenario of agricultural input and output prices in the case of very high oil prices to enable an assessment of farm adaptation strategies in regards to their economic and production output. Key elements of the price scenario are summarised and discussed from a related study conducted within the *agri benchmark* Cash Crop network (WALTHER et al., 2009) to provide a basic understanding of the topic.

2.4.3.1 Underlying concepts

The underlying concept involves the following assumptions:

(1) The minimum price for agricultural products is derived from the oil price.

(2) Ethanol production (due to its volume particularly in the US ethanol industry) has the greatest impact on grain markets, in particular for grains rich in starch.

(3) Biodiesel production is the relevant way of conversion for oilseeds.

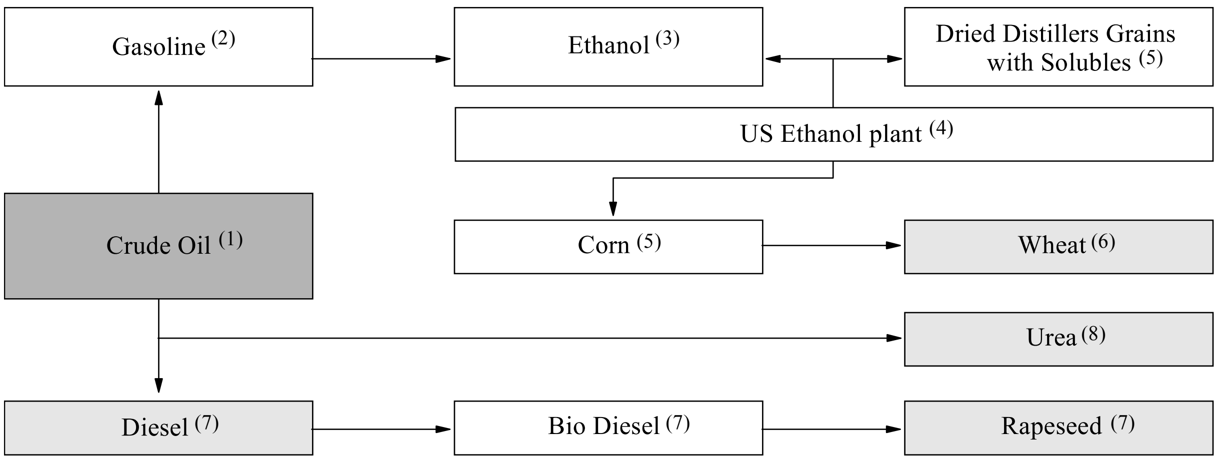
The oil price forecast of the World Energy Outlook 2009 published by the U.S. Energy Information Administration (EIA, 2009a) serves as the starting point for the derivation.

The basic scaffolding of the world market price scenario is constructed by evaluation of time courses with the help of linear correlation and economic efficiency calculations of US-ethanol plants and is complemented with price assumptions for other major crop inputs, such as Phosphorus (P) fertilizer, Potassium (K) fertilizer and pesticides.

2.4.3.2 Approach and calculation of commodity prices

The commodity price derivation is described in the following section. The paragraphs refer to the systematic shown in Figure 2.12.

Figure 2.12: Derivation systematic for high price scenario



Note: The light grey marked items are used directly for farm gate price calculations for typical farms.
Source: Own illustration.

(1) Crude oil price

Oil price prognoses of the US Energy Information Administration (EIA) have been used for the scenarios. The prognoses are published in the annual Energy Outlook 2009 (EIA, 2009a). The three price scenarios given there are described below, all in 2007 US$:

– Base scenario: 2010: 80 US$/barrel, 2020: 115 US$/barrel
– High price scenario: 2010: 91 US$/barrel, 2020: 183 US$/barrel
– Low price scenario: 2010: 58 US$/barrel, 2020: 50 US$/barrel

(2) Gasoline price

The gasoline price is deducted from the oil price using the linear regression

$y = 0.0271x + 0.105 \qquad R^2 = 0.95$

using time series for oil and gasoline prices with:

y = Gasoline: Los Angeles, CA, conventional gasoline regular Spot Price, FOB

x = Oil: Cushing, OK, WTI Spot Price FOB

The EIA records the spot market prices of oil, gasoline and diesel for every day of business. The monthly means have been calculated since June 1986 on the basis of these values (EIA, 2009b).

Western Texas Intermediate (WTI) is a crude stream produced in Texas and southern Oklahoma which serves as a reference marker for pricing other crude oil streams and is traded in the domestic spot market in Cushing, Oklahoma (EIA, 2011).

(3) Ethanol price

The ethanol price is then deducted from the gasoline price using the linear regression

$y = 0.6867x + 0.7705 \qquad R^2 = 0.8$

with:

y = Ethanol: Average Rack Prices FOB, Omaha, Nebraska

x = Gasoline: Los Angeles, CA, conventional gasoline regular Spot Price, FOB

The factor 0.69 corresponds to the relation of the energy contents of ethanol and gasoline. The premium of 0.77 US$/gal of ethanol can be explained by a subsidy of 0.51 US$/gal and a further premium of 0.26 US$/gal. The latter is paid because ethanol is used to increase gasoline octane rating. However, if further ethanol plants are built allowing for full coverage of the demand for gasoline blending this premium will decrease (TYNER, 2008).

Moreover, in a scenario of very high oil prices and correspondingly high food prices it is quite unlikely that bio-ethanol will still be subsidised. Thus the ethanol price is deduced from the gasoline price using the equation

$y = 0.69x$

with:

y = Ethanol: Average Rack Prices FOB, Omaha, Nebraska

x = Gasoline: Los Angeles, CA, conventional gasoline regular Spot Price, FOB

The time series used consists of monthly averages since 1982. The abovementioned gasoline prices and the ethanol prices published by the NEBRASKA ENERGY OFFICE (2009) are used.

(4) US ethanol plant

For the deduction of corn price from ethanol price a cost calculation of ethanol production from IOWA STATE UNIVERSITY (2009) is applied. This cost calculation considers the maximum (gross) payment reserve for corn (US$/t) for given ethanol prices. The following costs and conversion rates are assumed:

- Ethanol production: 2.8 gals per bu of corn
- By-product DDGS: 18 lbs per bu of corn
- Fixed cost: 0.2 US$/gal
- Natural gas cost: 0.28 US$/gal at an oil price of 40 US$/bbl, proportionally adjusted to higher oil prices
- Other variable cost (excluding corn or energy related): 0.23 US$/gal

(5) Dried Distillers Grains with Solubles (DDGS) and corn

In a further step the revenues of the DDGS have been accounted for in order to derive the net payment reserve for corn. The DDGS revenue has been calculated from the gross corn price using the regression

$$y = 0.56x + 40.14 \qquad R^2 = 0.7$$

with

x = Corn: No. 2 yellow, Chicago, Processor

y = DDGS: Lawrenceburg

The time series used for the regression are monthly means since 2003 provided by the USDA (2009). In a further step, the revenues of the unfermented residues DDGS have been accounted in order to derive the net payment reserve for corn.

(6) Wheat

The wheat price (European Union Market) is derived from the corn price (FOB US Gulf) using the regression

$$y = 1.19x + 33.65 \qquad R^2 = 0.64$$

with the price data from FAPRI (2009) for

x = Corn: FOB US Gulf

y = Wheat: European Union Market

(7) Diesel, biodiesel and rapeseed

Soybean and rapeseed prices have been calculated using biodiesel production cost. For this, the diesel price (US$/gal) is derived from the oil price using the regression

$$y = 0.0301x + 0.0165 \qquad R^2 = 0.98$$

with

x = Oil: Cushing, OK, WTI Spot Price FOB

y = Diesel: spot price Los Angeles FOB

Then a price discount of 0.32 US$/gal for biodiesel is included to account for its technical disadvantages compared to mineral diesel. From the biodiesel price the willingness to pay for vegetable oil is calculated using the production costs of a biodiesel plant in Iowa with net vegetable oil free costs of 0.47 US$/gal.

From the vegetable oil price the rapeseed price is derived using the regression

$$y = 0.39x + 62.65 \qquad R^2 = 0.89$$

with

x = Rapeseed oil: FOB Hamburg

y = Rapeseed seed: CIF Hamburg

(8) Urea

The urea price is derived from the crude oil price using the regression

$$y = 3.33x + 34.15 \qquad R^2 = 0.77$$

with

x = Oil: Cushing, OK, WTI Spot Price FOB

y = Urea: prilled bulk fob Black Sea

A time series of monthly means since 1997 provided by YARA (2009) for Urea (prilled bulk fob Black Sea) is used for calculating the urea prices

Using the methods as outline above, scenario prices have been derived for „base" and „high" price conditions for selected commodities (Table 2.3).

Table 2.3: Derived scenario prices for major commodities

	Unit	Base	High
Crude oil (WTI Spot Market)	USD/bbl	115	183
Corn (Iowa Ethanol Plant)	USD/t	140	242
Wheat (European Union)	USD/t	200	322
Rapeseed (CIF Hamburg)	USD/t	375	622
Soybeans (CBOT)	USD/t	330	537
Urea (FOB Black Sea)	USD/t	417	644

Source: Walther et al. (2009), own calculation.

From these scenarios the „high" price scenario is chosen and used for the following derivation of farm gate prices. Prices are rounded and further adjustments are made for the inputs and commodities that are not directly linked to energy prices.

The prices listed in Table 2.3 are world market prices and have to be recalculated to be considered as domestic farm gate prices. For Germany, the process of such a price calculation is described exemplarily in Section 2.4.3.3 according to WALTHER et al. (2009).

2.4.3.3 Derivation of farm gate prices

Exchange rate and value added tax (VAT)

For comparisons national currencies are generally converted into Euro (€) according to *agri benchmark* standards by using the average annual exchange rates. The EIA prognoses are based on US$ values from 2007.

Thus the calculations in this section refer to the 2007 exchange rate which averaged 0.68341 € per US$ 1.00. This exchange rate is used for all calculations in this section and all prices are VAT exclusive.

Rapeseed and wheat

For these two commodities 20 €/t are deducted from the world market prices for transport costs and traders' margins. Hence the German calculated farm gate prices are:

– 414 €/t rapeseed and
– 204 €/t wheat

Sugarbeet

The price for ethanol beets in the scenario situation has been determined by using the energy value, similar to corn, rapeseed and soybeans. The relationship of ethanol prices and crude oil prices has been determined as described in Section 2.4.2. In case of a scenario oil price of 180 US$/bbl an ethanol price of 0.63 €/l is corresponding.

In Germany, the Südzucker sugar company offers contracts to farmers to grow sugar beets for ethanol production with the price being determined by current ethanol prices.

GOLDHOFER et al. (2009) developed a gross margin calculation tool for ethanol sugar beets with up to date farm gate price offers in the case of different ethanol prices. For an ethanol price of 65 €-ct/l, a sugar content of 18 % and a distance of 50 km to the sugar factory they suggest a farm gate price of 29.56 €/t for sugar beets. The calculation basis is explained in more detail in GOLDHOFER (2006). Hence the (rounded) price to be used as the German farm gate price for:

– Sugarbeets (ethanol) is 31 €/t.
– Sugarbeet (quota) is 39 €/t (identical to reference scenario assuming constant market conditions according to EU sugar regime)

Nitrogen fertiliser

LINKER (2004) describes world market prices for urea as well as German farm gate prices of urea and calcium ammonium nitrate for the period of 1996 to 2004. The price difference between urea FOB Black Sea port and the same fertiliser type sold to a German farm in this period is approximately 0.15 €/kgN. The difference between the latter and calcium ammonium nitrate sold to a German farmer is another 0.15 €/kgN These figures are used to calculate the German farm gate prices of nitrogen fertilisers based on the world market prices scenario:

– Urea: 1.10 €/kgN (rounded)
– Ammonium nitrate (AHL): 1.20 €/kgN (rounded)
– Sulphate of ammonia (SSA): 1.20 €/kgN (rounded)

Potassium and phosphorus fertilisers

The EU is a net exporter of potassium fertilisers and there is no import tariff on these fertilisers. Hence, for Germany a smaller difference between the world market and the farm gate price can be assumed, as only domestic distribution and distributers' margins have to be covered. Based on the 0.15 €/kgN in the case of urea, it has been assumed that for KCl the difference is 0.05 €/kgK.

The EU is a net importer of P (P_2O_5) fertilisers. However, there is no import tariff imposed if the fertiliser comes from Israel, Morocco or Algeria and only 1.3 % tariff if imported from Russia. These countries are the four most important for phosphate fertiliser.

Given that phosphate fertilisers have to be imported, although with only very low tariffs, a somewhat bigger price difference of 0.10 €/kgP has been calculated. This revealed the following German farm gate prices:

– K-40 (33 % K): 0.96 €/kgK (rounded)
– Triplesuperphosphate (20 % P): 2.86 €/kgP (rounded)

Diesel fuel

As described above a regression of diesel fuel prices (untaxed) with crude oil prices is made for the calculation of the world market price. For the oil price scenario of 180 US$/bbl crude oil an untaxed diesel fuel price of 5.43 US$ per US gallon or 1.44 US$/l has been calculated. In Germany 0.47 € of taxes are levied per litre of diesel (not including VAT). The VAT free diesel fuel price therefore amounts to 1.52 €/l. Seven cents have been assumed to cover distribution and margins, resulting in the following German farm gate price:

– Diesel fuel: 1.59 €/l.

Heating oil

German heating oil prices for end consumers are calculated using a regression with crude oil prices. For the corresponding 180 US$/bbl scenario crude oil price, the calculated German farm gate price for:

– Heating oil is 1.17 €/l.

Organic fertilisers

In Germany organic fertilisers are considered under-priced due to their value of nutrients. In a scenario of long term high fertiliser prices this would push their use as substitutes to mineral fertilisers and increase their value. Another potentially even stronger increasing price factor of organic fertilisers is their energy value. Similarly to straw, many organic fertilisers, such as compost, meat and bone meal or sewage sludge can be burned to generate heat and electricity. Therefore consistent with the methodology used so far, the energy value of organic fertilisers can be used to calculate their lower price limit.

Compost has been available for free so far at least close to the production site. According to REINHOLD (2008), compost on average has about a third of the energy content of straw. A combined heat and power plant could therefore pay a third of the price of straw for compost if delivered to the plant. This is an estimate as certain types of compost are more suitable for burning than others. Additionally, the bigger bulk of compost material and its higher moisture content makes compost a less attractive fuel source. Taken all these factors into account compost is calculated delivered to the field un-spread:

– Compost: 30 €/t

Two other organic fertilisers that currently play a major role in German agriculture are considered here: Dry chicken dung and meat and bone meal. The prices in the scenario case have been determined based on the prices that were paid in the peak fertiliser price period of 2008. For dry chicken dung that is 30 €/t, for meat and bone meal it is 120 €/t. Taking the overall increase of the value of organic substance into account the following prices are used for the scenario:

– Meat and bone meal: 130 €/t

– Dry chicken dung: 35 €/t

Straw

LEIBLE et al. (2003) describes cost of production figures of combined heat and power stations by calculating at what straw prices such a plant can produce heat at the same costs as a heating oil based reference. The heating oil prices above have been used as a reference, creating a heating oil based reference price for heat of 0.13 €/kWh. It has been assumed that the power plants can sell electric power at the current state-mandated prices of 9.2 and 8.7 €-ct/kWh, depending on the power planting capacity. This produced equivalent straw prices, between 84 and 104 €/t (straw delivered to the plant[21]), depending on the size of the combined heat and power station. However, this method does not take into account that it is not economical to produce electric energy from heat if the electric energy costs are less than the heat sold directly.

Therefore it would only be practical to produce heat, which is on a similar price scale to yield higher straw prices. Such heating plants would have to be smaller to be able to sell all their produced heat to make them cost efficient. Therefore, an estimate of the equivalent straw price of 60 €/t a value in the lower range of the calculated prices for combined heat and power stations and considering the massive availability of straw has been used.

– Straw: 60 €/t.

---

[21] Transportation and loading/unloading costs of the straw are assumed as 350 € per truckload of 25 t for 100 km distance, equalling 14 €/t. This results in a farm gate price of straw of 60 €/t.

Agricultural policy

In Germany there are subsidies paid to agriculture according to the EU Common Agricultural Policy scheme (CAP). The CAP is currently under assessment to create the succession measures for the time after 2013.

The design of the new administrative framework is not predictable at the stage of this study. Thus, possible economic effects on farms are not part of this research project. The adaptation strategies of the German typical farm discussed in Section 4.2 assuming ceteris paribus conditions with regard to CAP in particular the direct payment system.

– Change nothing

For the selected locations in Australia a similar procedure is carried out. Table A49–A52 in the Appendix show the historical prices for the individual typical farms, realised during the investigation period from 2005 to 2009 and how they evolve if assumptions met in this chapter are compared to the reference situation.

The farm gate prices are the basis for the compilation of adaptation strategies of the respective typical farm and evaluation of potential changes of profitability and production output potential.

The following Table 2.4 summarises the scenario derivation for the investigation regions of this study considering the different products and production inputs. The scenario prices for each location are opposed to the reference prices (B-0) including the respective percentage change.

Table 2.4: Overview of farm gate prices in the status quo situation (Average 2005–2009) vs. scenario prices of typical farms in the comparison

		DE1300MB			AU4500SC			AU4000WB			AU2800CW		
Item	Unit	Avg. (05-09)	Sce-nario	%-change Scenario vs. avg.	Avg. (05-09)	Sce-nario	%-change Scenario vs. avg.	Avg. (05-09)	Sce-nario	%-change Scenario vs. avg.	Avg. (05-09)	Sce-nario	%-change Scenario vs. avg.
Crude Oil - WTI (Spot Market)	USD/bbl	71	180	+ 152	71	180	+ 152	71	180	+ 152	71	180	+ 152
Products (farm gate)													
Wheat	EUR/t	147	215	+ 46	141	187	+ 32	144	181	+ 26	145	196	+ 35
Barley (feed)	EUR/t	132	195	+ 47	122	165	+ 35	113	133	+ 17	131	177	+ 35
Barley (malt)	EUR/t				144	191	+ 32	136	167	+ 23	142	191	+ 35
Rye	EUR/t	118	170	+ 45									
Rapeseed/Canola	EUR/t	278	433	+ 56	258	388	+ 50	255	382	+ 50	255	399	+ 56
Corn	EUR/t	140	205	+ 47									
Sugarbeet (quota)	EUR/t	39	39										
Sugarbeet (ethanol)	EUR/t	26	31	+ 20									
Lupins	EUR/t				153	179	+ 17	142	173	+ 22	153	183	+ 20
Peas	EUR/t				166	202	+ 22	155	195	+ 26	164	197	+ 20
Oats	EUR/t										159	187	+ 18
Oaten hay	EUR/t				103	136	+ 32	101	132	+ 31			
Baled straw	EUR/t	--	60		--	45		--	45		--	45	
Inputs (farm gate)													
Seed													
Wheat-seed	EUR/t	338	486	+ 44									
Cereal-seed	EUR/t				159	227	+ 43	159	227	+ 43	159	227	+ 43
Rapeseed-seed/Canola	EUR/unit	180	252	+ 40	312	425	+ 36	312	425	+ 36	312	425	+ 36
All other crops	EUR/t				--	--	+ 20	--	--	+ 20	--	--	+ 20
Sugarbeet-seed	EUR/unit	214	256	+ 20									
Nitrogen (N)													
Urea 46 % N	EUR/kg N	0.61	1.10	+ 80	0.65	0.99	+ 54	0.68	0.97	+ 43	0.71	0.93	+ 30
	EUR/t	280	505	+ 80	296	457	+ 54	312	445	+ 43	327	445	+ 36
AHL[1] 28 % N	EUR/kg N	0.63	1.20	+ 91									
SSA[2] 21 % N, 24 % S	EUR/kg N	0.61	1.20	+ 97									
Flexi-N[3] 32 % N	EUR/kg N				0.78	1.20	+ 54	0.78	1.20	+ 54	0.79	1.21	+ 54
NS-41[4] 35 % N, 9 % S	EUR/kg N				0.65	0.99	+ 54	0.65	0.99	+ 54	0.67	1.02	+ 51
Phosphate (P)													
TSP[5] 20 % P	EUR/kg P	1.65	2.86	+ 73				1.73	3.13	+ 81	1.74	3.13	+ 80
MAP[6] 11 % N, 22 % P	EUR/kg P				1.49	2.58	+ 74	1.49	2.58	+ 74	1.49	2.61	+ 75
DAP[7] 17 % N, 20 % P	EUR/kg P				1.24	2.29	+ 85	1.30	2.36	+ 81	1.34	2.39	+ 78
Potassium (K)													
K-40[8] 33 % K	EUR/kg K	0.56	0.96	+ 71									
MOP[9] 50 % K	EUR/kg K				0.92	1.41	+ 54	0.92	1.41	+ 54	0.97	1.41	+ 46
Organic fertiliser													
Dry Chicken Manure	EUR/t	19	35	+ 84									
Meat and Bone Meal	EUR/t	51	130	+ 155									
Compost		--	30										
All pesticides		--	--	+ 20	--	--	+ 20	--	--	+ 20	--	--	+ 20
Diesel fuel	EUR/l	0.84	1.59	+ 89	0.48	0.82	+ 71	0.51	0.82	+ 62	0.54	0.85	+ 59
Heating oil	EUR/l	0.50	1.17	+ 134									

Notes: 1) AHL = Liquid N-fertiliser: 28 % N of ammonium nitrate and urea.
2) SSA = Sulphate of ammonia: 21 % N of ammonium, 24% S of sulphate.
3) Flexi-N = Liquid N-fertiliser: 32 % N in solution of ammonium nitrate and urea.
4) NS-41 = 35 % N of ammonium, 9 % S of sulphate.
5) TSP = Triple-superphosphate: 46 % P_2O_5 = 20 % P.
6) MAP = Monoammonphosphate: 52 % P_2O_5 = 22 % P, 11 % N of amminium.
7) DAP = Diammonphosphate: 46 % P_2O_5 = 20 % K; 17 % N of ammonium.
8) K-40 = Chloride of potash: 40 % K_2O = 33 % K.
9) MOP = Muriate of Potash: 60 % K_20 = 50 % K.

Source: EIA (2009a), BMWI (2009), Walther et al. (2009), own calculation.

In this study, the scenario has no temporal dimensions. Farm level adaptations are evaluated for assuming that prices of the scenario are stabile for a long time period. All further prices not considered in this scenario remain unchanged (ceteris paribus).

3 Overview and framework conditions for cash crop production in Germany and Australia

Germany and Australia are chosen for this study because both countries play an important role for global production and trade of agricultural commodities. The broad acre arable sector of both countries grows similar crops like cereals and oilseeds and thus competes in the same world markets. The performance of both countries on these markets, however, differs significantly in terms of total output and exports. These differences may provide indications about the general orientation of the sector and how world market conditions can affect primary production on farms. Hence, with regard to the objective of this study it is important to get a general idea about the specific role of Germany and Australia on global markets for arable commodities. This is described in the following Section 3.1.

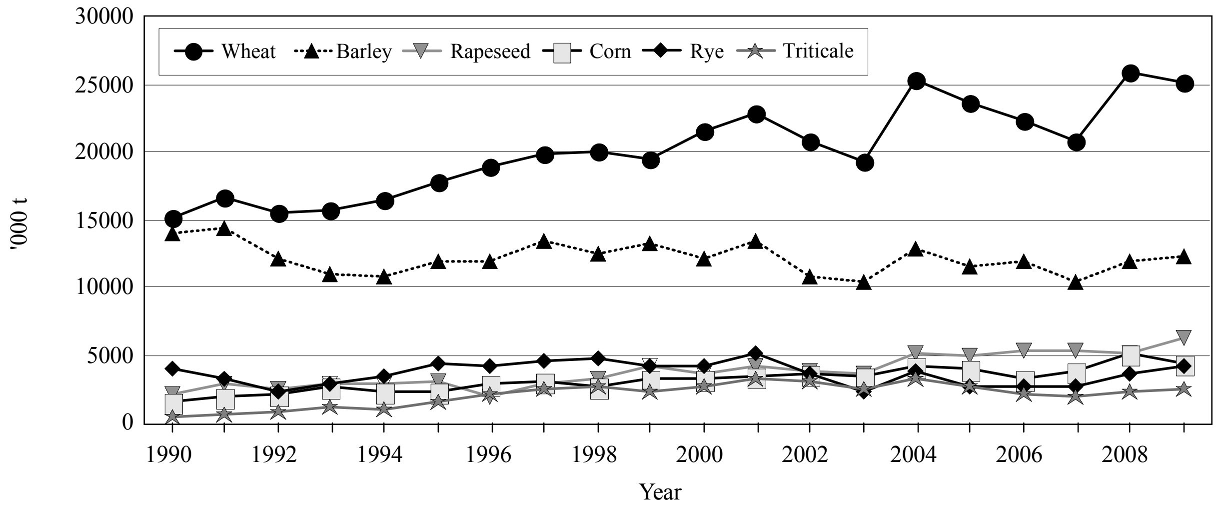
Cash crop production in Germany and Australia is diverse and operates under different natural conditions. Predominantly climate and soils vary between both countries and within these countries. These characteristics lead to distinctive regional production structures and intensity of land use systems and are used to choose the relevant investigation regions to establish the model farms. Section 3.2 outlines the considerations for how the locations are chosen. The Magdeburger Börde region is selected for Germany. The Western Australian Wheatbelt, the South Coast of Western Australia and the Central West of New South Wales are the respective regions selected for Australia.

Nevertheless, a main aim of this study is to analyse perspectives for crop production in the selected regions. Therefore the corresponding typical farms and their individual agronomic specifications are investigated to establish hypotheses for possible production adaptations. Agronomic specifications are closely linked to the specific local environment and therefore insights about natural conditions and production constraints are a sought for the interpretation of the results discussed in Section 3.3.

3.1 Production output and export of arable commodities

In this section, the production output and the export performance of the German and Australian arable farming sector is discussed. Figure 3.1 illustrates the evolution of production output of major crops in Germany from 1990 to 2009.

Figure 3.1: Germany – Production ('000 t) of major arable commodities from 1990 to 2009



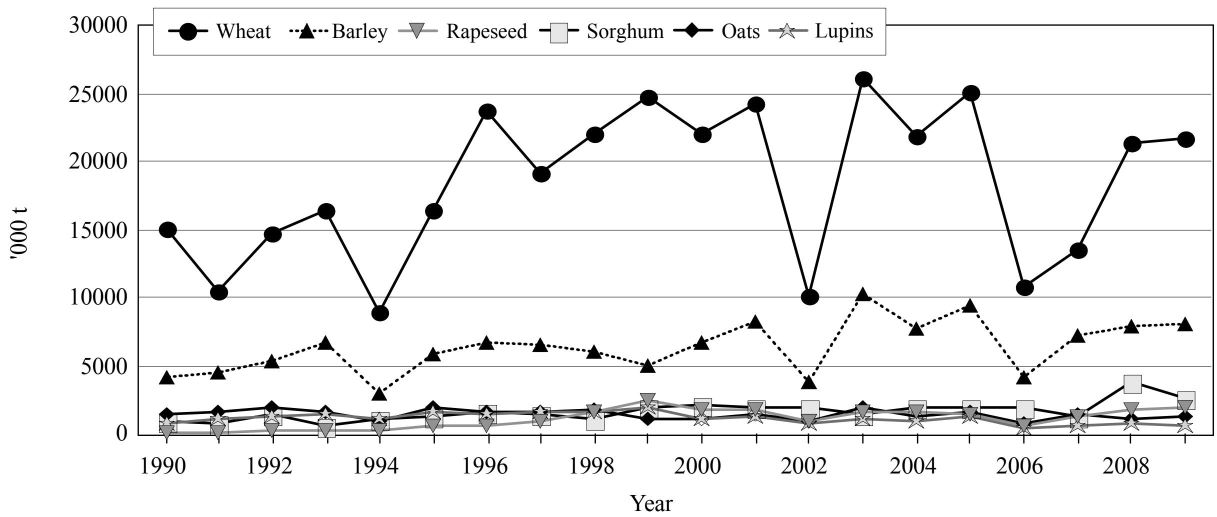
Source: FAOSTAT (2011); own illustration.

Most dominating crop grown in Germany is **wheat**, predominantly winter wheat. The total output increased by + 65 % during the ten years observed in Figure 3.1 reaching a record high of 26 Mt produced in 2008. The trend figures upwards rather steadily with two substantial exceptions in 2003 and 2007.

Outgoing from the same level in 1990 the production of barley decreased slightly to a level of 12 Mt. Other cereals range below 5 Mt. In this range the output of corn and triticale doubled. A further important crop grown in Germany is **rapeseed**. Its total production output increased steadily since 1990 and ranges above 5 Mt since 2004. The respective annual values underlying for Figure 3.1 are listed in Table A53 in the Appendix.

The following Figure 3.2 illustrates the evolution of production output of major crops in Australia from 1990 to 2009.

Figure 3.2: Australia – Production (‘000 t) of major arable commodities from 1990 to 2009



Source: FAOSTAT (2011); own illustration.

The dominating crop grown in Australia is **wheat.** Its production output increased to an approximate level of 22 Mt since the early 1990’s. However, this evolution is marked by extreme fluctuations and production depressions to around 10 Mt. The second important crop is barley which arranges around 7 Mt. Symptomatic for the vulnerability of the Australian production output is the strong uniformity between barley and wheat output which are affected simultaneously in bad years 1994, 2002 and during the last drought period in 2006/07. Other crops including rapeseed range below 4 Mt. The respective annual values underlying for Figure 3.2 are listed in Table A54 in the Appendix.

It is concluded, that the arable farming sector of Germany and Australia is primarily aligned on the production of cereals followed by oilseed. Wheat is the leading crop in both nations in terms of output which suggests the question how they are ranked in an international comparison.

The following Table 3.1 lists the wheat production output and export of the top-15 producing and exporting countries from 2006–2008.

Table 3.1: Wheat production and export (‘000 t) of major global producing and exporting countries from 2006 to 2008

Production ('000 tonnes)					Export ('000 tonnes)				
Country	Rank (2008)	Year 2006	2007	2008	Country	Rank (2008)	Year 2006	2007	2008
China	1	108,466	109,298	112,463	USA	1	23,377	32,947	30,093
India	2	69,355	75,807	78,570	France	2	16,581	14,386	16,293
USA	3	49,216	55,820	68,016	Canada	3	18,498	17,552	15,781
Russian Fed.	4	44,927	49,368	63,765	**Australia**	**4**	**8,685**	**7,444**	**14,707**
France	5	35,364	32,764	39,006	Russian Fed.	5	9,705	14,444	11,720
Canada	6	25,265	20,054	28,611	Argentina	6	9,697	9,645	8,772
Germany	**7**	**22,428**	**20,828**	**25,989**	Ukraine	7	4,671	1,619	7,511
Ukraine	8	13,947	13,938	25,885	**Germany**	**8**	**6,106**	**4,646**	**7,038**
Australia	**9**	**10,822**	**13,569**	**21,420**	Kazakhstan	9	4,195	6,178	4,951
Pakistan	10	21,277	23,295	20,959	United Kingdom	10	2,117	1,912	2,766
Turkey	11	20,010	17,234	17,782	Hungary	11	2,095	1,592	2,113
United Kingdom	12	14,747	13,221	17,227	Romania	12	905	207	1,989
Kazakhstan	13	13,461	16,467	12,538	Bulgaria	13	1,304	254	1,759
Argentina	14	14,663	16,487	8,508	Mexico	14	536	569	1,398
Iran	15	14,664	15,887	7,957	Lithuania	15	407	435	1,127
World		602,892	612,611	683,070	World		126,440	132,794	131,130

Source: FAOSTAT (2011), own illustration.

For wheat, Germany ranked 7th in production and 8th in export for the year 2008 while Australia ranked 9th and 4th respectively. Wheat production and exports increased in both countries from 2006 to 2008. However, while German wheat production remained relatively stabile during that time, Australian production more than doubled while exports grew by +70 %.

The following Table 3.2 lists the rapeseed production output and export of the top-15 producing and exporting countries from 2006–2008.

Table 3.2: Rapeseed production and export ('000 t) of major global producing and exporting countries from 2006 to 2008

Production ('000 tonnes)					Export ('000 tonnes)				
Country	Rank (2008)	Year 2006	2007	2008	Country	Rank (2008)	Year 2006	2007	2008
Canada	1	9,000	9,601	12,643	Canada	1	5,548	5,364	6,659
China	2	10,966	10,573	12,102	Ukraine	2	471	640	2,387
India	3	8,131	7,438	5,834	France	3	1,730	1,717	2,102
Germany	**4**	**5,337**	**5,321**	**5,155**	**Australia**	**4**	**228**	**472**	**1,067**
France	5	4,144	4,691	4,721	Romania	5	131	279	564
Ukraine	6	606	1,047	2,873	Hungary	6	345	399	483
Poland	7	1,652	2,130	2,106	USA	7	167	376	467
United Kingdom	8	1,890	2,108	1,973	**Germany**	**8**	**310**	**405**	**430**
Australia	**9**	**573**	**1,214**	**1,844**	Czech Republic	9	52	436	374
Czech Republic	10	880	1,032	1,049	Poland	10	132	508	258
Russian Federatic	11	522	630	752	United Kingdom	11	194	264	219
Romania	12	175	362	673	Lithuania	12	66	201	193
USA	13	633	650	656	Belgium	13	101	85	173
Hungary	14	338	486	655	Bulgaria	14	15	67	172
Denmark	15	435	589	629	Slovakia	15	100	113	152
World		48,025	51,477	57,862	World		10,476	11,772	15,946

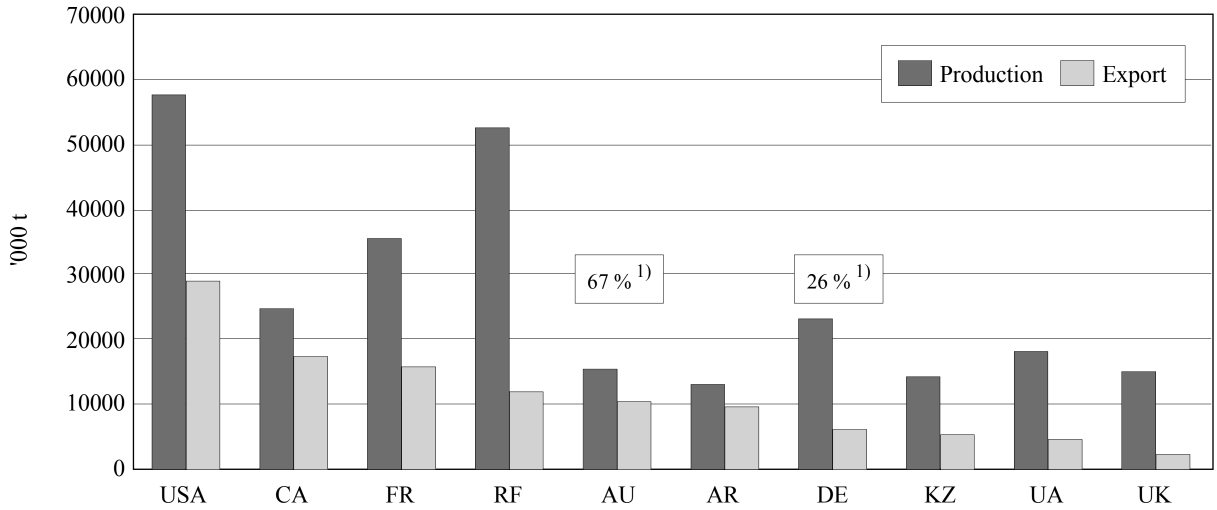
Source: FAOSTAT (2011), own illustration.

For rapeseed, Germany ranked 4th in production and 8th in export for the year 2008 while Australia ranked 9th and 4th respectively. Rapeseed production in Germany decreased slightly and of which less than 10 % were exported. In Australia, production and export almost quadrupled from 2006 to 2008.

Further, Germany and Australia are important producers and exporters in other markets for major agricultural commodities. The position of both countries on the global markets for barley and legumes is therefore displayed in Table A55, A56 and A57 in the Appendix.

The diverting ratios between production output and export suggest the assumption that global markets have a diverting relevance for the cropping sector. The following Figure 3.3 illustrates the average production output and export performance of the top ten wheat producers from 2006–2008.

Figure 3.3: Average wheat production and export (‘000 t) of top ten wheat exporting countries (2006–2008)



Note: 1) percentage share of export in total wheat production.
Source: FAOSTAT (2011); own illustration.

With the example of wheat, Australia shows a significant high share of 67 % of exports in total production output which is equal to Canada and Argentina. On average from 2006 to 2008, Germany has a relatively low export share of 26 %.

It is concluded from this Section that Germany and Australia are major producers and exporters of major agricultural commodities and thus play an important role on the respective global markets. Both countries are among the global top ten producers and exporters of wheat and rapeseed.

However, due to a significant high share of exports in the total production output the Australian cropping sector is heavily influenced by the development of global markets. Producers in Australia are thus exposed to price fluctuations on global markets to a greater extend than German farmers where the domestic market dominates the sales channels.

3.2 Regional production structures

The structure of cash crop production in Germany and Australia varies substantially. One reason for this is the area of land dedicated to agriculture and area under crops for both countries (Table 3.3).

Table 3.3: Total acreage, agricultural area and area under crops ('000 ha) in Germany and Australia in 2009

	Germany		Australia	
Land use	1000 ha	% of total area	1000 ha	% of total area
Total area	35,705	100	769,202	100
Agricultural area	18,764	53	409,029	53
Area under crops	11,945	33	27,511	4

Source: ABS (2010a); Statistisches Bundesamt (2009), own calculation.

The total landmass of Australia is approximately 22 times the total area of Germany. With 21.9 million inhabitants the population is about a quarter of the population of Germany. Furthermore, the Australian mainland is sparsely populated with the majority of the population (98 %) living in cities on the east and west coast. This leads to the assumption that comparatively larger land resources are available for farming. Indeed, the agricultural land area of 410 million hectare is more than double of the land available for agriculture in Russia (ABS, 2010b; MINISTERSTYO SELSKOGO CHOSJAISTVA ROSSIISKAJA FEDERAZIJA, 2008).

However, the sector's actual dimensions can preliminarily be depicted by focussing on agricultural land use. While both countries' share of agricultural area in total area is identical, significant differences can be found in the share of area under crops. In Germany the area under crops represents the major share of the agricultural area which is about one third of the total area. Australia's area under crop is less than 10 % of the agricultural area and amounts to 4 % of the total area. The land sown by Australian farmers represents 2.5 times the area of land dedicated to crops in Germany.

The differences in dimensions of agricultural land use require further clarification about regional structures which are determining factors for the different land use situations and hot spots for production discussed in the following section.

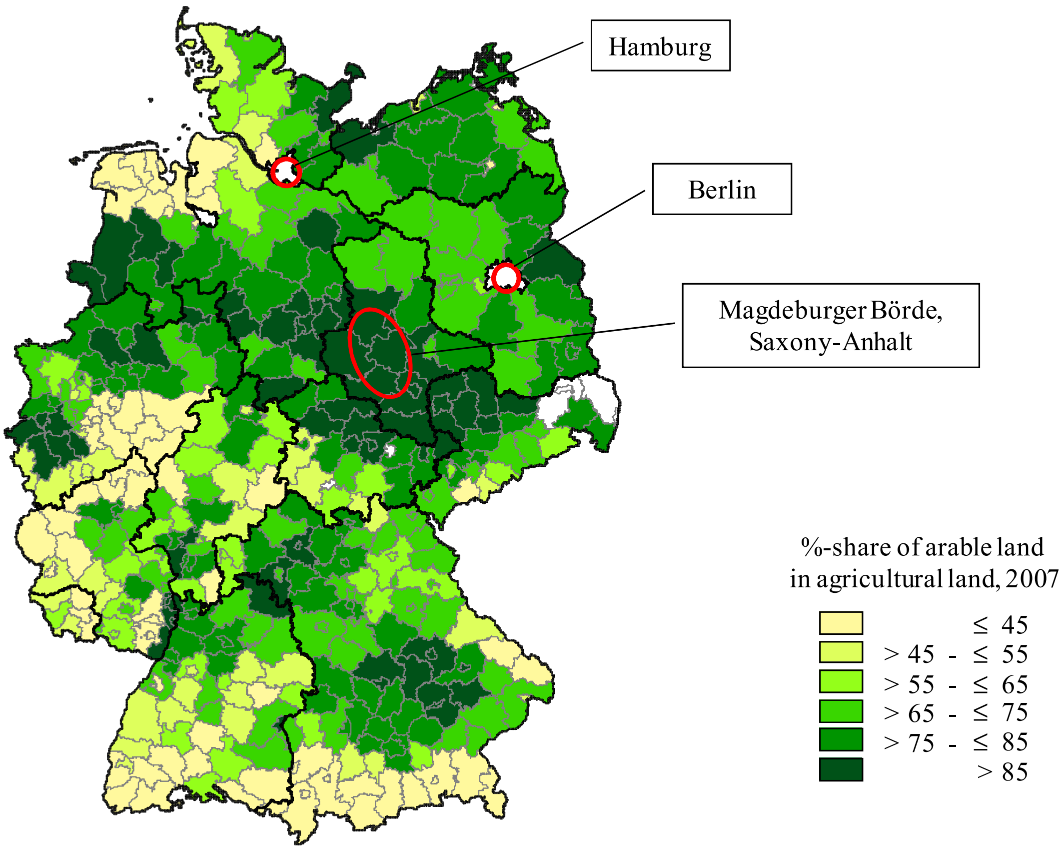
3.2.1 Germany

Due to its geographical location climate conditions in Germany can be described as marine in the north and temperate in the mid and south of Germany.

Agriculture is the most dominant land use (53 %) followed by forests (30 %), urbanised area (13 %), water area (2 %) and other area (2 %). However, due to the strong land demand for settlement, traffic and industrial utilisation the agricultural area is declining in favour of urbanised area and forests. The current land occupation for settlement, traffic and renaturation amount to 115 ha/day. The latter one accounts for the greatest share since political interventions are in place which promote sustainable use of natural resources (DEGGAU, 2006).

The following Figure 3.4 illustrates the land dedicated to crop production in Germany. Respective measure is the share of arable in agricultural land.

Figure 3.4: Germany – Percentage share of arable land in agricultural land (2007)

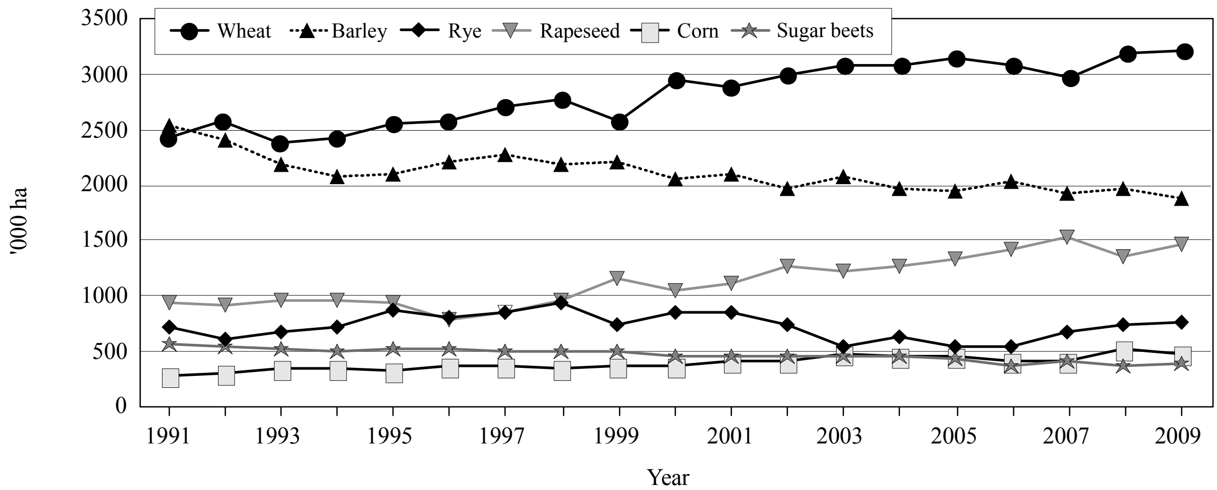


Source: Statistisches Bundesamt, Fachserie 3, Reihe 3 (2007); own illustration.

The production of Cash crops is relatively even distributed throughout the country with characteristic patterns of spatial concentration. Two third or more of the agricultural land is used for crop production in the north, in central Germany and in certain regions in the south. One centre of crop production is located in middle Germany east of the ranges "Harz".

The land coverage of major Cash crops in Germany is illustrated in Figure 3.5.

Figure 3.5: Acreage ('000 ha) of major cash crops in Germany from 1991 to 2009



Note: Corn includes Corn-Cob-Mix (CCM).
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3 (various years), own illustration.

Dominating crop in terms of land use is wheat. The acreage of wheat steadily increased since 1991 to approximately 3.2 million hectare to the detriment of barley. Rapeseed acreage increased since the end of the 1990's and covers approximately 1.5 million hectares.

The percentage share of individual crops in the arable land shows characteristic spatial patterns. Centres of German wheat production are located in middle Germany around the middle ranges "Harz", along the North Sea and Baltic Sea in the north as well as in the West. Similar outcomes can be obtained by analysing the spatial distribution of rapeseed and sugarbeet production. Respective illustrations are found in Figure A5–A7 in the Appendix.

Based on these findings, major parts of Saxony-Anhalt are assessed as an example for a highly specialised cropping region with a high share of cereals (>35 %) and oilseeds (15–25 %) in the crop portfolio. Saxony-Anhalt is thus in the focus of further investigation.

The importance of this production region for the German cash crop sector is measured by contribution to the total production output and the area of land for major crops. The respective figures can be found in Table 3.4.

Table 3.4: Production output and acreage of selected major cash crops in Saxony-Anhalt and Germany (Average 2005–2009)

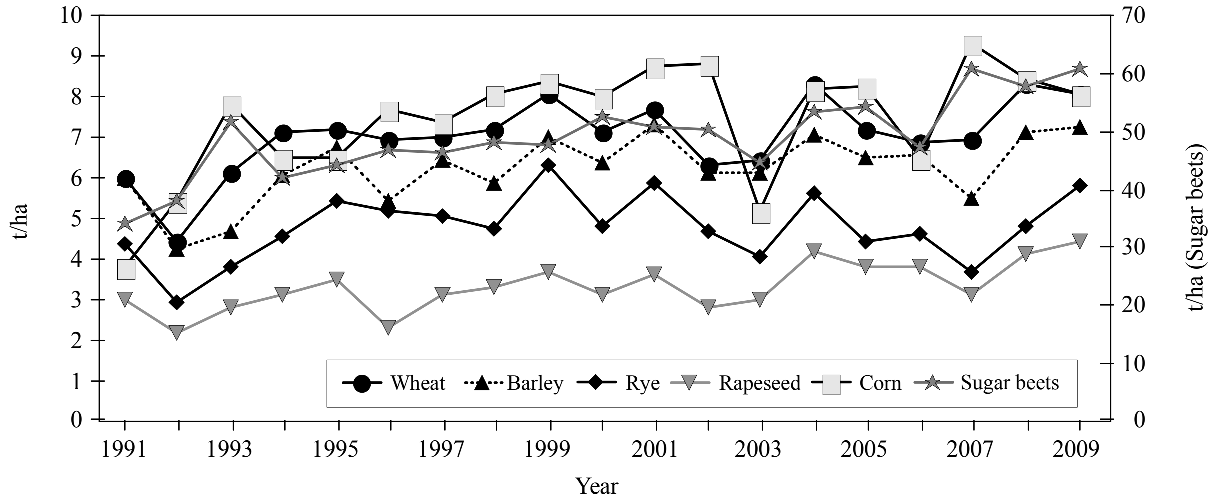
	Average 2005-2009					
	Saxony-Anhalt				Germany	
	Production	Share in total production	Acreage	Share in total acreage	Total production	Total acreage
	t	%	ha	%	t	ha
Wheat	2,503,967	10.6	333,705	10.6	23,595,377	3,134,360
Barley	797,354	6.8	120,708	6.2	11,645,839	1,945,714
Rye	366,250	11.3	77,711	12.0	3,230,625	649,048
Corn	151,430	3.6	18,682	4.2	4,181,442	446,442
Rapeseed	628,070	11.6	163,550	11.5	5,406,608	1,419,882
Sugarbeet	2,575,655	10.7	45,476	11.8	23,997,191	386,659
Peas	38,942	17.4	13,429	18.3	223,643	73,274

Source: Statistisches Bundesamt, Fachserie 3, Reihe 3 (various years); own calculation.

The figures for Saxony-Anhalt indicate a substantial share in the total land utilised for arable production and importance of its cash crop sector for the total German production of cereals and oilseeds. Hence, the relevance of this region is also given in terms of output shares (cp. SOP). Based on these conclusions, the region of Saxony-Anhalt is chosen for further analysis in this study.

To evaluate the farm data and respective results regarding yield potentials an overview of historical yield development for major crops provides a helpful analytical tool which is presented for Saxony-Anhalt in Figure 3.6.

Figure 3.6: Yields (t/ha) of major cash crops in Saxony-Anhalt from 1991 to 2009



Note: Corn includes Corn-Cob-Mix (CCM).
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3 (various years); own illustration.

	Wheat	Barley	Rye	Corn	Rapeseed
2009	8.11	7.27	5.80	8.11	4.41
Ø 1991-2009	7.03	6.25	4.78	7.44	3.31
Max [1)]	8.36	7.34	6.29	9.33	4.41
Min [1)]	4.42	4.24	2.92	3.80	2.20
CV [2)]	0.13	0.13	0.17	0.19	0.18

1) Maximum and minimum yields in the observed period.
2) Coefficient of variation.

Yields in Saxony-Anhalt have slightly increased across all crops presented in Figure 3.6 over the last two decades. Furthermore, wheat and barley show the smallest yield fluctuation compared to rapeseed and corn. Thus, the critical question suggested in this regard is if there is room for further yield improvement irrespective of the current positive trend.

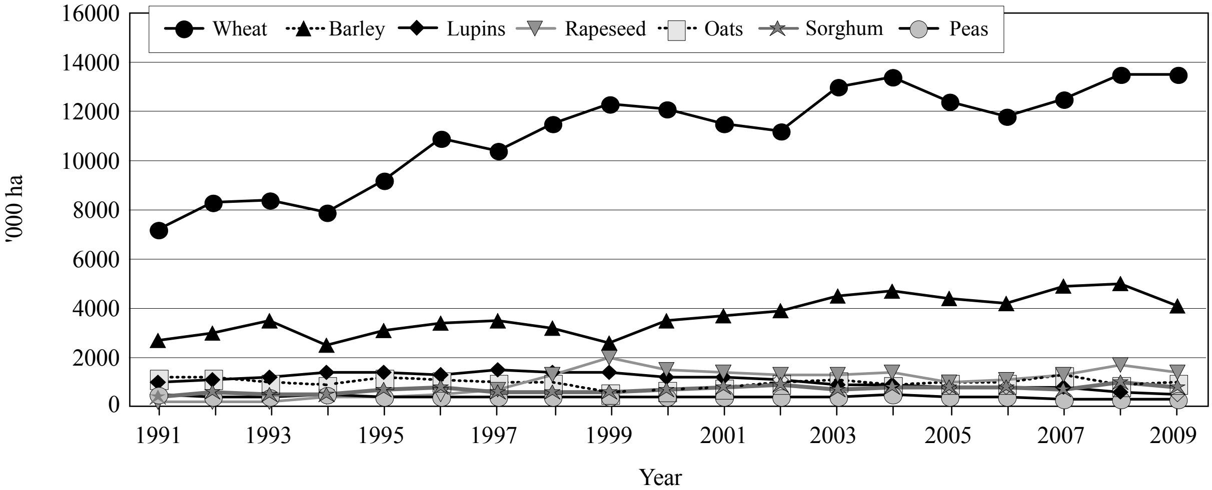
3.2.2 Australia

Australia is located in the southern hemisphere. Thus seasonality of all introduced Australian regions used in this study is shifted by six month compared to regions in Germany. Summer is from December to February and winter from June to August.

Australia is the world's sixth largest country and also the driest inhabited continent. The land use is primarily determined by natural conditions. Desert or semi-arid land also known as ‘outback’ makes up the largest portion of land (ZMP, 2008).

Land coverage of main crops in Australia from 1991 to 2009 are listed in Figure 3.7.

Figure 3.7: Acreage ('000 ha) of major cash crops in Australia from 1991 to 2009



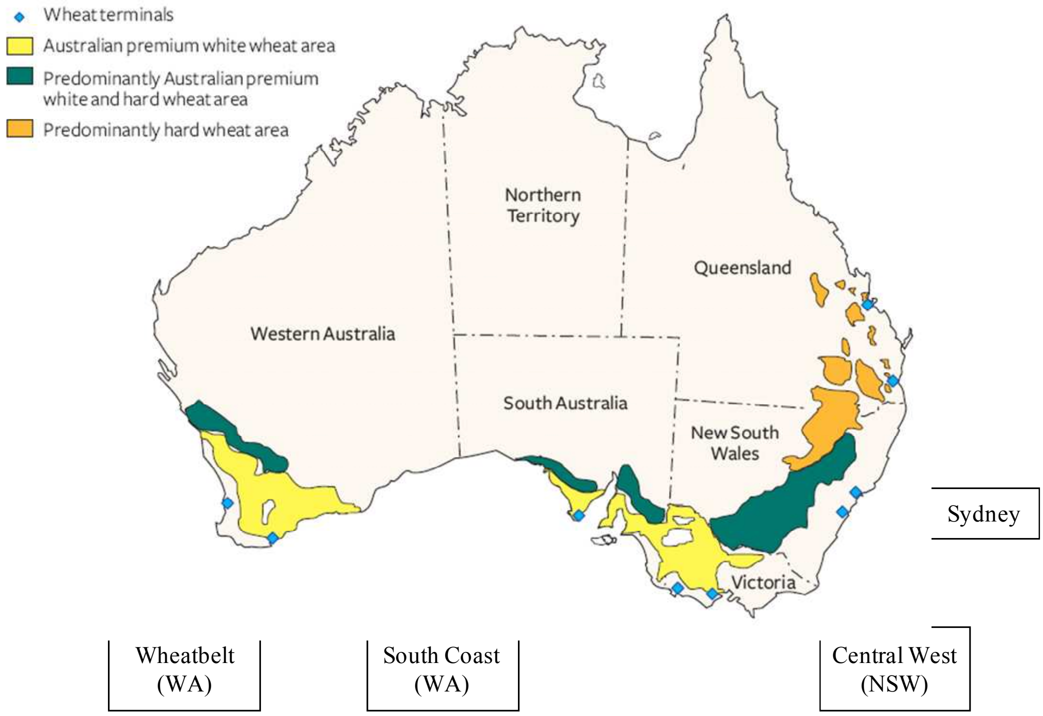
Source: FAOSTAT (2011), own illustration.

A dynamic increase is identified in land dedicated to wheat and barley to a certain extend. All other crops are of less importance in terms of acreage and remain relatively stabile below two million hectare.

Since wheat is the most dominating crop, the geographical regions of major wheat producing areas and are a reasonable indicator for the spatial distribution of cash crop farming in Australia and shown in Figure 3.8.

The production of cash crops in Australia is concentrated in the south-east and south-west of the continent due to the temperate climate and sufficient rainfall. The whole interior country known as the “Outback” is not suitable for crop production due to harsh climatic conditions. In the outer zones of the arable land, agricultural production is dominated by livestock farming in extensive grazing systems which account for 87 % of land managed by agricultural businesses (ABS, 2009a).

Figure 3.8: Spatial distribution of wheat production in Australia



Source: ABARE (2011); own illustration.

Western Australia and New South Wales are particularly suited for cash crop production. The relevance of these production regions for the Australian agricultural industry is further investigated by comparing the means of total production and size of land area for major crops, displayed in Table 3.5.

Table 3.5: Production output and acreage of selected major crops in Western Australia, New South Wales and Australia (Average 2005–2009)

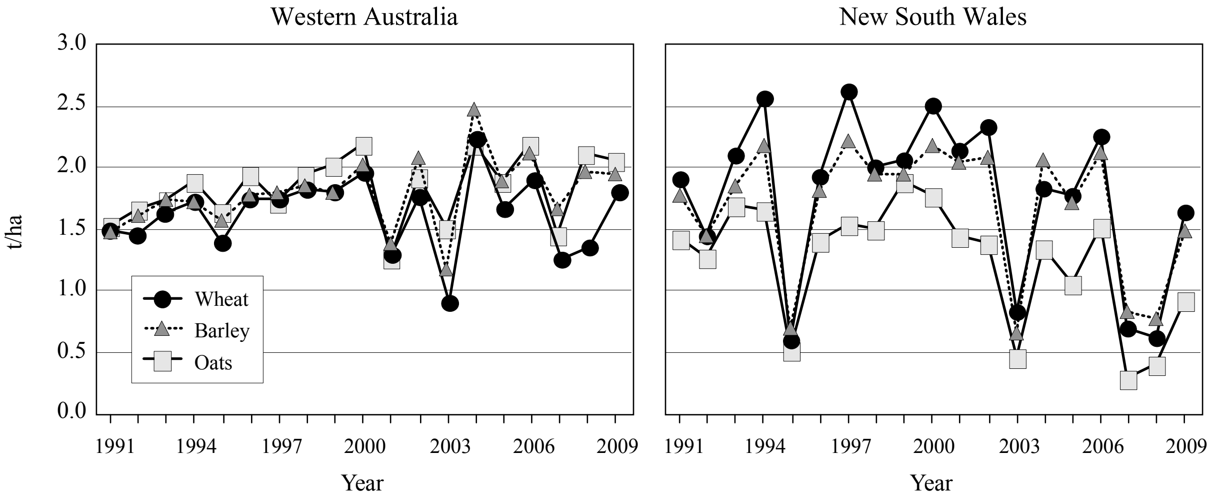
	Average 2005-2009									
	Western Australia				New South Wales				Australia	
	Production	Share in total production	Acreage	Share in total acreage	Production	Share in total production	Acreage	Share in total acreage	Production	Acreage
	t	%	ha	%	t	%	ha	%	t	ha
Wheat	5,813,160	36.6	4,532,420	35.8	5,498,400	34.6	3,921,960	30.9	15,877,020	12,673,780
Oats	591,360	46.0	302,300	30.7	325,580	25.3	388,940	39.5	1,285,200	984,120
Barley	2,445,000	33.7	1,269,280	27.7	1,419,900	19.6	1,008,180	22.0	7,261,580	4,584,940
Lupins	582,126	70.7	523,102	79.2	56,538	6.9	91,145	13.8	822,963	660,362
Canola	891,668	46.8	788,281	61.6	179,904	9.4	304,047	23.8	1,907,272	1,278,929

Source: ABS (2009b), own calculation.

The figures confirm a significant importance of the domestic cash crop sector of the two states for the total Australian output of cereals and oilseeds. Particularly in Western Australia over 70 % of the production of lupins and 45 % of canola takes place. Hence, the relevance of these regions is also given in terms of output shares according to the *agri benchmark* standard operating procedure to define typical farms.

Based on these conclusions, regions in Western Australia and New South Wales were chosen as the regional statistical scale for further analysis in this study. Indications about differences in production uncertainty are obtained from yield developments for major crops which are presented for the two states in Figure 3.9

Figure 3.9: Major crop yields (t/ha) in Western Australia and New South Wales from 1991 to 2009



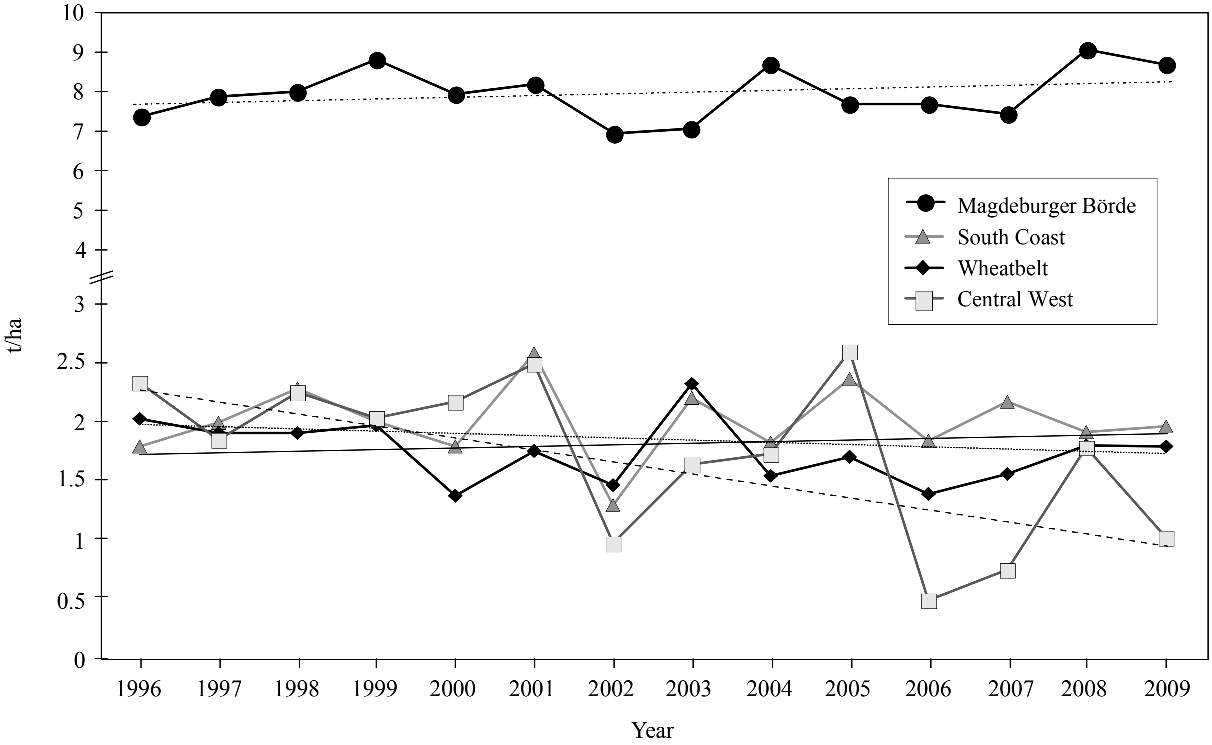
Source: ABS (2010c).

The selected states show substantial differences in yield evolution of major crops: Yield of cereals in Western Australia trend slightly positive and with fewer fluctuations compared to New South Wales. In the latter state, yields trend negatively with substantial yield failures. This is an indication for higher production uncertainty in NSW.

An objective of this study is to investigate locations with differentiating intensity levels in agricultural production along a gradient of intensity.

Therefore, within the introduced states a further regional containment is chosen to illustrate the output performance on a smaller scale. Since historical yield data for all crops is rarely available on shire-level, wheat yield was taken as a representative example to explain physical crop performance (Figure 3.10).

Figure 3.10: Evolution of average wheat yields (t/ha) in the investigation regions (shire-level) in Germany (Magdeburger Börde) and Australia (Wheatbelt and South Coast region of WA, Central West NSW) from 1996 to 2009



Source: Statistisches Bundesamt, Fachserie 3, Reihe 3 (various years); ABS (2010c); Scott F. (2009), own compilation.

		Germany Magdburger Börde	Australia South Coast WA	Australia Wheatbelt WA	Australia Central West NSW
Ø 1996-2009	t/ha	7.98	2.00	1.77	1.73
Max[1)]	t/ha	9.09	2.59	2.33	2.60
Min[1)]	t/ha	6.95	1.30	1.38	0.50
CV[2)]		0.08	0.16	0.15	0.39
Trend[3)]		0.04	0.00	-0.02	-0.09
Ø 2005-2009	t/ha	8.00	2.08	1.62	1.41
CV[2)]		0.09	0.12	0.13	0.64
Trend[3)]		0.33	-0.11	0.09	-0.19

1) Maximum and minimum yields in the observed period.
2) Coefficient of variation.
3) Regression coefficient.

Wheat yields on shire level are the closest proximity of official statistical data to the typical farm established in the region considering the availability of comparable data. By examining the wheat yields, the four selected regions are found to differentiate in the following characteristics:

– Different yield levels indicate different intensities and production systems which match different climatic conditions.
– Different yield trends can be the result of different performance of cropping or substantial changes in natural conditions.
– The annual performance of yields and its fluctuation indicates different levels of production uncertainty.

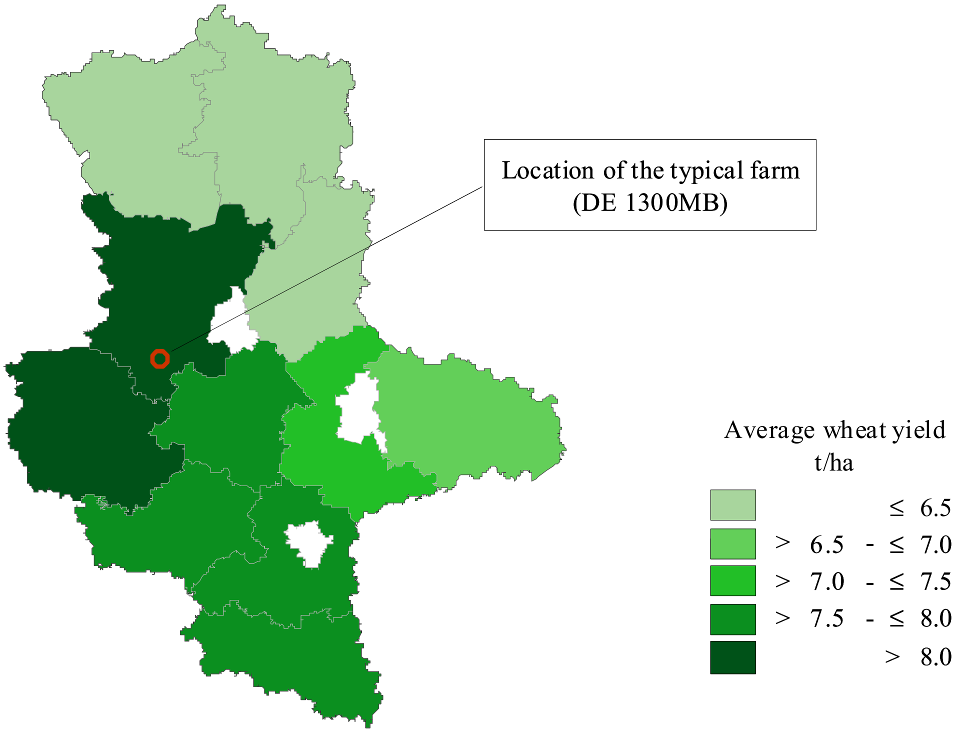
It is concluded, that cropping activity is spread into various smaller scaled containments which are not covered by state averages and perform unequal in terms of output and production risk, possibly due to natural conditions, which should be surveyed before focussing on the economics of production.

3.2.3 Selected regions and intensity levels of production

The following regions are selected for this study based on the findings about national production structures and first indications to define intensity levels:

In **Germany** the Magdeburger Börde[1] (Central German Dryland Region) in Saxony-Anhalt south west of the city of Magdeburg is selected. Figure 3.11 illustrates the yield levels realised in Saxony-Anhalt and the location of the typical farm.

Figure 3.11: Small scale wheat yields in Saxony-Anhalt and location of typical farm (Average 2006–2009)



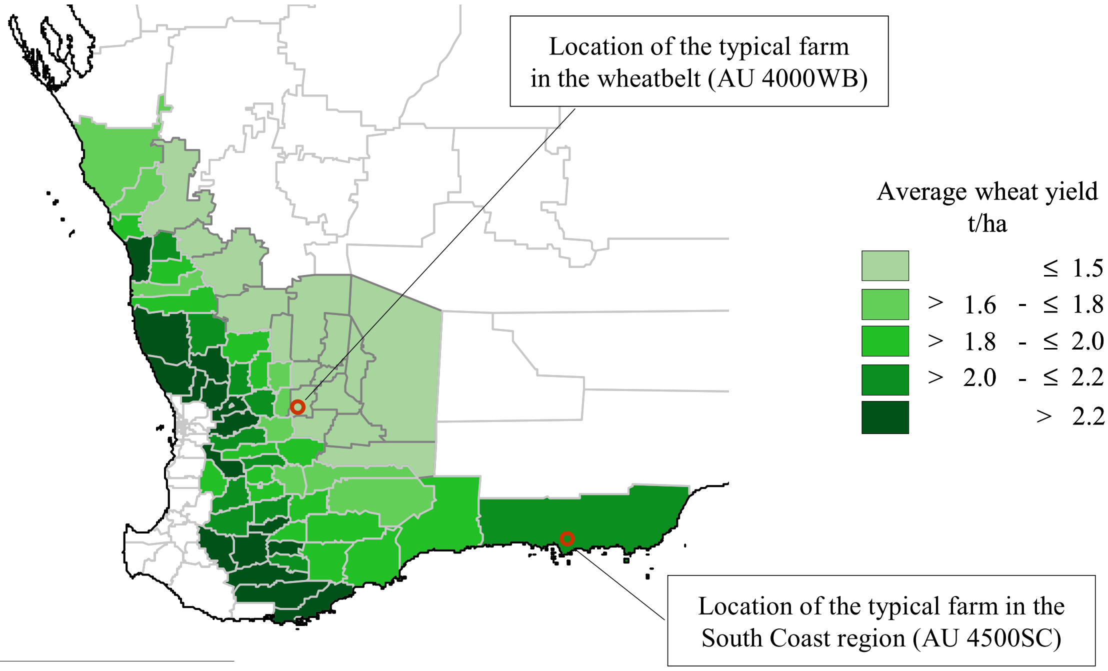
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3 (various years); own illustration.

– The **Magdeburger Börde:** very high intensity; specialised cash crop farms, high yield level, high fertiliser inputs and intensive or conservation tillage systems.

In **Western Australia** the **South Coast** region relating to the shire of Esperance and the **Wheatbelt** relating to the shire of Tammin, Kellerberrin and Merredin are selected. Figure 3.12 illustrates the yield levels realised in Western Australia and the location of the typical farms.

[1] Magdeburger Börde is a German toponym.

Figure 3.12: Small scale wheat yields in Western Australia and location of typical farms (Average 2004–2008)



Source: ABS (2010c); own illustration.

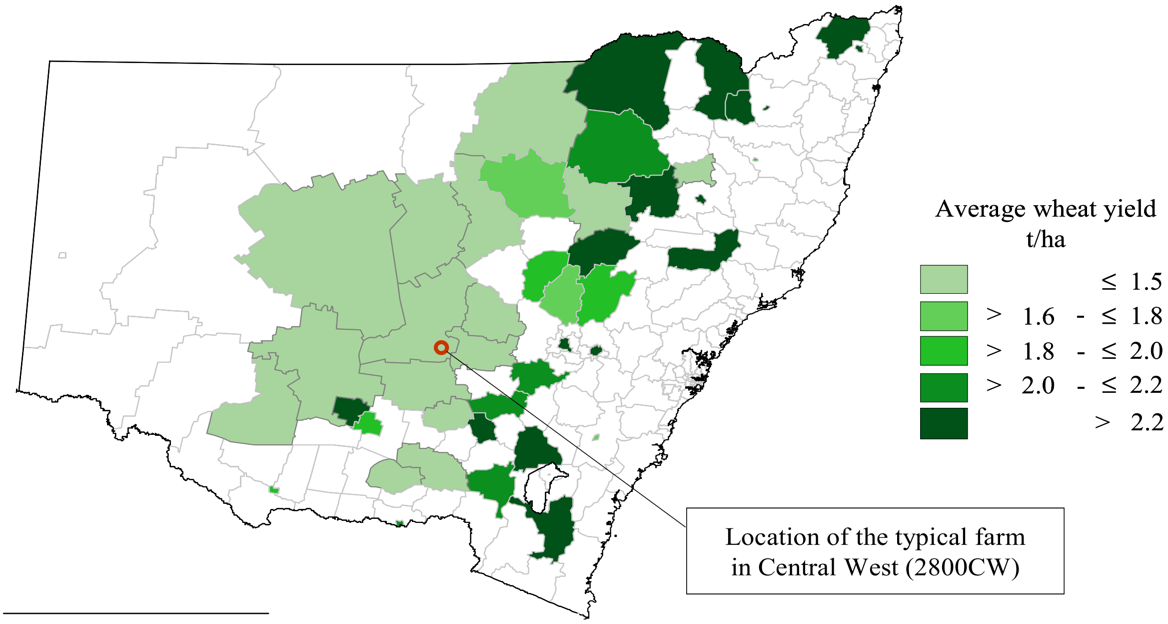
– The **South coast of Western Australia:** high intensity; specialised cash crop farms. Yield level and fertiliser inputs are above state average, moderate yield fluctuations and No-till production systems.

– The **West Australian Wheatbelt:** moderate intensity; mixed farming enterprises, moderate yield levels, high yield fluctuations, moderate fertiliser inputs and one pass seeding systems.

Figure 3.12 shows an extraction of Western Australia since crop production takes places only in the south west corner of the state. An impression about the regional dimensions of Western Australia is obtained by means of Figure A32 in the Appendix.

In New South Wales the Central West region relating to the shire of Condobolin, Forbes, Parkes and Wellington is selected. Figure 3.13 illustrates the yield levels realised in New South Wales and the location of the typical farm.

Figure 3.13: Small scale wheat yields in New South Wales and location of the typical farm (Average 2004–2008)

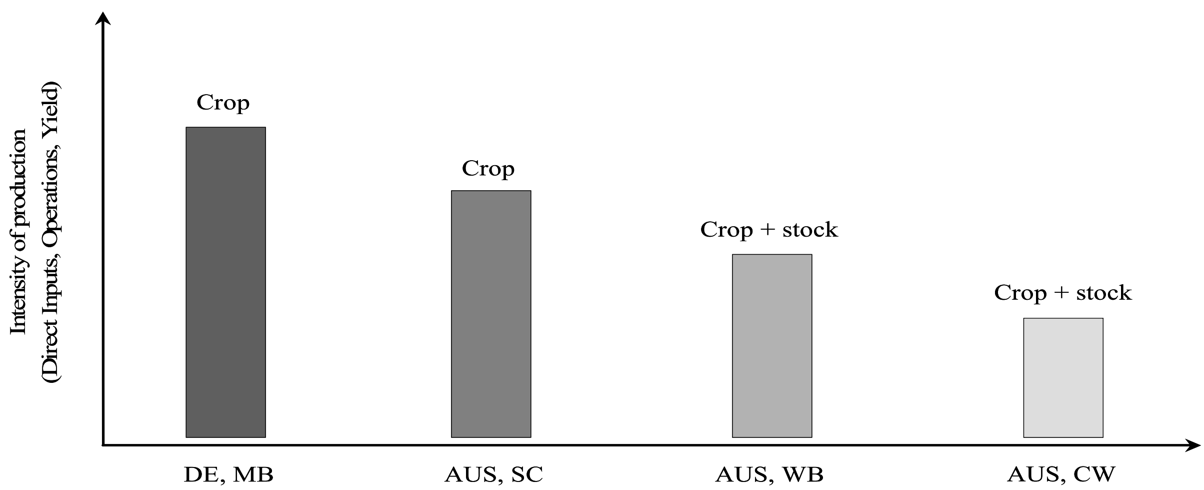


Source: Scott (2009); own illustration.

– **The Central West of NSW:** low intensity; mixed farming enterprises, low yield levels with extreme fluctuations, low to zero fertiliser inputs and partially unprogressive soil disturbing tillage systems in place.

To provide further insights about whether this selection satisfies the requirements of different intensity levels of production, further indicators for production intensity are elaborated with the discussion of the production systems in Chapter 4. The gradient of intensity which appears after the derivation of the investigation regions is presented in Figure 3.14.

Figure 3.14: Schematic illustration of the gradient of intensity realised with the selection of the investigation regions



The classifications and consulted indicators are a first attempt to generally assess production intensity for this thesis. Both do not comply with possible alternative definitions.

3.3 Natural conditions and limiting factors to production in the selected regions

The local natural conditions and production constraints are surveyed on a smaller scale to gain an understanding of differences. This would also reveal information on the environmental challenges farmers face in these regions and how production systems are potentially adjusted.

3.3.1 Soil and climate

3.3.1.1 Magdeburger Börde in Germany

The Magdeburger Börde is relatively flat and largely treeless. The underlying terrain mainly comprises of loose morainic material from the 'Saale glaciation' period with individual outcrops of older rock. This older bedrock and loose morainic debris is mostly obscured by a covering of wind-blown loess which later turned into a Black Soil layer.

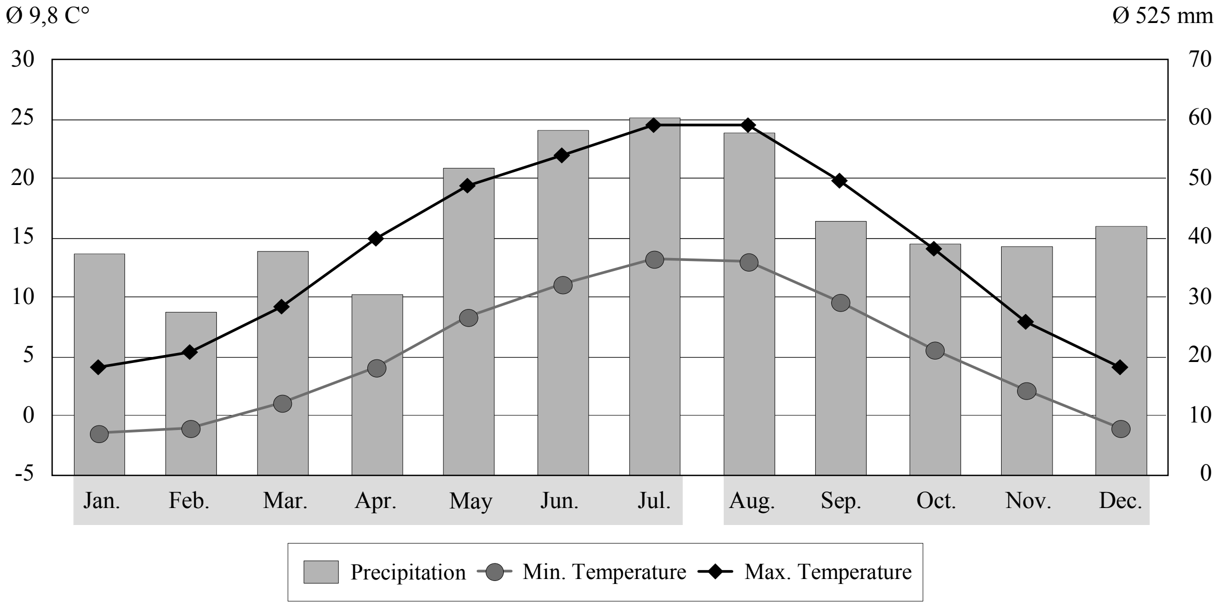
The Black Soil (Chernozem) is of advantage for crop production. It has a good water holding capacity for storing winter rainfall and warms up quickly after winter due to the dark colour and light surface texture. The land in the Magdeburger Börde was evaluated to be the richest soil in Germany and used as a benchmark for the general soil quality in the 1930's (SCHEFFER, 2002).

Figure 3.15 shows average weather data for Magdeburg from 1970 to 2009 with an average rainfall of 525 mm and an annual average temperature of 9.8° C.

Due to the location in the northern hemisphere winter is from December to February, summer is from June to August. Although there is reliable frost with occasional snowfall during winter, the majority of cereals and oilseeds are sown in late summer and autumn usually from August to October and rest during the winter (winter varieties).

Rainfall is unevenly distributed throughout the year and peaks in summer months. Spring precipitation is relatively small, which can lead to water shortages and can be a critical factor for cereal yields. This pre-summer aridity is characteristic for the Magdeburger Börde.

Figure 3.15: Climate chart Magdeburg weather station (1970–2009)



Note: Crops are in the field during labelled months.
Source: DWD (2010); own illustration.

Most winter rainfall can be stored and is available for crops after winter. Therefore the total annual rainfall is considered as growing season rainfall. This is important for comparing this location with Australian production regions. The growing season in the Magdeburger Börde differs from the calendar year. For comparison purposes in the following, the growing season is defined from August (seeding) until July in the following the year (harvesting).

3.3.1.2 South Coast of Western Australia

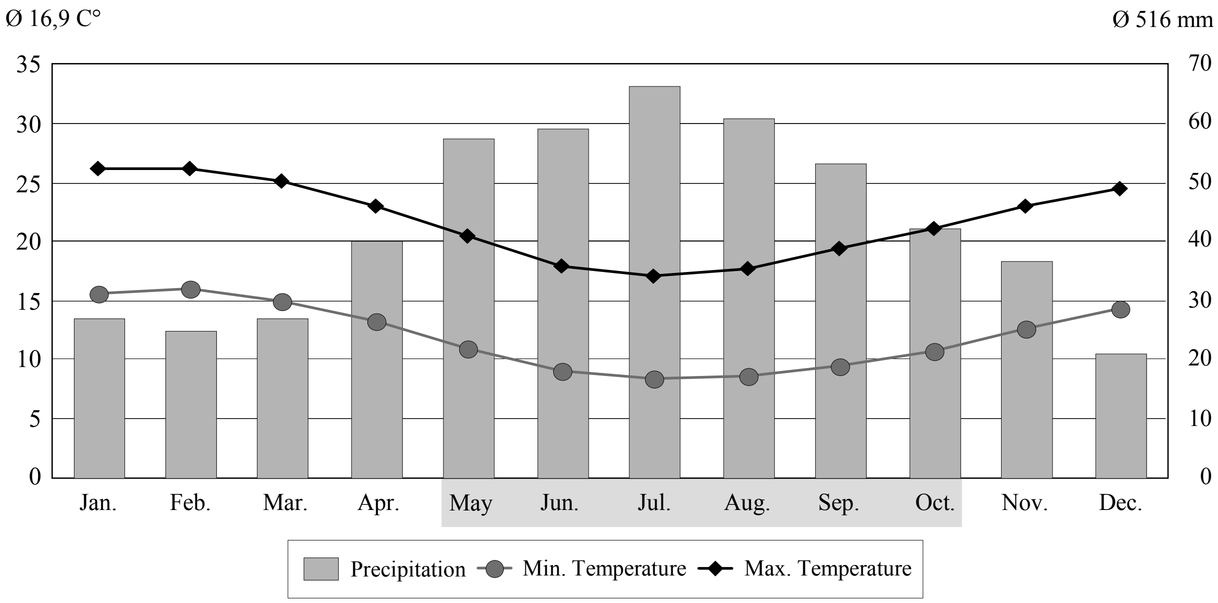
Western Australia is Australia’s largest state and occupies the western third of the Australian continent. The West Australian landmass was formed about three million years ago. The age of the landscape, the extreme geological stability and the absence of glaciations formed soils that are infertile, frequently laterised and generally quite saline (SCHEFFER, 2002).

The infertility of most of the soils has required heavy inputs of chemicals and fertilisers, particularly superphosphate. These artificial inputs have had a negative impact on invertebrates and bacterial populations. Heavy machinery and hoofed mammals compacted the fragile soils. Large areas of the state's “Wheatbelt region" have problems with dryland salinity and the loss of fresh water (SCHEFFER, 2002).

In Western Australia two regions were selected for research in this study: the South Coast region and the Wheatbelt east of Perth.

Figure 3.16 shows weather data for the Esperance Downs Research Station, approximately 30 km north of Esperance from 1970 to 2009. The station in the hinterland of the South Coast has an average rainfall of 516 mm and an annual average temperature of 16.9° C.

Figure 3.16: Climate chart Esperance Downs weather station (1970–2009)



Note: Crops are in the field during labelled months.
Source: BOM (2010); own illustration.

Due to the location in the southern hemisphere, winter is from June to September and summer is from December to March. In the selected region arable crops (summer varieties) are predominantly sown in autumn from April to May and harvested from late October till December.

Esperance has a mediterranean climate which is influenced by the Leeuwin Current in the Indian Ocean and Southern Ocean. Winters are generally in absence of frost or snowfall. Rainfall is unevenly distributed during the year and peaks in winter months. Summers are relatively hot and dry. The pre-summer finishing rain in September is critical for yield accumulation for all broadacre crops.

3.3.1.3 Wheatbelt of Western Australia

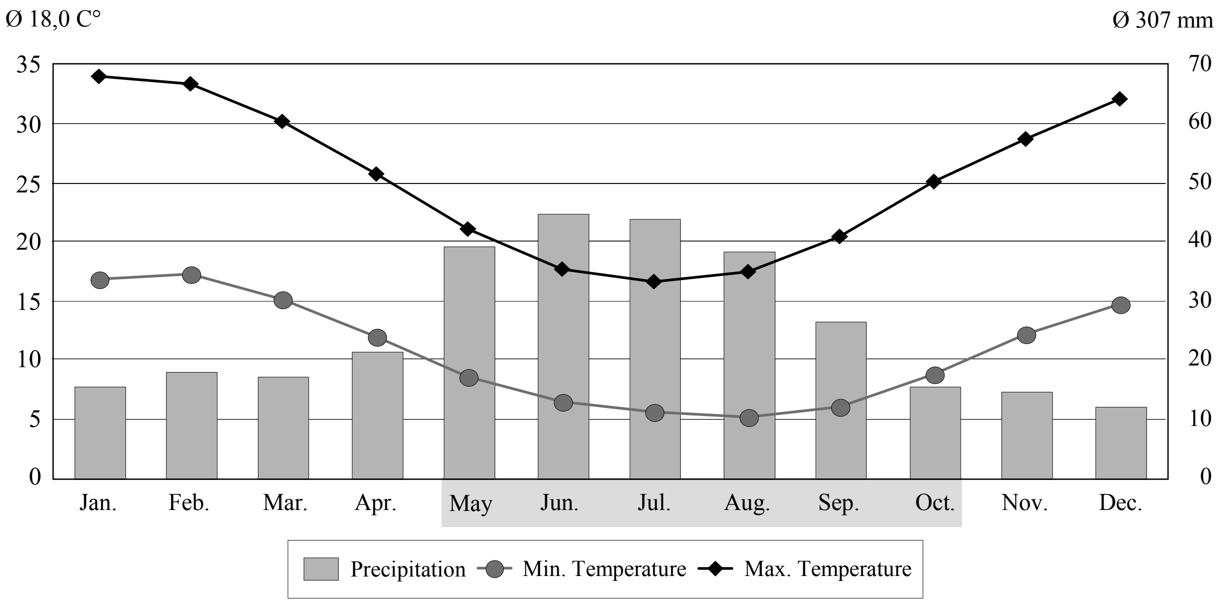
Salinity is a critical issue and a threat to agricultural production in all major production regions of Western Australia. However, it is most relevant in the Wheatbelt region.

In this study the Wheatbelt region and the typical farm are examples for soil degradation. During the early settlement periods after World War 1 and World War 2, the whole farmland has been used as arable land after the land has been cleared from native trees and bushes. The abrupt absence of deep rooting trees enabled the ground water to rise within the soil profile and this ground water has a high salt concentration. The movement of salt deposits to the upper part of the soil creates unsuitable conditions to grow the vast majority of crops currently farmed in Australia (EWING, 2010).

A large percentage of land which is out of production due to salinity is becoming constraint for whole farm performance and a thread for the sustainability of production techniques and productivity. A strategy to manage soil salinity is presented with the typical farm in the Wheatbelt (AU 4000WB) in Chapter 4.

Figure 3.17 shows the average weather data from 1970 to 2009 for Kellerberrin which is located in the Wheatbelt of WA approximately 500 km north east of Esperance and 200 km inland east from Perth. Annual rainfall averages 307 mm. Temperature averages 18.0° C. The total annual rainfall between the Esperance Downs Research Station and Kellerberrin differs by 200 mm.

Figure 3.17: Climate chart Kellerberrin weather station (1970–2009)



Note: Crops are in the field during labelled months.
Source: BOM (2010); own illustration.

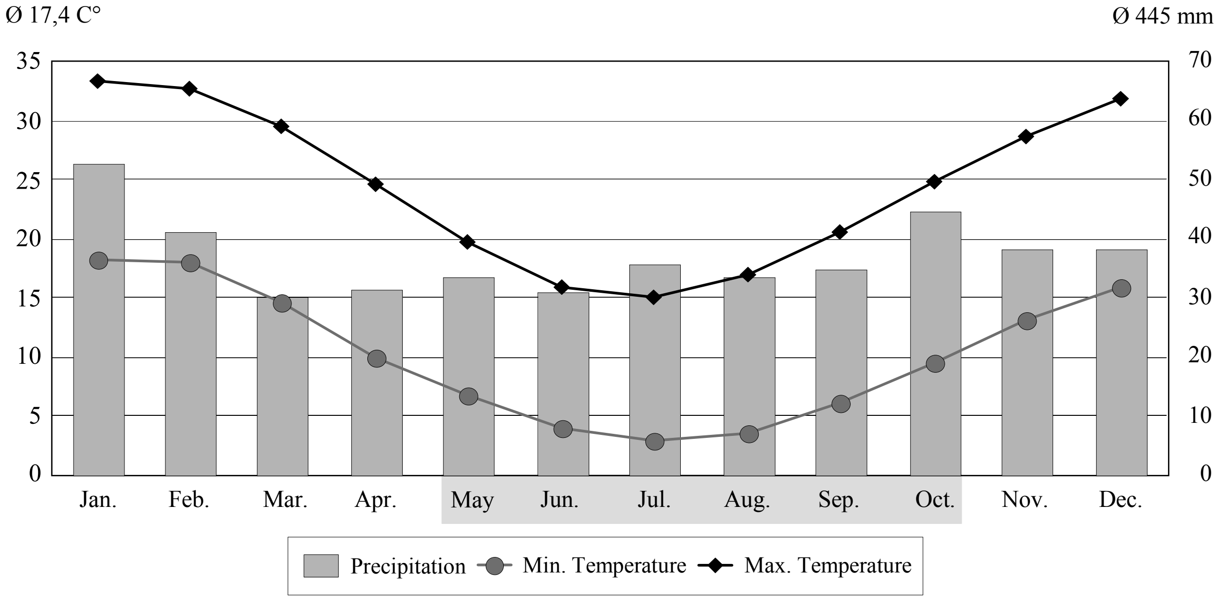
Yearly Rainfall is unevenly distributed with peaks in the winter months. From November to March evaporation usually exceeds rainfall and it is generally very dry.

Regular rainfall events in April which mark the start of the growing season (season break rainfall) and rainfall in September to finish the crops off are critical for the yield accumulation in the Wheatbelt region. Furthermore, frost has a negative affect on the crop performance. Broadacre crops such as wheat, peas, barley and canola are sensitive for frost damage during flowering in August and September.

3.3.1.4 Central West New South Wales, Australia

Figure 3.18 shows average weather data from 1970 to 2009 for Condobolin in the Central West region of New South Wales. The average annual rainfall is 445 mm and the annual average temperature is 174° C.

Figure 3.18: Climate chart for Condobolin weather station (1970–2009)



Note: Crops are in the field during labelled months.
Source: BOM (2010); own illustration.

The two Australian regions described earlier differ in temperature and rainfall compared to this location:

– Rainfall is summer dominated with peaks at the beginning of spring (October) and later in January and February.

– Low rainfall during the cropping period from May to October often cause drought conditions and crops fail which occurred in the last years.

- Minimum temperatures in June, July and August are well below 5° C which can be critical for crop performance as frost can damage crops during flowering.
- Summer rainfall distribution can evenly occur on a monthly basis, but usually summer rain falls concentrated in very few heavy rainfall events.

These weather patterns influence land use systems significantly. Rainfall from heavy rainfall events during summer is not beneficial for arable winter crop production. Farms in the Central West typically run a dominating share of pasture in their rotation to grow fodder for livestock during summer to utilize a certain share of the rainfall and to risk manage the cropping program. The summer in the investigation regions of Australia is not suitable for arable crop production since temperatures exceed crop's heat tolerance. The growing season reaches from April to October.

Only growing season rainfall (GSR) is available for plant growth, due to the low water holding capacity of soils in the selected Australian regions and high evaporation during summer months. The following section focuses on growing season rainfall compared to annual rainfall as it is common practice in Australia for comparing and evaluating the natural conditions.

3.3.2 Estimation of production uncertainty

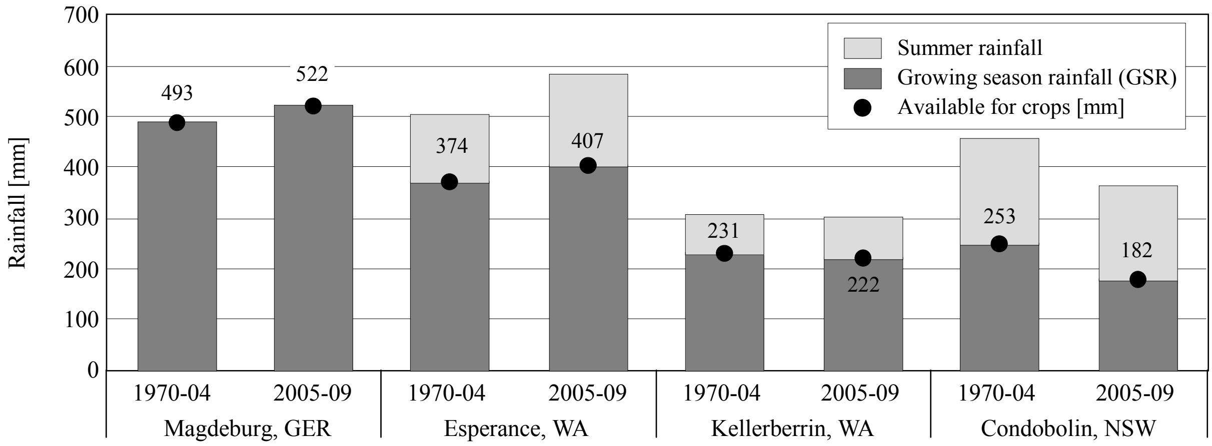
The most dominant natural production constraints are climate and soil conditions. In the previous sections rainfall and the thread of frost (Wheatbelt WA and parts of the Central West NSW) are identified as limiting climatic factors for production. Additionally soil conditions and nutrient availability seem to influence productivity.

This section will investigate these factors and provide a comparison of the different regions in terms of long term precipitation trends and an assessment of the rainfall situation over the past five years as well as results from recent soil investigations.

3.3.2.1 Precipitation trends

The following Figure 3.19 shows the precipitation pattern over the past forty years in the selected locations.

Figure 3.19: Rainfall trends for the selected regions in Germany and Australia from 1970–2009



Source: DWD (2010) & BOM (2010); own illustration.

The first column at each location marks the 35-year average rainfall from 1970 until 2004. The second column marks the five year average rainfall from 2005 until 2009 which coincides with the time period of this study. The dot refers to the actual available rainfall for crop growth (GSR) as defined in the previous chapter. The stacked bar shows the rainfall which is summer rainfall and not available for winter crops.

The average growing season rainfall in the last five years ranges from 522 mm per year in Magdeburg to 182 mm per year in Condobolin. When comparing the average annual figures from 1970–2004 and 2005–2009, several conclusions are drawn from the rainfall history.

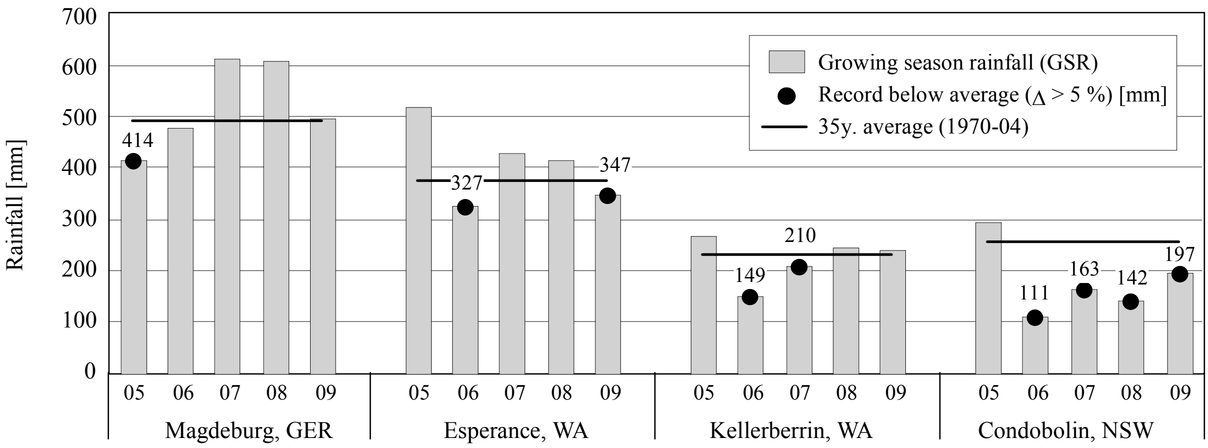
1. The growing season rainfall (GSR) in Magdeburg increased by 29 mm (+6 %) and this trend is supportive for crop production.
2. The GSR in Esperance increased by 33 mm (+9 %). This also includes an increase of the summer rainfall by 14 %. The growth in rainfall is expected to be positive for cropping operations.
3. The GSR in Kellerberrin (Wheatbelt) decreased marginal by 9 mm (-4 %) but the total annual rainfall remained the same. This indicates a shift to a summer dominated rainfall pattern.

4. For Condobolin the GSR decreased by 71 mm (-30 %). The summer rainfall also decreases but disproportionate to GSR by 20 mm (-10 %). These changes are severe. Serious drought conditions occurred during the growing seasons over the last years and indicate a shift to summer dominated rainfall.

For the analysis of different farming environments these findings are important, but additional information is required for the selected regions to interpret farm performance.

For a better understanding of the actual situation in the last five years (investigation period) and to assess the production uncertainty it is necessary to also take the annual rainfall over the last five years into account. In Figure 3.20 the GSR available for the respective harvest is compared with the 35-year rainfall average from 1970 to 2004.

Figure 3.20: Growing season rainfall from 2005–2009 and long term average rainfall



Source: DWD (2010) & BOM (2010); own illustration.

The dots represent the years (see bottom axle) when growing season rainfall deviated negatively more than 5 % from the average (line). These rainfall amounts represent dry conditions and have a negative impact on crop performance.

The comparison of the data shows remarkable results for the respective regions:

1. For the Magdeburger Börde only one dry season occurred in 2005 and two seasons with approximately 100 mm above average during 2007 and 2008.
2. The WA south coast region was affected by two dry seasons in 2006 and 2009 and one season in 2005 with more then 100 mm above average.
3. The WA Wheatbelt region suffered from two dry seasons in 2006 and 2007.
4. The cropping operations in the central west of NSW were hit hardest by drought conditions from 2006 to 2009. In 2006 the GSR was less than half the long term average and 2007 and 2008 it was less than 2/3 of the 35 year average rainfall.

3.3.2.2 Soil conditions

To address the principle resilience of soils for arable farming practices, soil samples are collected in the investigation regions and analysed. The analysis is carried out centrally by ENTSORGUNGSGESELLSCHAFT ELBE UMWELTLABOR GMBH (Magdeburg, Germany) to ensure harmonised methods. This section presents a selected indicator surveyed with recent soil-tests.

Soil pH is an expression of the degree of acidity or alkalinity of a soil. The soil pH is linked with many soil properties and is easily measured, which makes it one of the most important and most often available soil characteristics used to classify soils (SCHEFFER, 2002). Table 3.6 lists the pH-value of soils sampled in the selected regions.

Table 3.6: Soil reaction and classification sampled at the investigation regions

Country/state	Location (sample)	Acidity pH	Classification[1)]
DE/SA	Magdeburger Börde	6.3	slight
AU/WA	South Coast (heavy country)	5.1	moderate
AU/WA	South Coast (light country)	4.4	high
AU/WA	Wheatbelt (heavy country)	5.4	moderate
AU/WA	Wheatbelt (light country)	5.1	moderate
AU/NSW	Central West	5.7	moderate

Note: 1) According to Scheffer (2002).
Source: Own illustration.

Soil pH influences availability of plant nutrients significantly. Compared to neutral soils (pH 7.0) acid soils as prevailing at the selected regions to various extends are typically lower in nitrogen, phosphorus and magnesia available for plants. Furthermore, plants have a preferred soil pH for optimal vegetation and root development.

Since soil pH on some locations varies significantly from optimal values, production disadvantages and yield penalties have to be expected. On the other hand, soil pH can marginally be corrected with application of lime fertilisers. Although this is already practiced to a certain extend, liming is considered as an option for farm level adjustments intensification.

Further soil parameters of the investigation regions are found in Table A58 in the Appendix.

3.3.2.3 Summary

Germany and Australia are chosen for this study since both countries play an important role for global production and trade of agricultural commodities. The broad acre arable sectors of both countries grow similar crops like cereals and oilseeds and thus compete in the same world markets.

Beside this general endorsement, the selection of the countries and the selection of the regions within the countries discovered substantial differences in natural conditions relevant for crop production. Predominantly climate and soils vary between both countries and within these countries. These characteristics lead to distinctive regional production structures and intensity of land use systems which are key for the establishment of the typical farms and their detailed analysis in the following sections.

With the analysis of the environmental conditions and selected empirical values this perspective is extended and general production reliability of the regions can be assessed.

The farming systems in the investigation regions are prone to the following situations:

Magdeburger Börde: Generally favourable climate conditions with one out of five years with slightly below average rainfall of 525 mm. Average rainfall and average temperatures[2] tend to increase. Distinctive pre-summer aridity (April-June) as well as summer rain during harvest have negative impacts on yield and quality of combinable crops:[3]

– **Low production uncertainty**

South Coast WA: Climate conditions with two out of five years below average rainfall of 516 mm. Growing season rainfall (GSR) tends to increase, average temperatures remain constant. However, soil conditions are fragile with high acidity and additional expenses in fertiliser and soil improvement are expected:

– **Moderate production uncertainty**

Wheatbelt WA: Climate conditions with two out of five years below average rainfall of 307 mm and the additional risk of a major crop wipe-out by frost in one out of five years. Growing season rainfall tends to decrease and extreme temperature events (minimum and maximum) tend to decrease:

– **High production uncertainty**

---

[2] Respective analyses have been carried out however results are not explicitly displayed here due to the outline of this chapter.

[3] Combinable crops are gathered using a combine harvester. Combinable crops include all cereals, oilseeds and pulses.

Central West NSW: Drought conditions. Region receives below average rainfall of 445 for an extended period. In this case dramatic conditions prevailed in four out of five years. Furthermore, the distinctive evolution of reduced rainfall available for cropping is certifiable:

– **Extreme production uncertainty**

The production uncertainty evaluation is a first concept to support understanding and assessment of the typical farm situations. However, the use of these categories is limited and caution must be taken if applying to other regions.

4 Analysis and assessment of adaptation strategies for selected regions in Germany and Australia

4.1 Comparison and assessment of the initial configuration of typical farms

It is important to quantify the resources available for production to generate results about the farm level implications and the latitude of adaptation strategies at a later stage in this thesis. This is carried out in the following by focussing on the specification and performance of the production factors such as

– Land
– Labour and
– Capital fixed in tangible assets (machinery and buildings)

in addition to the previously outlined regional characteristics. The following Section is subdivided into five parts. Furthermore, the chapter is designed as a comparison of all four investigated typical farms to display the variation and approach differences in cost structures from various perspectives.

4.1.1 Farm and land

All farms used for this study are above the statistical average in size and economical performance and can thus be considered as top performing farms in the respective regions according to *agri benchmark* standards[1] (ZIMMER and DEBLITZ, 2005).

Table 4.1 includes an overview of the typical farms in the respective regions.

The typical farm in Germany is located in the western part of the state Saxony-Anhalt in the productive cropping region called Magdeburger Börde. The farm DE 1300MB is a cash crop enterprise with 1,300 ha in total area and gross revenue of 1,953,000 €/year. Due to the location within the administrative and economic framework of the EU, the gross revenue of the farm includes subsidy payments. These direct payments are contributing approximately 20 % to the gross revenue.[2]

---

1 Cp. Sections 2.2 and 2.4.

2 Cp. Table 4.3.

Table 4.1: Overview of the typical farms in Germany and Australia (Average 2005–2009)

		DE 1300MB	AU 4500SC	AU 4000WB	AU 2800CW
Country		Germany	Australia	Australia	Australia
State		Saxony-Anhalt	Western Australia	Western Australia	New South Wales
Region		**M**agdeburger **B**örde	**S**outh **C**oast Esperance	**W**heat**b**elt Tammin	**C**entral **W**est Condobolin
Farm size	ha	1300	4500	4000	2800
Farm type		Cash crop	Cash crop	Cash crop/sheep	Cash crop/sheep
Gross revenue	EUR	1,953,000	1,780,000	956,000	375,000
Market revenue crops	%	79	100	94	63

Source: Own calculation.

The typical farm on the South Coast of Western Australia is a 4,500 ha cash crop enterprise which averaged 1,780,000 € gross revenue per year during the time period of this study. Due to the absence of any subsidy payments or governmental protection in Australia, the gross revenue of this and of the other Australian farms is generated completely by market performance.

The typical farm in the Wheatbelt of Western Australia is a 4,000 ha mixed farming enterprise with cash crop and sheep production. This farm focuses is on the cropping program as it generates a considerable high share of 94 % in gross revenue of 956,000 €/year.

The fourth farm in this comparison is the typical farm in the Central West region of New South Wales. Its sources of income are cash crops and livestock (sheep production). The livestock enterprise has a greater influence (37 %) on the gross revenue (375,000 €/year) compared to the previous farm because the land suitable for cropping and the cropping intensity in this area are quite marginal,

The given land resources are used differently and the share of arable land differs substantially between the typical farms (Table 4.2).

Table 4.2: Land resources of typical farms in Germany and Australia (Average 2005–2009)

		DE 1300MB	AU 4500SC	AU 4000WB	AU 2800CW
Farm size	ha	1,300	4,500	4,000	2,800
Arable land[1)]	ha	1,250	4,200	3,600	2,100
Permanent pasture	ha	25	50	300	650
Other land	ha	25	250	100	50
Relief		flat	coastal	flat	undulating
Soil type		Chernozem Black Soil	Sand and clay over gravel	Sandplain, loam and heavy clay	Heavy clay, sandy loam
Arable land	%	96	93	90	75

Note: 1) Incl. rotational pasture.
Source: Own calculation.

Arable land

In the Magdeburger Börde and in Western Australia the share of arable land is 90 % and above which is considerably higher compared to the other region.

The arable land is predominantly used for growing cash crops on all farms with the exception of the two mixed farm enterprises. The latter ones have dedicated a certain share of the arable land to the livestock production additionally to the permanent pasture which rotates within the cropping program:

– 410 ha rotational pasture on AU 4000WB
– 1,200 ha rotational pasture on AU 2800CW

Only this rotational pasture is considered to be available for cropping when investigating the potential of expanding the cropping acreage as a strategy corresponding with rising prices to improve the profitability of the cropping enterprise.

Permanent pasture

The permanent pasture is commonly covered with perennial grasses and not suitable for cropping. Due to landscape characteristics such as soil type, hills or steep slopes, structure elements or too small scales the typical farm AU 2800CW in the Central West region of NSW has got a large share of permanent pasture.

Other land

The other land includes all remaining areas of the farm which are not suitable for any production. Such land can be occupied with farmyards, buildings, roads, limeways and airstrips. This share is in particular high on farm AU 4500SC due to the location in the coastal area which dominated by native bush, river beds and other coastal land.

On the typical farm in the West Australian Wheatbelt (AU 4000WB) approximately 500 ha of the farm are affected by some form of soil salinity:

– On this farm 100 ha are lightly salt affected which are suitable for cropping preferably with salt tolerant crops such as barley (included with *arable land* in Table 4.2)
– Further 300 ha are moderately salt affected. This land is suitable for grazing with salt tolerant perennial grass varieties or bushes such as Oldman saltbush (*Atriplex nummularia*) or Small-leaf bluebush (*Maireana brevifolia*). This land is included with *grassland* in Table 4.2.
– Another 100 ha are heavily salt affected. This land is often lower in the profile and entirely lost for any kind of production. (accounted to *other land* in Table 4.2)

Land cost

Land cost and land value are determined by land markets, the competitiveness of land use systems and their economic productivity. Markets can be disturbed by political interventions or subsidies under legal administrative frameworks and have an influence on the farm. Table 4.3 lists land cost, subsidies and ownership structures of land utilised by the typical farms.

Table 4.3: Land ownership, land cost and subsidies of typical farms in Germany and Australia (Average 2005–2009)

		DE 1300MB	AU 4500SC	AU 4000WB	AU 2800CW
Arable land	ha	1,250	4,200	3,600	2,100
Arable land owned	ha	500	3,150	3,340	2,000
Share of own land	%	40	75	93	95
Land rent	EUR/ha	345	60	60	46
Direct payments	EUR/ha	337	--	--	--
Net land cost	EUR/ha	8	60	60	46
Purchase price arable land	EUR/ha	13,000	1,300	1,200	1,500
Total land asset value	EUR	6,500,000	4,095,000	4,008,000	3,000,000
Equity fixed assets	%	50	78	75	65

Source: Own calculation.

The German typical farm has the lowest share of owned land with 500 ha out of the 1,250 ha arable land (40 %). This share is above the local average and the farmers in the panel considered it to be ambitious but realistic for top managed farms of this ownership structure in the region. However, land ownership varies between different farm types in eastern Germany. Other types of farms such as successors of former state owned farms tend to have much lower shares in landownership.

The majority of the land is leased from individual landowners whose ownership may contain from 0.1 ha up to several hundred hectares. Thus, the farm has to deal with several lease agreements. The basis for these lease agreements are contracts which are typically negotiated for 5 up to 12 years. Maintaining a good relationship to landowners is very important to secure the land configuration of the farm and takes up a decent share of the management capacity (KÜNZEL, 2010).

The German typical farm DE 1300MB is entitled to receive decoupled direct payments according to the EU Common Agricultural Policy Scheme (CAP). This annual payment amounts to 337 €/ha.

In Australia, the farms typically have a relatively high share of owned land. The span in this comparison is between 75 % on the South Coast of WA and 95 % in Central West NSW. In Australia there is not a big market for agricultural land to lease as farm development in most cases is carried out by purchasing land.

The different structure of land ownership requires analysing the land cost in more detail. As discussed in section 2.3.3.3 the calculated land cost consists of two cost compartments:

1. The **cash costs** which covers rent payments to off-farm landowners.
2. The **opportunity costs** covering a calculative compensation for owned land.

As indicated by the ownership structure a major part of land cost in Germany consists of cash cost whereas land cost for the Australian typical farms are dominated by opportunity cost.

4.1.2 Labour

The labour configurations of the typical farms differ from each other. To understand the constraints in labour cost and management, a brief overview of the different resources will be given before having a closer look at organisational characteristics.

The following approach is underlying for the analysis of labour cost:[3]

– Off-farm labour (hired labour) is calculated gross including insurance, tax and superannuation as originated on farm. Hired labour costs are cash cost.
– Family labour (predominantly the farm management) are calculated based on customary wage level (1) the family member would receive by working full time off farm according to capability. If this estimate is not feasible e.g. due to restricted off-farm job opportunities, the customary wage level (2) an off-farm manager would receive to run this type of farm is considered. Family labour costs are opportunity cost.

The **German typical farm DE 1300MB** is operated by by six people. The team consist of the farm manager, four full time general workers and a casual worker.

– The farm manager (family member) is performing 1,800 h/year on an income level of 50,000 €/year. His main duties are (1) organising the production process (2) land management and (3) administration of the farm according to external regulations. The farm manager is rarely involved in operating machinery. This is carried out by the other staff members.
– The four full time general workers (hired labour) are carrying out 2,000 h/year on an average yearly income of 34,000 € each.
– The casual worker (hired labour) usually backs up during the peak times from July to October. He typically performs 1,500 h on a yearly income of 19,000 EUR.

The **West Australian typical farm AU 4500SC on the South Coast** is operated with four people.

– The farm manager (family member) is working 2,000 h full time over the year on a wage level of 61,200 EUR. The farm manager is typically involved in the production and carries out logistics during seeding season (seed and fertiliser to seeding units) and harvesting (transport of grain from field to local delivery point). Due to the strong seasonality most other management tasks can be shifted to the off-season.
– The machines are typically operated and maintained by one full time operator (hired labour) working 2,000 h on a yearly wage level of 30,600 EUR. When working together with the casual workers, the full timer also takes over management tasks within the field work process.
– During the harvest and seeding season the farm hires two additional off-farm workers (hired labour) solely to operate machinery. They are typically performing 600 h each on a total of 9,800 €/year. It became more common to source these workers from New

[3] Cp. Section 2.4.2.3.

Zealand, North America or Europe since the local labour market cannot cope with the demand for highly skilled operators. On top of the payment casuals typically enjoy a package of free accommodation, food supplies and vehicle during the season.

The labour resources of the **West Australian typical farm AU 4000WB in the Wheatbelt** are very similar to the previous one. They contain of

– The farm manager (family labour) performing 2,000 h at 61,200 € yearly. Additional to the involvement mentioned above, the manager oversees the livestock program.

– One full time worker (hired labour) performing 2,000 h at 34,000 € yearly.

– One casual worker (hired labour) performing 600 h at 9,800 € yearly.

The **typical farm AU 2800CW in New South Wales** is more family labour oriented than the previous ones.

– The business is typically run by father and son or two brothers. One of them is full time on farm performing 2,000 h at 31,000 € annually while the other one performs 1100 h/a at 17,000 €/a respectively. It is common that they split their capacity into cropping and livestock.

– The business sources some extra labour capacity from one casual worker during the peak season from October to January. The casual worker typically performs 750 h at 11,500 € yearly.

The description of the labour resources indicates differences in two key aspects. They refer to (1) the physical labour input and (2) the monetary labour input (labour cost) and are thus analysed further in the following paragraphs.

Physical labour input

To describe and compare physical labour input the labour intensity can be used as an indicator. Therefore full labour units (2,000 h/year) are calculated against the farm land per 100 ha. The respective indicators can be found in Table 4.4.

Table 4.4: Physical labour input of typical farms in Germany and Australia (Average 2005–2009)

		DE 1300MB	AU 4500SC	AU 4000WB	AU 2800CW
Labour quantity		6	4	3	3
Labour input per year	h/a	11,300	5,200	4,600	3,500
Labour input per ha	h/ha	8.69	1.16	1.15	1.25
Labour intensity *	1/100ha	0.43	0.06	0.06	0.06

* Labour intensity = fulltime labour unit (2000h/year) per 100 ha farm land.

Source: Own calculation.

- The **German** typical farm DE 1300MB achieves 0.43 labour units per 100 ha. This is by far the highest labour density in this comparison but relatively low compared to the local average. A total of 11,300 h/year including operation and management are applied to the production system resulting in 8.69 h/ha.
- The labour intensity on the **Australian** farms amounts to 0.06 to 0.08 labour units per 100 ha and thus refers to a little more than one tenth of the European figure. The total labour input is less than half of the previous one and varies from 4,600 h to 5,200 h/year. The very low labour input on the two West Australian farms of 1.15 h and 1.16 h/ha is primarily owed to the appliance of No-Till technology in combination with large machinery capacity.
- It may surprise, that in the case of AU 2800CW the consecutive labour input per hectare differs from expectations. The total labour input of 1.25 h/ha on the typical farm in Central West NSW does not coincide with the expected marginal intensity. According to the panel, a significant share of tillage in the production system for wheat and the decent livestock enterprise which is considerably labour intensive.
- On a per hectare base the gap between the labour input of the investigated farms is relatively wide. The labour input of the German farm compared to the Australian farms is factored by 7.

Concluding from this, the different labour input configurations of the typical farms correlate to (1) labour demand of the production system according to the degree of mechanisation (2) the level of production intensity and (3) requirements to staff management and operational planning. The high labour input of the German is explained with key operations to be carried out during a relative short time period (e.g. harvesting, grain storage, knock down sprays, tillage and seeding during August). This concentration of fieldwork passes is rather typical for intensive European production system and leads to higher workforce. Since seeding and Harvesting does not periodically overlap in the selected Australian regions, key machines must not be operated simultaneously which is an advantage for the hired labour preposition of Australian farms. Hence, the physical labour input is an indicator for the effectiveness of production and should be kept in mind when discussing farm development at a later stage in this thesis.

Monetary labour input

The monetary labour input of the typical farms is characterised in Table 4.5.

Table 4.5: Monetary labour input of typical farms in Germany and Australia (Average 2005–2009)

		DE 1300MB	AU 4500SC	AU 4000WB	AU 2800CW
Labour cost per year	EUR/a	205,200	110,200	104,100	53,300
Labour cost per ha	EUR/ha	158	24	26	19
Labour cost structure (Ratio hired vs family)	%	76	44	41	12
Weighted av. labour cost *	EUR/h	18	21	23	15

* Weighted average labour cost [EUR/h] = Total labour cost (hired & family labour)/total labour input per year.
Source: Own calculation.

From this comparison the following observations can be made:

– The total labour costs of the German typical farm add up to 205,000 EUR. This accounts to approx. 10 % of the gross revenue of the farm[4]. Further, a share of 75 % of the labour cost are cash cost for hired labour. Thus labor costs are of significant importance for the cash management of the farm and it indicates that labour costs are one of the main drivers within the cost structure.

– The **Australian** farms implement total labour cost between 53,300 € and 110,200 €/year respectively. That accounts to 6 % of the gross revenue on AU 4500SC, 10 % on AU 4000WB and 14 % of AU 2800CW. This also indicates the importance of labour cost. However, the role for the cash management can be compensated by the relatively small cash compartment (44 and 41 % in WA respectively and rarely 16 % in Central West NSW).

– By analysing the labour cost per hectare it can be shown that the German farm realises labour cost of 158 €/ha compared to relatively uniform labour cost of 19 € to 26 €/ha on the Australian farms. Thus, the gap between the farms narrows but still factors 6.

This shift is caused by a different wage level in the investigated regions. As an indicator for the wage level the weighted average labour cost per hour[5] can be used with regard to

[4] Please refer to Table 4.1.

[5] Weighted average labour cost per hour= Total labour cost (hired & family labour) divided by total labour input per year.

the cash/opportunity cost approach used in this thesis. In this comparison the weighted average labour costs cover a span from 15 € to 23 €/hour as to be found in Table 4.5.

The nature of the wage level has (1) an internal dimension for the competitiveness of the production system as outlined above and (2) an external dimension for the farms to approach on the domestic or international labour market. A few observations to promote the later dimension can be made when comparing farming and agricultural jobs within their respective economic framework:

– The higher wages in WA indicate the tough situation on the domestic labour market. The competitor for agricultural labour is the mining sector in particular as their requirements are very similar. Thus it wasn't a big surprise that the mining industry has soaked a large number of farm labourers in rural areas during their bullish period.
– An intermediate average labour cost is accounted for the position of farm occupation on local labour market in the region analysed in Germany. The number of agricultural jobs is (1) of less significance for the overall labour appearance but (2) due to the high degree of mechanisation and locality quite attractive compared to relevant competitors e.g. the logistic sector. Furthermore there is still a prevailing overhang of skilled labour at this stage.
– The relatively low wage level in NSW must rather be seen in conjunction with the general farm performance and the unfavourable environmental conditions in the last years then with the off-farm labour situation. The respective panel in the Central West considered their income (family member's opportunity cost) to only 50 % of their Western Australian colleagues. However, this can only be due to a short term period of economic hardship on farms in the central west. In the long run the wage level is expected to equal with the West Australian level.

After analysing the labour situation of the typical farms in monetary terms the following tentative conclusions can be drawn, to be kept in mind when discussing adaptation strategies at a later stage in this thesis.

The Australian farmers have a comparative advantage of their labour situation in terms of (1) labour management as the production system does require reasonable lower labour input and (2) cash management as a minor share of the labour costs are cash.

Further, the low ratio of cash cost versus opportunity cost in important cost compartments like labour cost can also be seen as a risk management strategy to cope with low cash flow situations which may occur in coherence with yield or price failure. In that regard the German farm might have a structural disadvantage.

Disregarding the actual wage level and demand of labour it is an important outcome in all investigated regions that the availability of skilled labour is crucial for the further farm development. In particular against the background of raising energy prices, which is a basic assumption for this thesis, Australian farmers suspect a growing demand for labour from the primary industry sector.

4.1.3 Machinery, key operations and production management

This section has the prime objective to provide an overview over the configuration and characteristic operation modes of the machines used on the typical farms. This is important as the machinery configuration may be subject to change in the context of this investigation.

Furthermore, the operation of machinery is a key expense in the production program. This is linked to the amount of fixed capital (depreciation and finance), repairs and maintenance as well as the input of energy. These cost positions differ according to the mechanisation strategy and have a significant influence on the cost structure (ISERMEYER, 1981).

Thus, the chapter has the second objective to analyse and assess the constraints for implementation of agricultural equipment, machinery cost and risk management strategies in the investigation regions.

The following structure is used to classify the machines:

1. **Tractors** – all machines to tow and hitch various equipment but are not purpose built. Tractors are commonly used as towing units.
2. **Towed machinery** – equipment without own engine which is towed behind or driven by tractors
3. **Self-propelled machinery** – purpose built machines with own engine not to be used in combination with a towing unit.

Certainly a complete description of the entire machinery inventory of each typical farm would go beyond the focus of this thesis. Having that in mind the following paragraphs are highlighting only the machines used for key operations and crucial figures for the calculation of cost of production to provide the necessary information for the understanding of the production systems. A complete description of the machinery list of the equipment and depreciation details can be found in Tables A2–A5 in the Appendix.

4.1.3.1 Tractors

The **German typical Farm DE 1300MB** operates three tractors as shown in Table 4.6.

Table 4.6: Tractor inventory DE 1300MB (Average 2005–2009)

Tractor type		Front-wheel-assist	Front-wheel-assist	Front-wheel-assist
Engine power	hp	360	240	185
Utilisation	h/year	700	900	950
Depreciation period	year(s)	6	12	10
Machinery cost (fix) *	EUR/h	28	16	13

* Total depreciation, finance, repairs & maintenance per utilised hour.
Source: Own calculation.

The front-wheel-assist tractor with 360 hp carries out the majority of the tillage program with two different tillage units. Thus it is typically operated in 24 h-shifts from beginning of August (after harvest) thru to late October (cultivating land for sugar beet seeding in spring). In the off season it is used for farm logistics e.g. fertiliser and grain transport.

The second front-wheel-assist tractor with 240 hp carries out the seeding program of all combinable crops from August till October, seedbed preparation for sugarbeet in March/April and fertiliser spreading in spring. This tractor is typically traded in every twelve years in combination with the seeding equipment.

The third tractor is a smaller standard front-wheel-assist tractor with 185 hp engine power. It is typically used for plant protection passes during the whole growing season, grain transport during the harvest and sugarbeet seeding.

The tractor inventory of the **West Australian typical farm AU 4500SC on the South Coast** is found in Table 4.7.

Table 4.7: Tractor inventory AU 4500SC (Average 2005–2009)

Tractor type		Four-wheel-drive/tracks	Front-wheel-assist
Engine power	hp	330	220
Utilisation	h/year	550	370
Depreciation period	year(s)	5	5
Machinery cost (fix) *	EUR/h	65	77

* Total depreciation, finance, repairs & maintenance per utilised hour.
Source: Own calculation.

The main tractor with 330 hp can either be four-wheel-drive or on caterpillar tracks. This tractor carries out the seeding program from April to May and tows the chaser bin during harvest. Due to the timely restrictions of the operations the utilisation is 550 h per year considering 24 h operations on seven days a week.

The second tractor on farm is a 220 hp standard front-wheel-assist tractor. This machine is used for fertiliser spreading and occasionally towing the chaser bin during harvest. It may surprise that the annual utilisation is just 370 h per year but this is due to the fact that a self-propelled boomspray is commonly used for the plant protection program in this region.

Both machines are traded before their total operating performance has been reached in order to prevent high repair cost and receive a reasonable salvage value.

The towing units on the **West Australian typical farm AU 4000WB in the Wheatbelt** may seem to be identical to the previous one. However they are fitting into slightly different requirements (Table 4.8).

Table 4.8: Tractor inventory AU 4000WB (Average 2005–2009)

Tractor type		Four-wheel-drive	Front-wheel-assist
Engine power	hp	400	200
Utilisation	h/year	300	960
Depreciation period	year(s)	10	10
Machinery cost (fix)*	EUR/h	119	22

* Total depreciation, finance, repairs & maintenance per utilised hour.
Source: Own calculation.

The larger tractor is commonly a 400 hp front-wheel-assist tractor. By choosing this machine the intention is to have the largest tractor-seeder unit available with the highest performance due to the short seeding window between April and May and the yield penalty occurring with late seeding. Thus, this tractor performs only 300 h/year despite running 24 h at seven days a week during this time.

The smaller tractor is predominantly used for the plant protection program towing the boomspray as this farm does not operate a self-propelled sprayer. Consequently the annual utilisation amounts to 960 h.

The mechanisation of the **typical farm AU 2800CW in New South Wales** is reflecting the tough economical situation of the farm in the previous years. Only essential investments in machinery are made primarily in used machines such as the two key towing units as listed in Table 4.9.

Table 4.9: Tractor inventory AU 2800CW (Average 2005–2009)

Tractor type		Four-wheel-drive	Front-wheel-assist + loader
Engine power	hp	350	120
Utilisation	h/year	200	300
Depreciation period	year(s)	15	15
Machinery cost (fix)*	EUR/h	97	32

* Total depreciation, finance, repairs & maintenance per utilised hour.
Source: Own calculation.

The four-wheel-drive tractor is carrying out the seeding and the tillage program on the dedicated arable land. Since these operations claim for 200 h per year the machine can be depreciated for a longer period than on the previous farms.

The second tractor on the farm is a 120 hp unit front-wheel-assist and typically equipped with a front-end loader. Beside the relatively low plant protection operations this machine is used to carry out logistics for the livestock enterprise. The hourly output per year amounts to 200 h. Consequently it can also be used for a longer period of 15 years.

Given these information on tractor utilisation and depreciation the following Table 4.10 provides a comparison of the analysed typical farms.

Table 4.10: Tractor configuration of typical farms in Germany and Australia (Average 2005–2009)

		DE 1300MB	AU 4500SC	AU 4000WB	AU 2800CW
Tractor density	hp/ha	60	12	15	17
Total hours per year	h	2,550	920	1,260	500
Total hours per ha	h/ha	1.96	0.20	0.32	0.18

Source: Own calculation.

Independently from the farm organisation there seems to be a comparative advantage of tractor prices in Germany. On a per horsepower basis the German farm realises 200 € less purchase price compared to the Australian typical farms. It can be assumed that this is caused by market and logistical disadvantages since Australia imports the majority of agricultural machinery.

The tractor configuration of the German farm results in 60 hp/ha whereas this is a straight and competitive typical farm situation compared to the average in the Magdeburger Börde and abroad. On the Australian farms the towing capacity is significantly less high compared to the previous one. The density varies between 12 and 17 hp/ha which indicates very low machinery and towing capacity input to the production.

4.1.3.2 Towed machinery

The following chapter applies to the key units of the towed machinery setting of the typical farms. Since towed machines are most commonly used to carry out tillage or seeding processes which determines the characteristic of the production system it is worthwhile having a closer look at the operating mode to understand the status quo in production technology and to define possible further developments with regard to this thesis.

By means of the tillage equipment and their operation mode, tillage systems can be classified as displayed in the following Figure 4.1.

Figure 4.1: General classification of tillage systems and placement of typical farms in Germany and Australia

Tillage System	Criteria	Intensity	Example
One-Pass-Seeding	Seeding into undisturbed ground with…	low	
Zero-Till	… with disc openers for 'minimal' soil disturbance		AU 4500SC
No-Till	… with narrow point openers for 'reduced' soil disturbance		AU 2800CW
Direct Drill	… sweeps for full soil disturbance		AU 4000WB
Minimum Tillage	A full disturbance cultivation before sowing		AU 2800CW
Conservation Tillage	Reduced stubble breaking and/or soil cultivation, prevailling mulch seed, only occasionally ploughing		DE 1300MB
Intensive Tillage	Deep, most upturning soil cultivation (plough), intensive soil preparation pre-seed with partially active driven soil preparation equipment	high	not included in this comparison

Source: Desbiolles (2008), Zimmer and Nehring (2008), own illustration.

The **German typical Farm DE 1300MB** adopts **conservation tillage** which has been introduced to the typical farm about ten years ago. Displacing the plough as the traditional tillage technology brought several organisational benefits which are discussed in more detail in Section 4.2.1.

The machines presented in Table 4.11 are forming the core part of the conservation tillage strategy.

Table 4.11: Tillage equipment DE 1300MB (Average 2005–2009)

Type of machine		Disc harrow	Field cultivator	Seeding combination
Working width	m	8	6	6
Utilisation	ha/year	1,240	950	1,150
Depreciation period	year(s)	15	7	7
Machinery cost (fix) *	EUR/ha	3	12	13

* Total depreciation, finance, repairs & maintenance per utilised hectare.
Source: Own calculation.

Shallow stubble tillage is carried out with a disc harrow. This machine is most commonly equipped with two rows of discs (diameter of approximately 25 cm) mounted with a slight angle to the driving direction followed by a heavy roller. The purpose of this machine is to break the surface structure to a maximum of 5 cm to reduce evaporation and cover and compress weed seeds and losses with a soil layer to trigger emergence. It is operated typically but not necessarily with the large tractor immediately after harvest of combinable crops.

The second tillage machine is a heavy field cultivator. Main elements are tines fitted with soil working tools in different sizes and a roller. Commonly shallow tillage (8–15 cm) is carried out with tools cutting thru the soil horizontally to prevent ascending water by destroying the capillarity structure and to interfuse crop residues with soil to trigger decomposing of the organic material. Further deep tillage (20–25 cm) is carried out with soil loosening tools to prepare the root zone for the following crop. Especially the performance of rapeseed, sugarbeet and wheat after wheat depends on good conditions for root development. The field cultivator is towed by the large 360 hp tractor.

The seeding unit is a 6 m pneumatic disc system towed behind the 240 hp tractor. It carries out the seeding of all combinable crops (cereals and rapeseed) in autumn. It is fitted with a seedbed preparation unit and a levelling unit to work the topsoil, a roller and the seeding unit which is most commonly a single row disc seeding tool mounted independently to the main frame to secure precise seeding depth. The seed tank is on top of the machine and can be filled by using an auger or big bags.

The panel assesses the conservation tillage technology well established in the Magdeburger Börde. The disadvantages (critical weed situations, increased root disease pressure in cereal dominated rotation) are absorbed by adjusting the herbicide and plant protection program.

For plant protection passes further machines are used:

– Pesticide applications are carried out with a 30 m boomspray with 5,000 l tank towed behind the 185 hp tractor. According to the number of applications of chemicals and liquid fertiliser in crop this machine performs 7600 ha per year.

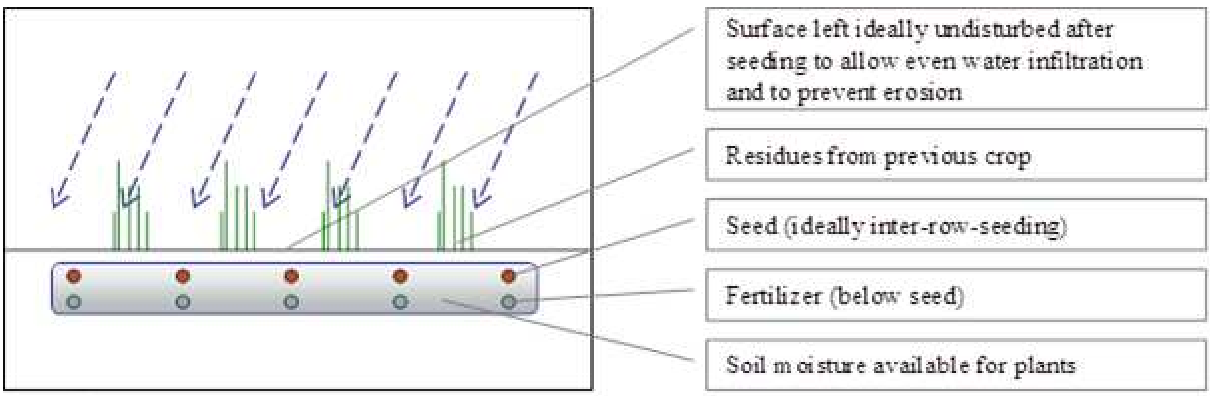
– Spreading of mineral fertiliser is done with a mechanical driven disc spreader behind the 185 hp tractor fitted with a crop nitrogen sensor. The construction limits this spreader in distributing unformulated fertilisers (e.g. prilled urea) to the maximum working width of 30 m. According to the panel, this machine is putted up for disposition in the light of rising fertiliser prices. Spreading of fertiliser post-seeding has a much greater importance to the production system in the Magdeburger Börde compared to the one-pass-systems discussed in the following where the majority of the nutrients are distributed with the seeding operation.

Further towed machines of the typical farm in the Magdeburger Börde are used for logistic and handling and can be found in Table A2 in the Appendix. They are of minor relevance for the production system and are not specified in more detail for the purpose of this thesis.

The two West Australian typical farms are utilising one-pass-seeding systems according to the definition in Figure 4.1.

The **West Australian typical farm AU 4500SC on the South Coast** uses Zero-Till technology. Due to the proximity to the coast, a large share of the land is fragile and soils are prone to erosion. To encounter this Zero-Till technology aims to reduce soil disturbance to a minimum and leave as much stubble and crop residues on the surface as possible. This is meant to achieve a more even water infiltration and to maintain the soil structure (Figure 4.2) (McCallum, 2007).

Figure 4.2: Schematic profile disc seeding



Source: Own illustration.

Seeding of all crops is done with an Airseeder equipped with disc seeding units cutting a narrow slot to place fertiliser (small black tube) and seed (white tube) closed by a press wheel as to be seen in Figure 4.3.

Figure 4.3: Disc seeding unit implemented on AU 4500SC

Source: Own picture.

Seeding goes in accordance with application of fertiliser. The machine is equipped with respective tanks and dosage facilities on a separate trailer towed behind or between the tractor and the seeding bar. Specifications can be found in Table 4.12.

Table 4.12: Seeding equipment AU 4500SC (Average 2005–2009)

Type of machine		Airseeder incl. seedcart
Working width	m	12
Utilisation	ha/year	4,200
Depreciation period	year(s)	5
Machinery cost (fix) *	EUR/ha	10

* Total depreciation, finance, repairs & maintenance per utilised hectare.
Source: Own calculation.

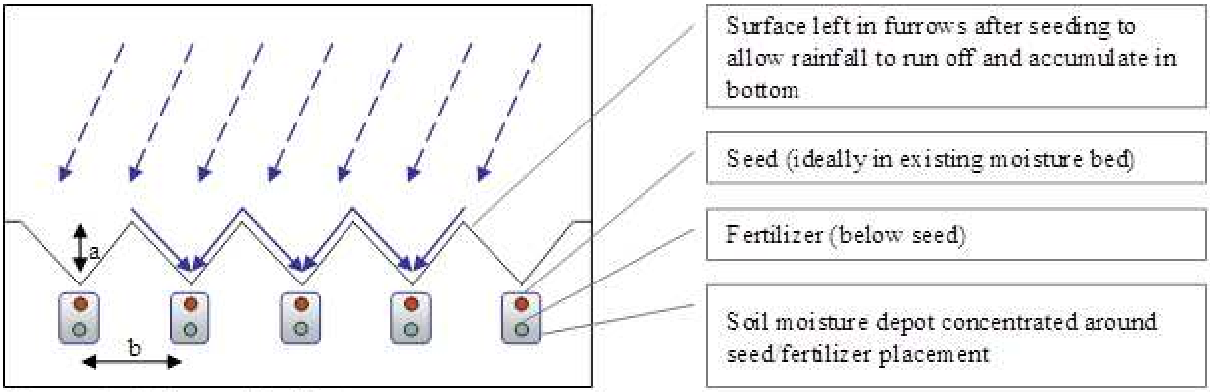
Further towed machines on this typical farm are a 30 t Chaser bin used to transport grain from the header to the field bins on the paddock and a small fertiliser spreader used for a top up fertiliser application in the crops. Both machines are of less importance for the production system. Details can be found in Table A3 in the Appendix.

The **West Australian typical farm AU 4000WB in the Wheatbelt** also uses one-pass-seeding technology but with a slightly higher intensity: Direct drill.[6] This is due to an iconic symptom of the higher elevated sandplain country in the West Australian Wheatbelt: *Non Wetting Soils*. By reason of the soil particle's texture rainfall does not immediately infiltrates into the profile but rolls off. Only an already existing moisture build up allows further rain to accumulate and to be available for plant roots instead of staying at the surface and evaporating. This is especially true for small amounts of rainfall (below 5 mm).

The technology respond to this is a soil management technique called *water harvesting*. Instead of disturbing the soil only to place the seed as in the case of the previous mentioned system on the South Coast, optimal plant growth conditions are obtained when the surface is worked with the seeding pass and turned into a pronounced furrow profile, ideally V-shape furrows (see Figure 4.4).

Residues from the previous crop are of less importance and not constraining this practice for two reasons: (1) Straw yield levels are significantly lower than in the previous case and (2) stubble paddocks are typically grazed with livestock after harvest.

Figure 4.4: Schematic pronounced furrow profile



Note: a = depth of furrows (10 – 15 cm).
b = row spacing (22.5 – 30 cm).
Source: Own illustration.

Direct drill is carried out with an Airseeder equipped with tines and sweep tools to create the furrow (see Figure 4.5). In the wide open slot fertiliser is placed as a band in the bottom (green tube) and the seed on top (black tube). The seed is covered with a soil layer by the following roller.

6 Cp. Figure 4.1.

Figure 4.5: Tine seeding unit implemented on AU 4000WB

Source: Own picture

The Airseeder typically has a working width of 14 m for what the higher engine power of the towing unit (400 hp) is necessary. Analogue to the previous one, it is equipped with a cart to carry seed and fertiliser. Details can be found in Table 4.13.

Table 4.13: Seeding equipment AU 4000WB (Average 2005–2009)

Type of machine		Airseeder + Cart
Working width	m	14
Utilisation	ha/year	3,700
Depreciation period	year(s)	15
Machinery cost (fix) *	EUR/ha	7

* Total depreciation, finance, repairs & maintenance per utilised hectare.
Source: Own calculation.

Further important towed machinery on AU 4000WB is a 7,000 l boomspray used for crop maintenance and pre-seeding knockdown sprays and a chaser bin. Depreciation details can be found in Table A4 in the Appendix.

The different size categories of the seeding equipment used by the almost equal West Australian typical farms are a first indication for different priorities in machinery implication to the local conditions. For reasons discussed in detail in Section 4.4.1 of this thesis, the timing and performance of the seeding operation has a significant influence on the crop rotation and the crop performance in the Central Wheatbelt. Thus farmers here tend to invest in larger machinery capacity, whereas on the South Coast the conditions are more reliable and a longer seeding window as a result from relatively smaller scaled machines is still acceptable.

The **Australian typical farm AU 2800CW in the Central West of New South Wales** utilises minimum tillage and No-Till technology. Consequently towed machines enumerate the tillage equipment as outlined in Table 4.14.

Table 4.14: Tillage equipment AU 2800CW (Average 2005–2009)

Type of machine		Disc cultivator	Airseeder incl. Seedcart
Working width	m	6	12
Utilisation	ha/year	600	900
Depreciation period	year(s)	15	15
Machinery cost (fix) *	EUR/ha	6	15

* Total depreciation, finance, repairs & maintenance per utilised hectare.
Source: Own calculation.

The disc cultivator is used to cultivate the land once or twice after pasture before bringing the land into cropping.

The Airseeder is equipped with narrow knife point openers, a levelling implement and press wheel to be used on cultivated land and with one-pass-seeding. An illustration can be found in Figure 4.6.

The challenge with seeding in this region is to place the seed favourable to get access to the already stored soil moisture as sufficient rainfall is expected to occur before seeding.[7]

In this context the pre-seeding tillage pass is contentiously discussed. Since advantages are more even seedbed conditions and reduced herbicide input, the disadvantages of accumulated soil moisture losses and soil organic matter losses may prevail from an agronomical and sustainability point of view. Thus, the tillage pass might be a subject to change when discussing adaptation strategies in Section 4.5.

7 Refer to Section 3.3.1.4.

Figure 4.6: Tine seeding unit implemented on AU 2800CW

Source: Own picture.

Further details of the machinery configuration of the typical farm in NSW can be found in Table A5 in the Appendix.

The different towed machinery especially tillage and seeding machines, implemented on each of the investigated farm locations provide a first understanding about the wide range of land use systems in place. While this chapter is primarily focussed on the illustration and assessment of machinery, the machinery configuration and management, the agronomical background is conjoined closely and will be discussed in detail when focussing on the production system in Sections 4.2–4.5.

4.1.3.3 Self-propelled machinery

The group of self-propelled machines is dominated by harvest equipment. The following Table 4.15 provides an overview of the different machines used for harvesting on the typical farms.

Table 4.15: Harvesting equipment of typical farms in Germany and Australia (Average 2005–2009)

		DE 1300MB	AU 4500SC		AU 4000WB	AU 2800CW
Type		Combine (hybrid)	Swather	Combine (hybrid)	Combine (single rotor)	Combine (single rotor)
Quantity		1	1	2	1	1
Working width	m	9	11	11	9	9
Utilisation	ha/year	850	1,000	2,100	3,200	900
Depreciation period	year(s)	9	5	5	8	15
Machinery cost (fix) *	EUR/ha	40	18	23	9	19

* Total depreciation, finance, repairs & maintenance per utilised hectare.
Source: Own calculation.

The combine type is determined by the yield level. High yielding crops in the Magdeburger Börde, Germany and on the South Coast of Western Australia require a more sophisticated threshing system (hybrid threshing system).

Further, on the South Coast the harvest of canola is done in two steps: 1) windrowing of the crop and 2) picking up windrows for threshing. This is due to the harsh wind and changing temperatures in proximity to the coast to secure an even ripening with minimal losses. The windrowing is done with a conventional header front driven by a swather. The two step harvesting has disadvantages for machinery cost and the competitiveness of canola production.[8]

In the lower yielding regions (Wheatbelt of WA and Central West NSW) harvesting of all combinable crops is carried out with single rotor combines.

The annual utilisation differs significantly between the selected locations. This is due to the flow capacity and the conditions during harvest. While the indicator shown in Table 4.15 refers to the maximum capacity of the machine per year in Germany and in Western Australia, the annual utilisation on AU 2800CW is limited by the available acreage. To realise acceptable machinery cost, the combines are typically used for a longer period.

Further significant equipment in this category is used for transport and logistics (trucks and loaders) with an exception on AU 4500SC. This farm operates a self-propelled boomspray to match the requirements of in-crop sprays in canola at late stages. Single depreciation details can be found in Tables A2–A5 in the Appendix.

8 Cp. Table 4.15 and Section 4.3.

4.1.3.4 Comparison of machinery configurations between farms

The previous sections offer detailed insights in the mechanisation strategy of the typical farms. From there it can be summarised that a wide range of technologies are implicated in the investigated regions. Major differences are found particularly in tillage and seeding technology which is the most important fieldwork pass in extensive production systems.

Further differences are found with the analysis of annual utilisation of key machines and replacement strategies which result in cost differentials with regard to operation of the respective machine. This perspective will be recaptured when focussing on economics of crop production at a later stage of this thesis.

The different machinery configurations also result in specific values of the machinery capital on farm level as to be found in Table 4.16.

Table 4.16: Capital invested in machinery of typical farms in Germany and Australia (Average 2005–2009)

		DE 1300MB	AU 4500SC	AU 4000WB	AU 2800CW
Orginal value	EUR	1,035,000	1,634,000	956,000	673,000
Original value per ha	EUR/ha	800	360	240	240
Current value	EUR	724,000	1,241,000	622,000	327,000
Current value per ha	EUR/ha	560	280	160	120
Current value [share of new value]	%	70	76	65	49

Source: Own calculation.

The variation of the original values of machinery, representing the original purchase prices, is relatively small. That means the initial capital deployed in machinery is relatively even irrespective of the size and production intensity throughout the analysed regions. One might by surprised by this considering the significant differences in farm organisation.

When comparing the machinery original value acreage-related Table 4.16 shows the opposite. The variation of the original capital input to machinery per hectare is much greater and correlates positively to the intensity of production. When taking the replacement strategy into account by focussing on the current value per hectare the difference becomes even greater.

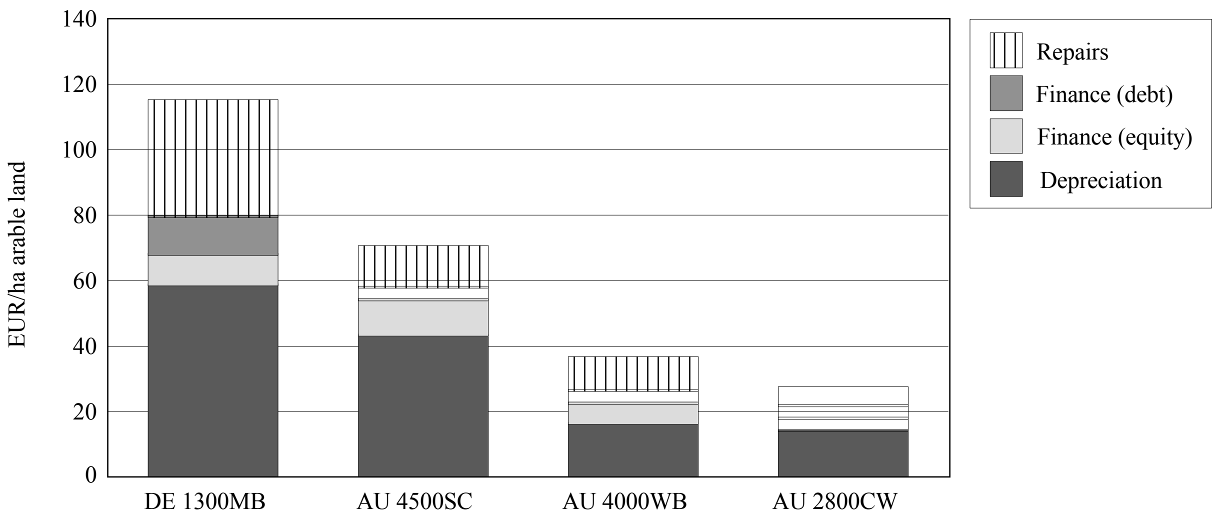
The bottom line of Table 4.16 shows the percentage share of the current value in the new value. This figure can be used to assess the technical status of the machinery pool. The comparison of this indicator displays the effect of the replacement strategy:

1. The earlier replacement of units results in an up-to-date machinery pool and allows participating in latest technology to increase reliability and efficiency (GPS parallel tracking, fuel efficient electronic engine management). The downside is having liquidity tied up in machinery which, in the case of the Australian farms, can only be used for a very limited period.
2. Long replacement strategies are leading to an older machinery pool which may not participate in the latest technology improvements but the capital tied up in machinery is consequently less.

From a **productivity** point of view, the first strategy secures advantages in performance and efficiency of a modern machinery pool. They are applied on the farm in Germany and on the South Coast of Western Australia with more intense production system and relatively stable yields. The predominant challenge here is to use direct inputs (fertiliser, chemicals and fuel) and labour as efficient as possible.

When it comes to **cost advantages**, the different strategies may be assessed in a different way. Figure 4.7 shows the average machinery cost per hectare differentiated by the compartments repair cost, finance cost and depreciation as stacked bars for the analysed typical farms in € per hectare arable land.

Figure 4.7: Machinery cost of typical farms in Germany and Australia (€/ha, Average 2005–2009)



Source: Own illustration.

The cost of owning (not operating) the machinery as outlined in this chapter covers a span from approximately 150 €/ha on the German typical farm to approximately 30 €/ha in Central West NSW, Australia.

Early replacement which applies on DE 1300MB and AU 4500SC results in a high share of depreciation cost (as a measure of long term fixed capital) in machinery cost. When extending the depreciation period as it is the case on the other Australian farms the cost structure involves less importance of depreciation cost which is partially replaced by repair cost. Repair cost (cash expenses paid to external workshops, allocated to individual machines) can be classified as cash cost paid on demand.

Furthermore, repairing older machinery is commonly carried out by farms themselves and involves further labour input on top of cash expenses paid to external workshops. These "repair-hours" are included in the labour configuration and not involved in Figure 4.7. Thus, total repair costs on are expected to be higher, especially on farms with long depreciation durations (AU 4000WB and AU 2800CW).

Hence, from a **risk management** perspective, long depreciation periods (second strategy) are an appropriate way to manage high production risk as found in the Wheatbelt of WA and the Central West of NSW. Having only limited financial resources tied up long term in machinery can help to sustain in tight economic situations.

Furthermore, in the case of AU 2800CW the share of long term fixed capital is further reduced by using second hand machinery. The latter case is a prime example about how to risk-manage machinery cost under extreme production uncertainty.

4.1.4 Buildings

A further share of the capital stock of the typical farms is fixed in commercial buildings. This category accounts for farm buildings and grounded structural works which support production processes, provide shelter for farm goods (inputs, outputs and equipment) or enable specific procedures on farm (STEINHÄUSER et al., 1992).

While a complete list of the individual farms' buildings can be found in Table A6 – A9 in the Appendix, Table 4.17 provides an overview of the total capital invested in commercial buildings available to the typical farms in this investigation.

Table 4.17: Capital invested in farm buildings and building cost of typical farms in Germany and Australia (Average 2005–2009)

		DE 1300MB	AU 4500SC	AU 4000WB	AU 2800CW
Orginal value	EUR	650,200	250,357	314,630	357,478
Original value per ha	EUR/ha	500	60	80	130
Current value	EUR	424,882	176,761	147,564	204,327
Current value per ha	EUR/ha	330	40	40	70
Current value [share of new value]	%	65	71	47	57
Building cost *	EUR/a	46,900	27,700	22,600	25,400
Building cost per ha **	EUR/ha	36	6	6	9

* Total depreciation, finance & repairs.
** Total depreciation, finance & repairs per hectare farmland.
Source: Own calculation.

The variation of the original value of buildings (representing the historical construction prices) is relatively high. That means the initial capital deployed in buildings varies significantly. One might by surprised by the fact that the smaller Australian farm in Central West NSW has a higher original value of buildings compared to the West Australian farms.

When comparing the original value of buildings acreage-related (farmland) Table 4.17 shows a stronger effect. The variation of the original capital input to buildings per hectare is much greater and correlates negatively to the farm size. When focussing on the current value per hectare, the difference becomes considerably higher.

However, the percentage shares of the current value in the new value as an indicator to assess the technical status shows relative uniformity throughout the compared typical farms.

The observed differences in building values can be explained by focussing on the operation mode. The investigation yielded major distinctions of building utilisation to be found in a) different strategies of post harvest grain handling and b) handling of livestock. Both specifics of the farming operation should thus be explained briefly to understand the economics and potentials of building utilisation in each case.

Post harvest grain handling

The farm in the Magdeburger Börde is equipped to store and preserve 6000 t grain after harvest. The equipment necessitating this adumbrates roofed bunker silos with concrete flooring, aeration facilities and several fans. Furthermore, a considerable share of farms has installed a weighbridge to track bulk transfers.

Grain storage is filled during harvest by transport vehicles coming directly from the harvester on field. The grain is than stacked to a height of up to 5 metres by telehandler. During filling ventilation channels are placed to allow air streaming thru the crop. This air-flow is used to dry and cool the product to the optimal storage temperature of 8 °C. At this temperature micro biotical activity can be stopped and calamity of insects and storage pests e.g. *Sitophilus granarius* can be prevented (REICHMUTH, 1997).

According to HUMPISCH (1998), ventilation drying can be used to dry combinable crops from a maximum harvesting-moisture[9] of max 20 % to the storage-moisture of 14 %. On DE 1300MB a certain section (approximately 20 % of wheat and 10 % of rapeseed) is harvested wet in an average year and requires this drying process to secure product quality and merchantability. The remaining part of the crops harvested for grain does not require this kind of treatment and is typically only stored, cooled and fractioned on farm.

Figure 4.8 provides an impression about the set up and functionality of a typical grain storage facility in the Magdeburger Börde, Germany.

Figure 4.8: Grain storage and ventilation facility used on DE 1300MB

Source: Own picture.

Once conserved in the described way, grain can be stored until marketing which is typically accomplished within the following 10 months. Storage-logistics and loading for delivery to the assembly points in the region is carried out using a standard telehandler. Commonly, off-farm transport is sourced out to local freight forwarding businesses.

9 Moisture = Water content in the product in % H_2O.

The infrastructure used for the post harvest processes on the typical farm has a current value of approximately 292,000 € and accounts to 32,000 € annual fixed building cost. Thus, grain storage itself accounts for the greatest share (approx. 70 %) of the capital fixed in buildings and building cost on DE 1300MB.[10] However, the annual fix equipment cost for storage equates to 5.30 € per tonne general storage capacity. Assuming that cost can only be allocated to one single load per year, these additional cost need to be covered with price advancements of marketing at a later stage instead of directly out of the actual harvest.

On farm grain handling on the Australian typical farms is facilitated differently from the previous example. Marketing of major grains is commonly carried out by a grain handling cooperative, operating decentralised logistic and storage facilities. These local facilities are spread over the main growing regions in consideration of an effective accumulation of tonnage and of moderate freight distances. Once delivered into the system crops are stored, fractioned, commissioned and marketed while different marketing tools e.g. cash price, forward contracting and different grain pools are employed for pricing. A detailed description of qualities, marketing options and the function of Cooperate Bulk Handling (CBH) in Australia can be found in CBH (2009).

Due to the capable and efficient network of storage facilities, long term on-farm storage is of less importance for the marketing performance under current conditions. Hence, farms are rather equipped for fast transhipment of grains from harvester to on road transport. This is carried out using high volume chaser bins, field bins and augers.

Figure 4.9 provides an impression about the set up and function of a grain transhipment facility typically utilised in Western Australia.

Transhipment places on farm are ideally located centrally and easy accessible for road trains[11]. The place is typically equipped with field bins available from 30–110 t capacity of grain. Smaller field bins are round sheet metal constructions to be shifted by light farm vehicles. They are lined up and operated with transportable or fixed augers. Crops are collected from harvesters, carted and overloaded to the bins and commissioned to full truck loads. Farms do usually hold a truck or road train themselves as a basic on-road transport capacity and do contract external freight forwarding businesses in for over-volume.

[10] Cp. Table 4.17.

[11] Road Trains are a unique element of the Australian transport sector. Their payload can reach up to 110t portioned out to a towing vehicle and several semi-trailers. An illustration for the dimension of a road train is found in Figure A8 the Appendix.

Figure 4.9: Grain storage facility used on AU 4500SC

Source: Own picture.

The size of the handling equipment varies with the tonnage harvested per hour (harvester capacity) and the distance to the delivery point. Taking the West Australian farm on the South Coast as an example would result in 12 field bins with a total capacity of 480 t plus two augers.[12]

The infrastructure outlined above has a current value of approx. 72,200 € and causes 11,600 € annual fixed building cost. Thus, grain storage is of less importance for the total building cost on AU 4500SC.[13] The fix equipment cost for the transhipment gear amounts to approximately 0.20 € per tonne total output per year, assuming respective equipment is used equally for all crops harvested.

The remaining farm buildings (fertiliser storage, workshop and machinery shed) account for the significant share in value and annual cost. This is especially true for AU 4500WB and AU 2800CW since both farms operate facilities to handle livestock.

Livestock handling

The typical farms in the Wheatbelt of Western Australia and in Central West New South Wales run a sheep enterprise. Although this enterprise is primarily focussed on production of meat lambs, the sheep flock adumbrates a considerable share of wool

12 Details for the other Australian farms are found in Table A8 and A9 in the Appendix.

13 Cp. Table 4.17.

breeds. Regardless, these animals still need to be shorn once a year in summer and therefore a purpose build shearing shed is utilised on these farms.

The shearing shed contains different sections to manage the flock before and after shearing and provides an elevated level for the shearing crew to work, sufficient space to class the wool, storage room for the wool bales and social facilities. Furthermore it is equipped with technical appliances to drive the shearing machines. Compared to the other buildings on those mixed farms the shearing shed is the most sophisticated building which causes the relatively high construction cost.

This is especially true for the two farms in this comparison, where the shearing facilities are taking a considerable share of the building value and annual building cost[14] even though the typical depreciation period exceeds the farm average (75 years). This is due to the short time period of the year in which these facilities are used and the absence of any alternative utilisation.

Besides the economic performance of livestock as outlined in the following subchapters, from the latter fact tentative conclusions for the path-dependency and the position of the sheep enterprise on farm can be drawn. Both seem to be significantly stronger compared to the cropping enterprise due to the decisive amount of capital fixed in infrastructure long term. This must be kept in mind, when potentially considering the livestock enterprise of these typical farms being reduced in favour of a prospering cropping enterprise under new framework conditions.

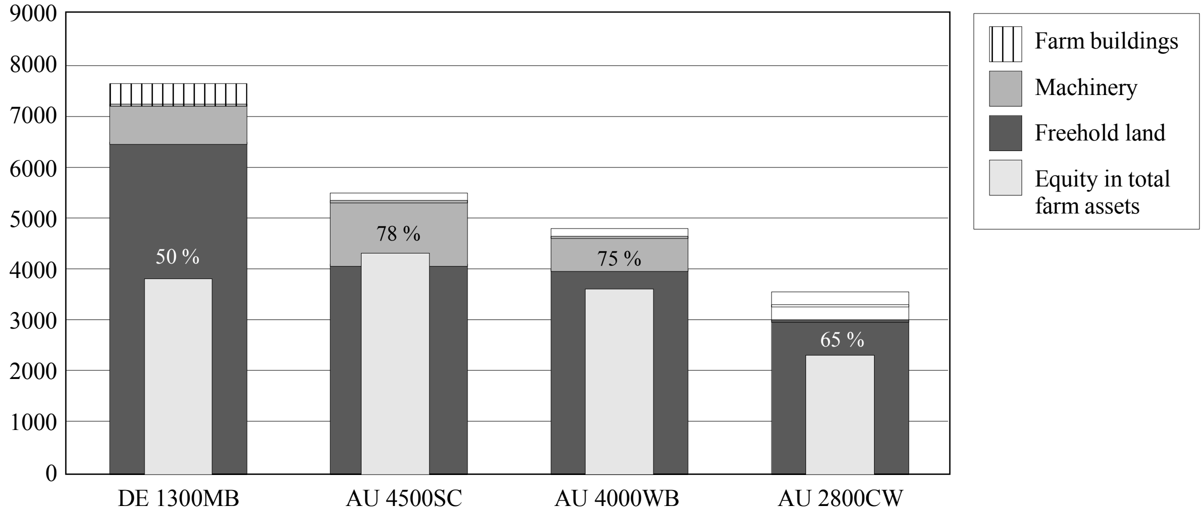
4.1.5 Capital structure of fixed assets

Land, machinery and building configurations of the typical farms have been discussed separately in the previous chapter according to their classification in economic theory. However, their activation accounts to the fixed asset balance in agricultural enterprises (STEINHAUSER et al., 1992).

In the following, the balance of the available fixed assets and the corresponding equity share should be used for a final assessment of capital intensity and exposure to risk. The results are presented in Figure 4.10.

[14] Cp. Table A8 and A9 in the Appendix.

Figure 4.10: Fixed asset value of typical farms in Germany and Australia and equity share in total fixed assets (‘000 €, %-share)



Source: Own illustration.

The stacked bars represent the fixed assets of the individual typical farms in total values. This adumbrates freehold land, machinery and buildings.[15] Generally, the bars run accordingly the meanwhile consolidated grade of intensity levels of the selected locations. They range from 7.6 m€ fixed asset value of DE 1300MB to 3.5 m€ for the typical farm in Central West NSW.

While freehold land accounts for the major share within the asset portfolio, the progressive impact of land price becomes obvious especially when comparing the Magdeburger Börde typical farm against all Australian farms. Furthermore, the different impact of machinery and building configurations can finally be localised.

Further important conclusions can be drawn from the distribution of equity across the typical farms in this comparison. The equity in total fixed assets is stated in the grey bars supplemented by the respective percentage. Due to significant distinctions in equity shares, the gap between the farms narrows decisively. Consequently, this issue is put on trial in the panel discussions:

– The German farmers in the Magdeburger Börde approved the presented equity share (50 %) to be typical for top managed farms in the current situation. It is declared as a consequence of the ambitious land purchase strategy of farms in the region but also assessed as being a financial borderline situation only acceptable with top performing

[15] Perennial crops, land improvement and livestock has been neglected due to insignificance.

farms. The current land market situation drives progressive farms to their debt service limit.

– The participants in all panels held in Australia assessed an equity share of 65 % being the lowest accepted by finance institutions to support further operation of the farm. Hence, the Western Australian farms in this comparison have a considerable investment reserve whereas the typical farm in the Central West currently has to cope with a tight financial situation presumably brought up by the poor cropping performance of the last five years linked to the recent rainfall patterns.

The statement of the panel participants regarding the finance situation brought up further assumptions regarding the influence of production uncertainty and on-farm equity requirements of finance institutions.

Banks financing agricultural enterprises like DE 1300MB farming in an environmentally advantaged region seem to accept a lower share of equity in farm assets. (= taking over a considerable higher portion of entrepreneurial risk). This seems to be especially true in presence of the outlined economic framework which contains subsidy payments and thus a virtual guarantee for a certain share of the farm revenue.

It can further be concluded, that farming enterprises operating under higher production uncertainty are required to maintain a higher share of equity in their farm assets to sustain their financial support. Under these conditions the entrepreneurial risks of the operation remains with the farm owner to a larger extend.

The quantification and estimation of production resources of the typical farms brought out remarkable results according to the objective of this thesis. These results will be incorporated in the following elaboration of individual production processes and their possible adjustments. Beside this, the assessment of the financial situation is prerequisite to understand the farm level implications of the underlying price assumptions and the financial capability of the farms to implement adaptation strategies generally.

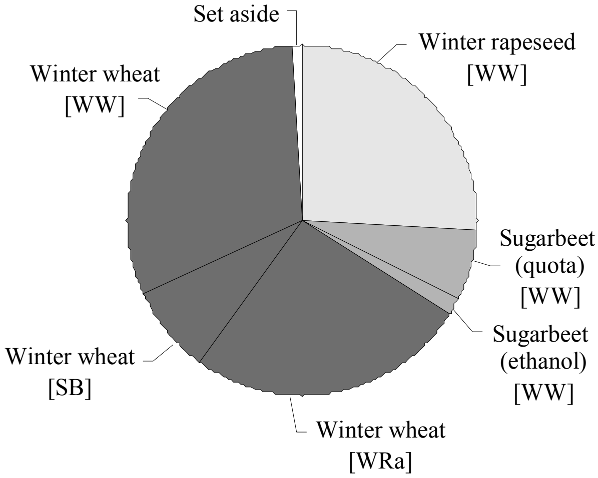
4.2 The German typical farm in the Magdeburger Börde

4.2.1 Status quo crop portfolio and production system

The cropping enterprise of the German typical farm in the Magdeburger Börde is primarily aligned on the production of wheat and oilseed. Additionally, sugarbeet for sugar production (quota) and industrial consumption (ethanol) are grown. Figure 4.11 provides an overview about the acreage and percentage share of crops in the crop portfolio.

Figure 4.11: Acreage (ha), share in the crop portfolio (%) and yield (t/ha) of crops grown on DE 1300MB (Average 2005–2009)

Crop	Pre-crop	Acreage [ha]	Share [%]	Yield [t/ha]
Winter rapeseed	WW	325	26	4.1
Sugarbeet (quota)	WW	81	6	58,6
Sugarbeet (ethanol)	WW	19	2	58,6
Winter wheat	WRa	325	26	8,6
Winter wheat	SB	100	8	7.8
Winter wheat	WW	387	31	8.0
Set aside	--	13	1	--
Total acreage		1250	100	



Typical crop rotation:
Sugarbeet/Rapeseed -- Wheat -- Wheat -- Rapeseed -- Wheat -- Wheat (6-year-cycle).
Note: Legend of diagram contains main crop name and the abbreviation of the pre-crop in square brackets.
Source: Own illustration.

The typical crop portfolio of the Magdeburger Börde has a relatively fixed relation of 1/3 broadleaf crops (rapeseed and sugarbeet) versus 2/3 cereals (wheat). The typical rotation of these crops is established as the following:

Sugarbeet/Rapeseed – Wheat –Wheat – Rapeseed – Wheat – Wheat

in a six year cycle according to the general rotation frame broadleaf – cereal – cereal.

Further insights about the cropping operations are found by focussing on the production system of the individual crops grown on DE 1300MB. To maintain an acceptable level of detail and comparability, this section will concentrate on production of the major crops a) wheat and b) rapeseed as these crops can also be found on the typical farms in Australia.

Wheat production

Wheat is the most dominating crop grown on DE 1300MB. The favourable natural conditions allow production of premium wheat for human and feedstock consumption in the Magdeburger Börde. Therefore winter varieties are exclusively grown.

The total share of wheat in the cropping portfolio adds up to 65 % referring to the diagram of Figure 4.11. Wheat is either grown on rapeseed, sugarbeet or on wheat. The significant differences in yield point on the high agronomical sensitivity of wheat:

– Rapeseed has a high preceding crop value to the following wheat since it is harvested in order to allow an optimal seeding window for wheat by end of September as the latest. Furthermore, an improved soil structure, virtual absence of cereal pests and diseases, the carry over of nutrient deposits and crop residues rich in nitrogen left by the cruciferae pre-crop are beneficial for the following wheat.

- Sugarbeet are of low preceding crop value on DE 1300MB since they are harvested in late autumn till December resulting in late clearing of fields for the following wheat. This penalises wheat performance since pre-winter crop establishment is limited. Furthermore, sugar beet consume high amount of water leaving a considerable soil moisture deficiency which influences the following wheat adversely.
- Wheat as the preceding crop has also a lower value since establishment of the following wheat crop is under pressure from crop rotational diseases predominantly Blackleg (*Gaeumannomyces graminis* var. *tritici*), Cereal eyespot (*Pseudocercospo-rella herpotrichoides*) and Brown foot rot (*Fusarium culmorum*). Further effects of cereal dominated rotations on the phytosanitary status and pathogens are intensively discussed in the literature such as HOFFMAN and SCHMUTTERER (1999) or OBST and GERING (2002).

Since winter wheat following itself has the largest acreage share in the cropping rotation the latter fact must be kept in mind, when analysing the production system for wheat which is illustrated in Figure 4.12.

Figure 4.12 Production system of winter wheat (following winter wheat) on DE 1300MB and physical direct inputs differentiated by month and type of operation

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost [EUR/ha]	Operating cost [EUR/ha]
1	end 08	Stubble tillage	Disc harrow, working depth 5cm		15
2	beg 09	Spreading	Dry chicken manure (organic) N40 P22 K30 CaO86 Mg7 S2	39	10
3	beg 09	Spreading	Chloride of Potash (mineral) K17 Mg2	9	3
4	beg 09	Stubble tillage	Field cultivator, working depth 18cm		42
5	mid 09	Spraying	Total herbicide	6	5
6	end 09	Seeding	Seeding combination, seed fungicide treated	48	28
7	end 09	Other	Molluscicide	7	3
8	beg 10	Spraying	Selective herbicide	37	6
9	beg 03	Fertiliser	Sulphate of ammonia (mineral) N16 S18	13	3
10	mid 03	Fertiliser	Urea (mineral) N46	28	3
11	beg 04	Plant protection	Growth regulator	2	6
12	end 04	Fertiliser	Urea (mineral) N51	31	3
13	beg 05	Plant protection	Selective herbicide, fungicide, growth regulator	31	6
14	end 05	Plant protection	Selective herbicide, fungicide, leaf dressing Mg1 S1	35	6
15	beg 06	Fertiliser	Urea (mineral) N37	22	3
16	mid 06	Plant protection	Fungicide, insecticide	19	6
17	beg 08	Harvest	Combine harvest		60
18	beg 08	Transport	On farm from field to storage		11
19	beg 08	Other	On farm handling at storage facility		9
			Total	327	227

Summary				
Crop		Winter wheat (following winter wheat)		
Tillage		Conservation tillage with mulch-seed		
Seed	kg/ha	130	48	EUR/ha
Fertilisation	Nutrient kg/ha	N190 P22 K46 CaO86 Mg10 S23	144	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (3), insecticide (1), other (3)	135	EUR/ha
Yield	t/ha	8.0		

Source: Own calculation.

The single fieldwork passes carried out during the eleven month production phase are categorised in the following sections. Hereby, the production processes and agronomical causalities are explained in greater detail.

Conservation tillage and seeding

The production system for winter wheat starts in late August with a shallow stubble tillage pass to stimulate germination of weeds and losses from the previous crop. Within a two weeks period a deeper stubble tillage pass is carried out to prepare seedbed. The total herbicide applied before seeding is an integrative part to control weeds germinating after the second tillage pass and before seeding by the end of September. The seeding window for wheat is rather flexible compared to other combinable crops since wheat does not require a certain growth stage to endure winter conditions, especially frost (DIEPENBROCK et al., 1999).

However, the panel assesses end of October (20.10.) to be determinant for proper yield accumulation in winter wheat. After seeding and before winter a molluscicide is spread to control slugs. This became a common measure with the broad application of reduced tillage. A grass and broadleaf selective herbicide is applied to control weeds in the germinating crop.

Fertilisation program

After the vegetation break in winter a fast effective N fertiliser is spread as soon as possible (typically in March) to provide nitrogen nutrition on the first warm days during tillering (BBCH 2)[16] before soil nitrogen depots from the manure are accessed thru microbial mineralisation[17] and urea is available for plants. The second urea application is carried out at the end of April to systematically promote stem elongation phase (BBCH 3) while the third urea application targets on flowering and fruit development (BBCH 5 and 6). The latter nitrogen application has also a significant influence on the product, first of all crop yield and protein content. Thus, it is oriented on the targeted yield and intended product quality under consideration of the actual weather conditions: At this stage the nitrogen uptake ability or even general yield accumulation process can susceptibly be disrupted by pre-summer aridity.[18] With exception of the first nitrogen application in March, fertilisation is carried out using nitrogen sensor technology to adjust the spreader. This application measures the greening index of the plant, determines the optimal nitrogen supply and varies the spreading rate (YARA, 2004).

Further macro nutrients (Phosphorus, Potassium, Magnesium and Sulphur) are predominantly delivered from organic sources. As shown above, this is typically carried out in September using *Dry chicken manure* or alternatively *Meat and bone meal.* Dry chicken manure (total input 3–5 t/ha) requires specific handling equipment not held by the farm. Therefore spreading and logistic is typically carried out by a contractor. The basic nutrient quantity is calculated in relation to crops nutrient absorption[19] and applied once or twice per rotation to winter wheat or winter rapeseed. The split of the physical amounts and operating expenses to single crops are considered in Figure 4.12 and in the following calculations. The supply with Phosphorus is per se essential for the crop

[16] BBCH = Growth stages standard of mono-and dicotyledonous plants; cp. MEIER (2001).

[17] Cp. SCHILLING (2000).

[18] Cp. Section 3.3.1.1.

[19] Cp. Table A10 and A11 in the Appendix.

performance since it is steadily fixed in the soil reaction with rising soil pH, which has been proven for the Magdeburger Börde.[20]

Furthermore, the fertilisation strategy includes a leaf dressing with micro nutrients to secure sound nutrition with Copper, Zinc and Manganese.

Plant protection program

Beside the pre-seed total **herbicide**, further selective herbicides are applied after seeding in October and May to control weeds, predominantly grasses e.g. Slender foxtail (*Alopecurus myosuroides*), Wild oat (*Avena fatua*) and Brome grass varieties (*Bromus Sp.*) in the developing crops. A further reasonable injurious effect of weeds is caused by Creeping thistle (*Cirsium arvense*) which is targeted by an optional second herbicide applied differentiatedly in May.

Leaving the crop residues of the previous crop on the surface is a core part of the conservation tillage program of DE 1300SA. In the case of wheat following wheat the infection pressure of root diseases is further increased since decomposing stubble is left in proximity to the newly developing root system. The higher infection pressure is targeted with the plant protection regime which contains a minimum of three **fungicide** applications in spring (BBCH stage 32, 37 and 7). Additional to the previously mentioned root diseases, a range of fungal leaf pathogens are threatening crop performance and targeted with the plant protection regime. Mildew (*Erysiphe graminis*), Septoria leaf blotch (*Septoria tritici*), Yellow leaf spot (*Dreschlera tritici repentis*) and Brown rust (*Puccinia recondita*) are of significant commercial relevance. OBST and GERING (2002) provide further information about these pathogens live cycle biology, yield damage potential and typical control mechanism.

The application of **insecticides** is targeted on vermin infesting the stalk, foliage and head. The major insects threatening crop's performance are Grain aphids (*Rhopalosiphum padi*), Cereal leaf beetle (*Oulema gallaeciana*) and Wheat blossom midge (*Contarinia tritici*). These pathogens become relevant during yield formation (BBCH 7) in June.

The application of **growth regulators** has two purposes a) growth regulator stimulates the intended sound development of two to three stalks per plant coming into ear to increase the number of heads and b) promote the stalk stability to reduce the crops tendency to laying down in the final stage. Therefore the process of crop growth is guided by an early growth regulator application (BBCH 25-29) carried out in April and a later one (BBCH 32) in May.

---

[20] Cp. Section 3.3.2.2.

Harvest and handling

Wheat harvest usually takes place from end of July during August. Under the described production circumstances an average crop yield of 7.3 t/ha is realised in the investigation period. The harvest operations include the transport from field to the farm storage facilities and the handling operations.

The herewith introduced production system can in principle be generalised for wheat production on the typical farm DE 1300MB. Minor changes in the timing of single passes, tillage program, fertiliser and chemical inputs are found according to the respective preceding crop effects of sugarbeet and winter rapeseed. Figure A9 and A10 in the Appendix contain overviews to provide an adumbrating comparison of the different constellations.

Further cereals (e.g. cereal rye, durum or barley) as mentioned by EBMEYER (2008) are considered niche crops and are implied to the cropping portfolio by individual farms respectively. Their position would compete with the described winter wheat grown on wheat.

Production of rapeseed

The second dominating crop by acreage is rapeseed which is typically grown on 26 % of the arable land (Figure 4.11). This includes rapeseed for food consumption (edible oil) or for industrial purposes mainly bio-diesel production.

The health status of the rapeseed crop correlates sensitively with the acreage share in the cropping portfolio. This is caused by the accumulating pathogen potential of rotational diseases. PAUL (2003) states Finger-and-toe disease (*Plasmodiophora brassicae*); Stalk rot (*Phoma lingam*) and Collar rot (*Sclerotinia sclerotiorum*) to be of exceptional relevance.

On DE 1300MB winter rapeseed is typically planted in a triennial frequency following winter wheat to manage self-intolerance. After having long term experience of rapeseed production in the area, panel participants assessed the current share of 26 % of the arable land to a) reflect a reasonable equilibrium between phytosanitary soil health and plant protection effort and b) be the maximum acreage to maintain a sustaining yield level above 4.0 t/ha on average.

Furthermore, the winter rapeseed production program (Figure 4.13) shows significant differences from the previously introduced winter wheat program which are outlined in the following paragraphs.

Figure 4.13: Production system of winter rapeseed (following winter wheat) on DE 1300MB and physical direct inputs differentiated by month and type of operation

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost [EUR/ha]	Operating cost [EUR/ha]
1	end 07	Stubble tillage	Disc harrow, working depth 5cm		15
2	beg 08	Spreading	Dry chicken manure (organic) N70 P39 K52 CaO151 Mg13 S4	68	18
3	beg 08	Stubble tillage	Field cultivator, working depth 25cm		47
4	mid 08	Seeding	Seeding combination, seed fungicide & insecticide treated 70 % hybrid vs. 30 % line varieties	44	28
5	mid 08	Seedbed preparation	Optional land roller where seedbed is critical		3
6	end 08	Plant protection	Pre-emergence selective herbicide	5	3
7	beg 09	Plant protection	Post-emergence selective herbicide	74	6
8	mid 09	Other	Molluscicide	1	1
9	end 09	Plant protection	Selective herbicide, insecticide, leaf dressing B1	32	6
10	beg 10	Plant protection	Fungicide	31	6
11	end 02	Fertiliser	Sulphate of ammonia (mineral) N44 S48	35	3
12	beg 03	Fertiliser	Urea (mineral) N46	28	3
13	beg 04	Plant protection	Fungicide, insecticide, leaf dressing B1	27	6
14	mid 04	Fertiliser	Urea (mineral) N69	42	3
15	end 04	Plant protection	Fungicide, insecticide, leaf dressing N17	49	6
16	mid 08	Harvest	Combine harvest		60
17	mid 08	Transport	On farm to storage facility		11
			Total	435	222

Summary				
Crop		Winter rapeseed (following winter wheat)		
Tillage		Conservation tillage with mulch-seed		
Seed	kg/ha	3-4 (35,000 - 40,000 Plants/ha)	44	EUR/ha
Fertilisation	Nutrient kg/ha	N246 P39 K52 CaO151 Mg13 S52	200	EUR/ha
Chemicals	Applications	Herbicide (3), fungicide (3), insecticide (3), other (1)	192	EUR/ha
Yield	t/ha	4.1		

Source: Own calculation.

The production period of winter rapeseed is slightly longer (twelve months) compared to winter wheat. However, operation peaks fall into the same time period which requires harvesting winter wheat and seeding winter rapeseed running parallel in August.

Conservation tillage and seeding

The winter hardiness of winter rapeseed varieties depends on the development stage during the vegetation break. DIEPENBROCK et al. (1999) consider the 6–8 leaf stadium (BBCH 16-18) optimal to outlast the frost period. This consequently determines the seeding window. In case of DE 1300MB seeding takes place by mid August which involves an early maturing preceding winter wheat crop to enable the first shallow tillage pass by end of July.

A further operational challenge is caused by the required development depth of the tap root, which has a strong influence on the yield development of winter rapeseed (SCHÖNBERGER, 2009). Therefore the second deep loosening stubble tillage pass with a working depth of 25 cm by beginning of August is essential to provide a supportive soil structure for the sound root establishment.

Since the operation window between harvest of the preceding wheat crop and seeding of rapeseed is too short to allow natural soil structuring processes for an optimal seedbed, a land rolling pass can be necessary to prevent a delayed germination. The short time window is also decisive for the reduced effect of a total herbicide application. Weed control typically takes place by means of selective herbicides after seeding.

Fertilisation program

In comparison to the previously discussed winter wheat, rapeseed requires a higher fertiliser input relative to the harvestable yield. This is due to a) the physiological content of rapeseed seeds[21] and b) the wide balance of nutrients stored in the product versus straw. While the high content in protein and glucosinolates cause the sulphur demand, the high content of nitrogen and potassium in the vegetative plant material is fundamental for the supportive preceding crop effect of rapeseed. Furthermore, rapeseed would not require a categorical split of the spring application since yield development processes are running parallel and can not be influenced directly as in the case of cereals. However, a split of applications increases nitrogen efficiency and enables fertilisation according to natural conditions (DIEPENBROCK et al., 1999).

On DE 1300MB the fertilisation of rapeseed is typically split in five applications. Basic nutritive demand is delivered by organic sources in autumn. However, nitrogen and sulphur fertilisation is carried out with mineral fertilisers (sulphate of ammonia, urea and ammonium nitrate in combination with pesticide) in February, March and April.

Plant protection program

The limited option of pre-seed total **herbicide** application requires an increased input of selective herbicides sprayed after seeding in August and September to control weeds and emerging losses in the developing crops. A further reasonable negative effect on the harvest conditions is caused by Creeping thistle (*Cirsium arvense*) and Goosegrass (*Galium aparine*) which is targeted by an optional herbicide applied differentiated in spring.

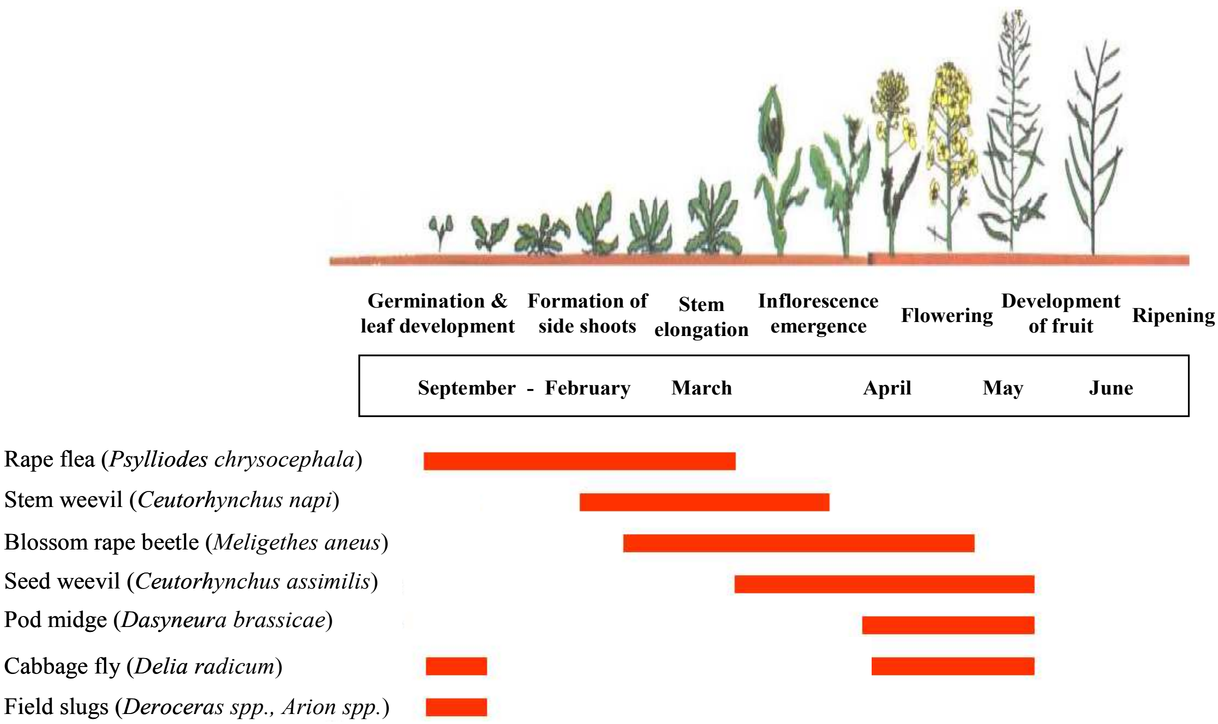
---

[21] Fat synthesis requirements and typical fat acid pattern of rapeseed cp. SCHILLING (2000).

The higher infection pressure of fungal diseases is targeted with the plant protection regime which contains a minimum of three **fungicide** applications in autumn and spring. While the early applications provide systemic protection against Stalk rot (*Phoma lingam*) and Downy mildew (*Peronospora brassicae*) the later one has a more complex effectiveness: The pesticide is sprayed during flowering to contaminate vegetative plant material and the petals in the flower cluster which are released at a later stage and presumably rest in the axil of lower-lying leaves. This is the preferred source of infection of the soil-borne fungus Collar rot (*Sclerotinia sclerotiorum*) which can be delayed in order with this so called blossom spraying. PAUL (2003) provides further information about these pathogens live cycle biology, yield damage potential and typical control mechanism.

Pest control is of high relevance in winter rapeseed production, since a wide range of insects and field slugs are having adverse effects. Figure 4.14 provides an overview about major pests and their periodical occurrence.

Figure 4.14: Major pest affecting winter rapeseed crops and their periodical occurrence in the Magdeburger Börde, Germany



Source: HEIMBACH (2009), DIEPENBROCK ET AL. (1999), PAUL (2003), own compilation.

The flowering rapeseed crop does also attract beneficial insects, most prominent bees (*Apiformes*). Hence, bee tolerance is an important criterion for the certification of insecticides and limits the range of active substances significantly. According to IMKAMPE (2007) this led to the perennial application of a sole active substance group (Pyrethroids) what induced a chemical resistance of the Blossom rape beetle (*Maligethes aeneus*) during the last decade. Although this has temporarily been overcome, the panel assesses pest control in winter rapeseed fragile and expects increasing insecticide cost.

The range of pests and their periodical occurrence indicates that winter rapeseed crops are under significant attack during the growing period. This requires an intensive **insecticide** regime (molluscicides respectively) which in the case of DE 1300MB contains insecticide seed treatment, pre-seed slug control and three spraying applications during spring.

Harvest and handling

Harvest of winter rapeseed is typically carried out in August as a direct harvest pass. The typical farm in the Magdeburger Börde realised an average yield of 4.1 t/ha in the investigation period. Due to the physiological characteristics of the product, rapeseed is not suitable for long term on-farm storage and commonly delivered during harvest.

Production of sugarbeet

A further broadleaf crop in the portfolio is **sugarbeet** which accounts for 8 % of the total arable land (green body in Figure 4.11). This acreage comprises sugarbeet grown for a) sugar production (6 %) regulated and limited per farm by the quota regime of the EU common market organisation for sugar and b) industrial consumption for the production of bio-ethanol (2 %). The cultivation of latter ones became relevant from the production year 2007 onwards.

Contrary to the previously introduced crops, sugarbeet are a summer crop. Thus crop establishment takes places from spring (seeding in April) till autumn (harvest from September till November). The detailed production system of sugarbeet is found in Figure A11 in the Appendix. Harvest refers to the v-shaped beet, which is the physiological storage organ of the plant. It contains a considerable high share of sugar (approx. 18 %). Taking the total physical yield of 56 t/ha into account this leads to a total white sugar output of 10.1 t/ha.

The strict differentiation of land dedicated to sugarbeet and rapeseed in former years has been overcome due to the occurrence of active herbicide ingredients enabling the weed control of re-emerging rapeseed in sugarbeet crops. However, rapeseed is in the range of Beet nematode (e.g. *Heterodea schachtii*) host plants and may increase their population in case sugarbeet acreage increases relatively to rapeseed (DIEPENBROCK et al., 1999).

A particularity of this typical farm is the inclusion of the **set aside** in the cropping program. Initially established as a regulation measurement to restrict production in context of the European Union Common Agricultural Policy (CAP) the mandatory fallow of ten percent of the arable land was lifted in November 2008. However, farmers receive decoupled payments for set aside which adumbrates 13 ha on DE 1300MB. Fallowed land must be grassed and mowed once a year due to be eligible according set aside regulations (EUROPEAN COMMISSION, 2009a).

Field peas, as considered being typical by the panel conducted by EBMEYER (2008) are not longer proven to be in the cropping program. Their position is substituted by sugarbeet for ethanol and winter wheat.

Evolution of tillage practices

An additional influence on the crop portfolio and the aforementioned fixed relation between broadleaf crops and cereals is caused by a technological shift from ploughing a certain share of the cropland as observed by EBMEYER (2008) towards the total application of conservation tillage on the typical farm in the Magdeburger Börde. This development is a trade-off for the panel farmers of the following agronomical implications:

Tillage incorporating ploughing

– Ploughing does increase the flexibility to grow a wider range of cereals at the third element in the broadleaf – cereal – **cereal** rotation. The thread of re-emerging lated shoots e.g. from cereal rye or barley in the next premium wheat crop and thus quality issues can be reduced.
– Ability to handle high amounts of crop residues e.g. after crops laying down or if time for seedbed preparation of the following crop is critical.
– Upturning tillage improves the phytosanitary status of the crop land and is an efficient mechanical weed and pest[22] control method.

Conservation tillage with mulch seed

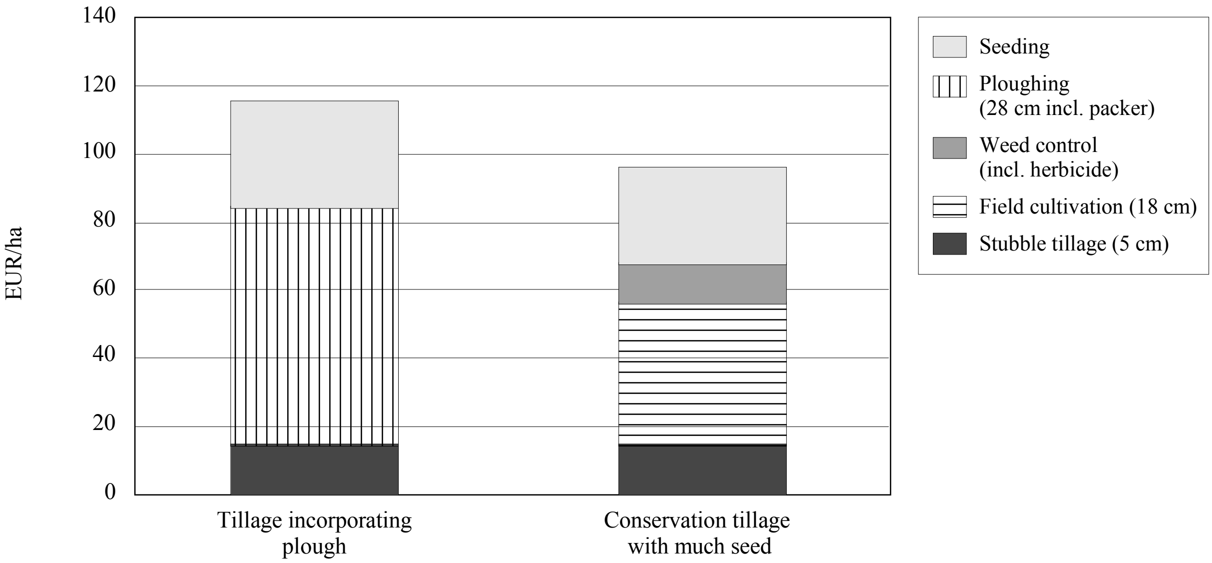
– The range of cereals is significantly limited. The effects on the production management comprise a stronger timely concentration of operations and an increased exposition to production risk and marketing uncertainties.
– Conservation tillage leads to an increased water infiltration, horizontal structure and (micro-) biological activity which are beneficial for the cropping performance. The panel participants reported a positive yield effect in sugarbeets.
– Land is left roughly structured and covered by crop residues and thus more effectively protected against erosion and evaporation.

---

[22] E.g. field mice (*microtus arvalis*).

– Acreage performance and fuel consumption are advantageous and result in a cost benefit of approximately 20 €/ha. The calculation of the respective operating cost is displayed in Figure 4.15.

Figure 4.15: Operation cost (€/ha) comparison of a tillage system incorporating plough vs. conservation tillage as applicable to winter wheat production on DE 1300MB



Source: Own calculation.

The cost benefit is evident even in due consideration of an additional spraying pass including total herbicide (6 €/ha direct cost) to replace the mechanical weed control effect of the ploughing pass.[23] It is assessed as a significant technological development in the recent decade initially as an adjustment to decreasing output prices (MALY, 2006).

– The further concentration on chemical weed control in the production system supports the establishment of niche weed populations. According to WOLBER et al. (2008) problematic coverage are observed especially with grasses such as Brome grass (*Bromus L.*) or Foxtail (*Alopecurus pratensis L.*). In addition to that, the latter one establishes resistances to a broad spectrum of selective herbicides groups.[24]

During the investigation period, establishing herbicide resistances are effectively controlled by an increased herbicide input but the panel assesses a sound weed

[23] Cp. ZIMMER and NEHRING (2008).

[24] E.g. Isoproturon (phenylurea herbicides, IPU) or Fenoxaprop (aryloxyphenoxypropionic hebicides, FOP).

management to be critical for the long term success of conservation tillage and expects increasing herbicide cost.

– The absence of the plough in the production systems leads to more even and levelled fields allowing wider working widths of the following equipment (e.g. seeder, header).
– The current tractor used for tillage purposes[25] can not be used to tow ploughing gear properly in-furrow due to the width of tractor tyres (>800 mm) required for other operations.

Acknowledging the previously outlined compromises the panel assessed conservation tillage to be typically adapted on DE 1300MB. In the long run, the implementation of conservation tillage did not have a significant negative impact on yields. The plough is not a subject to be reactivated in presence of the price assumptions of this thesis.

This outcome stands in remarkable contradiction with the long term accepted agronomic opinion that profitable crop farming in the Magdeburger Börde is not sustainable in absence of upturning tillage by ploughing (RÜBENSAM and RAUHE, 1964).

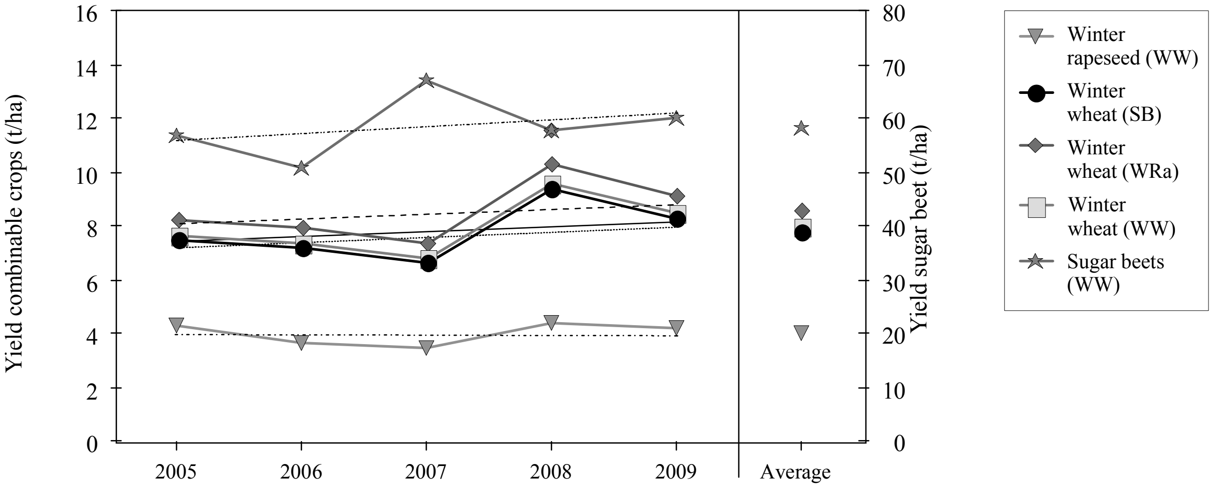
Evolution of crop yields and estimation of production uncertainty

By utilising the abovementioned production systems in the natural framework conditions of the Magdeburger Börde, the typical farm DE 1300MB generated crop yields during the five year investigation period from 2005 to 2009 significantly above the statistical average of the region. The yield patterns of single years are illustrated in the following Figure 4.16.

The figure shows relatively consolidated yield levels for each single crop. Sugarbeet raw-yield (right axis) vary between 51 and 67 t/ha, winter wheat responds effectively to the preceding crop and yields approximately 0,8 t/ha lower if following sugarbeet and winter wheat compared to winter rapeseed. Winter rapeseed typically levels around one half of the winter wheat yield.

[25] Cp. Section 4.1.3.1 and Table 4.6.

Figure 4.16: Evolution of crop yields (t/ha) and five year average (2005–2009) of DE 1300MB



Source: Own calculation.

Crop		Sugar beet	Winter wheat	Winter rapeseed	Winter wheat	Winter wheat
Precrop		WW	SB	WW	WRa	WW
Ø 2005-2009	t/ha	58.60	7.80	4.10	8.60	8.00
Max[1)]	t/ha	67.00	9.37	4.43	10.33	9.61
Min[1)]	t/ha	51.00	6.67	3.45	7.36	6.84
CV[2)]		0.10	0.13	0.11	0.13	0.14

1) Maximum and minimum yields in the observed period.
2) Coefficient of variation.

On closer inspection Figure 4.16 indicates further properties of the crop yield pattern relevant for the continuation of this investigation:

– Crop yields appear to track a positive trend (ascending linear trend line) during the investigation period. However, this trend differentiates between the individual crops. The strongest effect can be observed at sugarbeet yet flattens at winter wheat and rapeseed.[26]

– Crop yields evolve relatively continuous compared to their respective yield level during the observed harvest years (cp. internal CV in Figure 4.16). This indicates a relatively low relative production uncertainty of DE 1300MB with regards to the other typical farms in this study.

[26] The individual crop yield trends observed on farm level DE 1300MB are not statistically proven. However, identical results have been observed by ZIMMER and ALBRECHT (2011) on a broader regional scale.

Acknowledging the limited explanatory power of the statistical indicators generalisation from this data are certainly not feasible. However, the abovementioned indications regarding the agronomical performance influence the position of the panel participants and are considered when interpreting the results.

4.2.2 Profitability analysis and production cost

The previously introduced detailed production systems for winter wheat and rapeseed are covering the main agronomical framework. In the following section the focus is set on the profitability of production on the German typical farm in the Magdeburger Börde.

The following Table 4.18 summarises the total cost account of single crops on a per hectare basis and ordered by the individual crop's gross margin contribution. The final column (grey shaded) refers to the average farm performance of the cropping enterprise of DE 1300MB per hectare cropped land computed by means of the acreage-weighted figures of single crops.

Market revenues of single crops vary significantly between the crops in the portfolio. The revenue of sugarbeet for quota is the highest and ranges about 1,000 €/ha above the remaining crops. However, due to their restricted acreage the influence on the average is revenue is marginal. Hence, this figure levels in the range of winter wheat at 1,246 €/ha.

The highest net revenue over direct cost (gross margin) in the cropping portfolio is generated by sugarbeet for quota followed by sugarbeet for ethanol production. Winter wheat gross margins vary due to the significant effect of the preceding crop. The most profitable winter wheat crop is grown after winter rapeseed. This is why panel farmers do internally calculate further 50–100 €/ha preceding crop effect to winter rapeseed which performs with considerable distance to the other crops. The average gross margin amounts to 862 €/ha.

Table 4.18: Profitability of single crops and farm average DE 1300MB (2005–2009)

Crop		Sugar beet (quota)	Sugar beet (ethanol)	Winter wheat	Winter wheat	Winter wheat	Winter rapeseed	Set aside	Farm average
Previous Crop		WW	WW	WRa	WW	SB	WW		
Acreage	ha	81	19	325	387	100	325	13	1,250
Crop yield	t/ha	59	59	8.6	8.0	7.8	4.0		
Output price	EUR/t	39	26	147	147	147	278		
Market revenue	**EUR/ha**	**2,285**	**1,524**	**1,264**	**1,176**	**1,147**	**1,118**	**0**	**1,246**
Seed	EUR/ha	235	235	47	48	56	44		62
Nitrogen (N)	EUR/ha	74	74	113	116	113	150		119
Phosphorus (P)	EUR/ha	14	14	27	14	24	25		21
Potassium (K)	EUR/ha	46	46	9	9	15	0		10
Other	EUR/ha	5	5	8	5	8	24		11
Fertilizer (total)	EUR/ha	139	139	157	144	159	200		161
Herbicides	EUR/ha	132	132	49	57	57	91		69
Fungicides	EUR/ha	33	33	43	62	43	77		56
Insecticides	EUR/ha	0	0	6	6	6	24		10
Other	EUR/ha	4	4	10	9	3	1		6
Pesticides (total)	EUR/ha	169	169	107	135	108	192		142
Crop establishment cost	**EUR/ha**	**544**	**544**	**311**	**327**	**324**	**435**	**0**	**365**
Dry energy cost	EUR/ha	0	0	6	5	5	1		4
Crop insurance (hail)	EUR/ha	14	11	9	8	7	12		10
Other	EUR/ha	0	0	0	0	0	0		0
Finance field inventory	EUR/ha	8	8	5	5	5	7		6
Total direct cost	**EUR/ha**	**566**	**563**	**331**	**349**	**341**	**451**	**0**	**384**
Gross margin[1)]	**EUR/ha**	**1,719**	**961**	**933**	**827**	**806**	**667**	**0**	**862**
Labour	EUR/ha	274	274	131	182	160	150	19	164
Contractor	EUR/ha	230	230	108	10	5	18		55
Machinery	EUR/ha	111	111	76	145	133	137	7	120
Diesel	EUR/ha	47	47	37	67	54	63	9	55
Other	EUR/ha	11	8	6	6	6	6		6
Total operating cost	**EUR/ha**	**673**	**669**	**358**	**409**	**358**	**373**	**35**	**400**
Operating profit[2)]	**EUR/ha**	**1,047**	**292**	**575**	**417**	**447**	**293**	**-35**	**463**
Building cost	EUR/ha	69	46	38	35	35	34		38
Total land cost	EUR/ha	347	346	346	346	346	346	345	346
Decoupled payments	EUR/ha	331	331	331	331	331	331	331	331
Net land cost[3)]	EUR/ha	16	15	15	15	15	15	14	15
Miscellaneous cost	EUR/ha	173	116	96	89	87	85		95
Total cost	**EUR/ha**	**1,497**	**1,409**	**838**	**898**	**836**	**957**	**49**	**931**
Profit[4)]	**EUR/ha**	**788**	**115**	**426**	**278**	**311**	**160**	**-49**	**316**

1) Gross margin = Net revenue over direct cost.
2) Operating profit = Net revenue over direct and operating cost.
3) Net land cost = Total land cost reduced by decoupled payments.
4) Profit = Net revenue over total cost.
Source: Own calculation.

In terms of operating profit the gap between sugarbeet and cereals narrows significantly due to the relative intensive machinery input and the significant allocation of overhead labour cost to the high return of this crop. The average operating profit during the investigation period adds up to 463 €/ha.

The profit per hectare which is presented in the bottom line of Table 4.18 is computed considering net land cost (offset of decoupled payments against total land cost).[27] It is concluded that all cropping activities of the typical farm are profitable and cover their total cost while sugarbeet for quota and winter wheat after rapeseed perform outstandingly compared to the remaining crops in the portfolio. The average profit of DE 1300MB is 316 €/ha.

Based on these figures, the profit margin[28] can be used as a general indicator for the profitability of the enterprise. Profit margin calculation comprises profit divided by market return. During the investigation period 2005–2009 the typical farm DE 1300MB averaged a profit margin of 25 %.

Based on these findings it is necessary to investigate further, how the economics of production developed in single years during this time period and how the high price scenario would influence the performance of the farm per se without any adaptations (Scenario S-0). The respective findings are described in the following by means of the Figure 4.17.

The underlying calculations can be found in Table 4.18 and in Tables A12 to A17 in the Appendix.

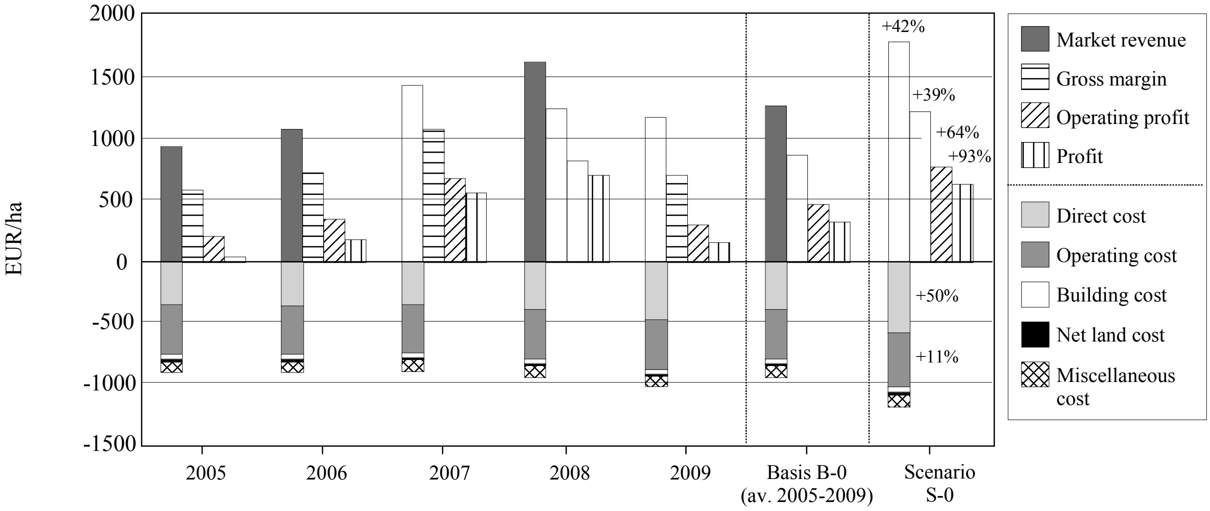
The Figure shows selected economic indicators for the typical farm DE 1300MB in different temporal dimensions. Firstly, single years of the investigation period are displayed and based on this the following conclusions can be drawn:

– The typical farm is able to cover the total cost of the crop production enterprise in every single year of the investigation period. Moreover, in 2008 and 2007 substantial equity (> 500 €/ha) is gained. The latter effect is caused by increasing revenues due to high commodity prices in 2007 and above average crop yields in 2008.
– From 2005 to 2008 total cost of production and the cost structure is relative stable at a level of 900 €/ha. In 2009 total cost increased by approximately 100 €/ha which is assessed by the panel being a time delayed effect of the previous high commodity price period.

[27] Cp. Section 2.4.2.3.

[28] Average profit margin (return on sales ROS respectively) = profit/market revenue.

Figure 4.17: Cost, revenue and profitability indicators of the DE 1300MB cropping enterprise (€/ha) in selected years, 5-year average (2005–2009) and under scenario conditions (Scenario S-0)



Note: 1) Net land cost calculation incorporates decoupled payments.
2) Percentage figures typify the increment (delta) of selected positions based on basis scenario B-0.
Source: Own calculation.

The basis scenario (B-0)[29] established using the five-year-average figures from 2005–2009 eliminates the individual price and yield bias. In the following section this provides the general reference farm situation for further analysis. In a first step, the high price scenario[30] established in this thesis is adapted without any changes to the production system or farm configuration. The economic effect of this scenario (S-0) is also illustrated in Figure 4.17 and can be assessed as the following:

– The high price scenario results in a significant increase of the gross and net return figures. While market revenues settle at approximately 1,780 €/ha, which is above all measures of the previous five years, the margin and profit situation can roughly be compared with the harvest year 2008.

– The observed gap between market returns, gross margin and operating profit respectively is caused by a significant increase of the production cost, in particular direct cost. This is traced back to the increasing prices for energy related inputs, especially fertiliser and fuel.

– Building cost, net land cost (incl. decoupled payments) and miscellaneous cost do not vary between B-0 and S-0 since the reference farm setup is considered ceteris paribus.

[29] An overview over the specific scenario configurations can be found in Chapter 2.4.1 in Table 2.2.

[30] The relevant scenario prices for DE 1300MB can be found in Table A49 in the Appendix.

With regard to the differentiating production systems which incorporate varying direct and operational inputs the observations above lead to the assumption, that single crops performance might response differently to the high price scenario. This issue will be addressed in the following.

Direct cost and gross margin

With the exception of the sugarbeet (quota), all crops in the portfolio are able to gain significant increments in gross margins. The strongest response (+58 %) can be observed at rapeseed which benefits generally from a stronger price increase within the scenario compared to the other crops in the comparison. Hence, although rapeseed production comprises an intense fertilisation regime (especially nitrogen), market revenues in the high price scenario compensate increasing fertiliser cost and narrow the gap to sugarbeet for ethanol and winter wheat. Gross margins of the latter one respond relatively uniform (approx. +44 %) in all pre crop configurations. The respective illustration and calculations are found in Table 4.18, Figure A12 and Table A17 in the Appendix.

Operating cost and operating profit

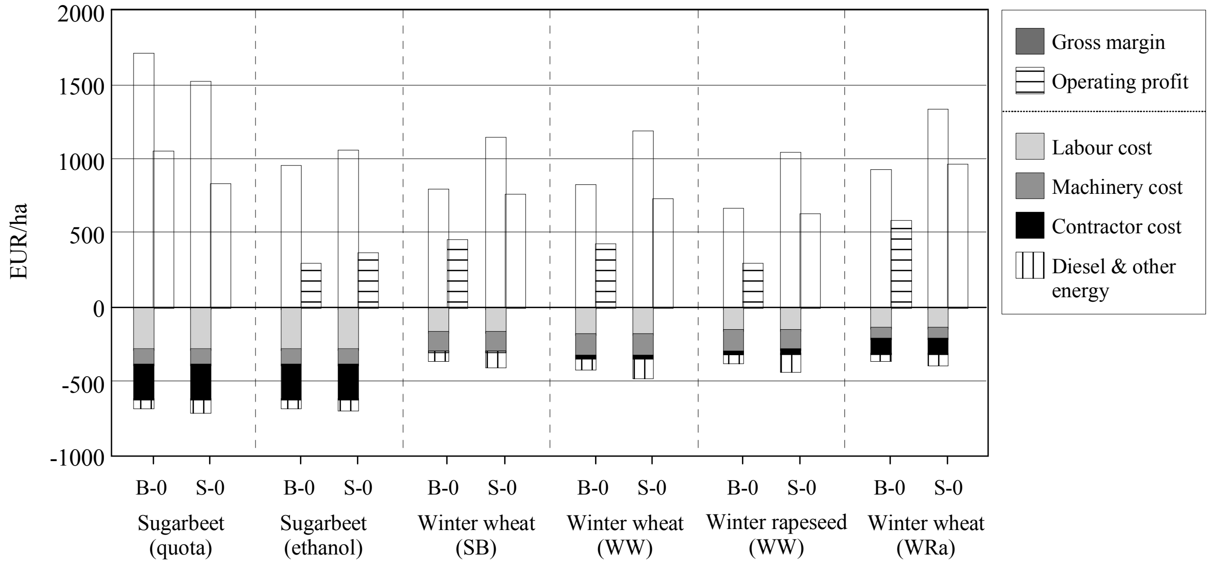
Since the production system for cereals and sugarbeet incorporates different fieldwork passes utilising different machinery, the plain gross margin comparison is not sufficient enough to assess the on-farm competitiveness of the individual crops. Hence, the operating profit was chosen as an indicator.

Figure 4.18 displays the comparison of gross margin, operating cost structure and operating profit of crops grown on DE 1300MB in the reference scenario (B-0) versus high price scenario (S-0). Respective calculations are found in Table 4.18 and Table A17 in the Appendix.

Production of sugarbeet on DE 1300MB benefits disproportionally from the high price scenario in relation to the combinable crops on DE 1300MB. Market revenues of sugarbeet for ethanol in the S-0 scenario offset rising direct cost. However, the marginal response of operating profit (+26 %) shrinks the former position in favour of winter rapeseed. Sugarbeet for ethanol is by far the weakest crop in terms of operating profit contribution under high price conditions. This needs to be considered when focussing on possible adaptation strategies in the next section.

The unmodified market revenues of sugarbeet produced under quota regulations is due to beet prices kept constant in the underlying price scenario. Thus rising direct cost (most prominent fertiliser and seed) and marginal increasing operating cost shrink operating profit (-20 %). Sugarbeet for quota move from the best performing crop in terms of operating profit to second rank with a 120 €/ha monetary gap behind winter wheat following winter rapeseed.

Figure 4.18: Comparison of gross margin, operating cost structure and operating profit (€/ha) of major crops on DE 1300MB, reference scenario (B-0) vs. high price scenario (S-0)



Operating profit response	-20 %	+26 %	+69 %	+74 %	+115 %	+66 %

Source: Own calculation.

The high price scenario applied to the reference situation of the typical farm in the Magdeburger Börde changes the competitive positions of crops in the production portfolio: Quota beets are falling behind winter wheat while beet production for ethanol becomes the least attractive enterprise.

4.2.3 Analysis and assessment of adaptation strategies

Adaptation strategies for the typical farm DE 1300MB are presented in the following chapter. They refer to the typical farm under high price scenario conditions and are structured into two categories:

1. Agronomical adjustments of the cropping program under high price conditions (scenario S-1)
2. Adjustments to the general farm configuration under high price conditions (scenario S-2)

The following section lists the particular measures in each category and describes the effect on the farming operations and constitutes the assessment of the panel.

Scenario S-1 – Adjustment referring to DE 1300MB

Crop portfolio adjustments

The application of the high price scenario to the typical farm (scenario S-0) resulted in a shift of operating profit relations. While winter wheat production remains relatively stabile, winter rapeseed developed disproportionally strong and sugarbeet in general and sugarbeet for ethanol in particular lost competitive advantage. Given the latter two crops are broadleaf and can possibly substitute each other in the cropping rotation an adjustment of the acreage in favour of winter rapeseed is assumed according to economic theory. This is true even more considering the positive preceding crop effect of winter rapeseed on the following winter wheat.

In due consideration of the economics, the panel shared the opinion that an increase of winter rapeseed acreage would affect the phytosanitary status of the crop rotation negatively, leading to declining winter rapeseed yields. A short term expansion of overall shares of rapeseed to a certain extend (max 30 %) is possible but would not be anticipated. Respective ambitions have been undertaken by the participants and proved ineffective.

On the other hand, sugarbeet production is well established on farms in the Magdeburger Börde region with constant yield improvements[31] and considerable synergy effects. Furthermore, panel participants expect a positive response of producer prices of sugarbeet under scenario conditions (both quota and ethanol) which would reinforce the position of sugarbeet in the long run. Ethanol beets are kept as a niche crop.

– No changes to the given crop shares in the rotation

A further consideration regarding the crop portfolio is the admission of corn. Therefore a potential acreage of 200 ha (15 % of the arable land) of corn is suggested to the panel as a possible adjustment strategy of DE 1300MB.

To target the current demand situation in the region, corn can either be utilised as silage in biogas plants or harvested as grain maize. The first option would be realised on the basis of contracted production which can be assessed as profitable in the reference situation. A comparison of operating profits indicate an advantage of 300 €/ha with the production of corn compared to winter wheat following winter wheat. On the one hand this is a strong financial incentive to reassess the current cropping portfolio but contracted production of corn silage is also a risk management strategy to hedge price fluctuations on a certain share of the arable land. A respective calculation is found in Table A46 in the Appendix.

---

[31] Cp. Figure 4.16.

However, the key operations of the production systems of corn (seeding, harvesting and transport) would be sourced out to a contractor which a) reduces the utilisation of the existing machinery configuration and b) reduces the entrepreneurial scope of the typical farm.

The second option deterred the panel participants since grain maize production features harvesting in autumn or winter under unfavourable conditions and high moisture content of the grain. Intensive drying operations would be required with additional cost burdening the profitability of grain maize production. Yet, the admission of corn as a spring crop would diversify the crop rotation in terms of splitting production risk and levelling operational peaks, but would not enhance the agronomical diversity of the crop rotation. Since corn acreage would replace winter wheat (WW) as the second cereal in the rotation, the cultivation of the following winter rapeseed is restricted due to seeding window overlap.

– Acknowledging these findings, the panel assessed the admissions of corn to the crop portfolio not feasible at this stage.

In appreciation of the favourable farming environment in the Magdeburger Börde, the cropping program of the typical farm will consistently be dominated by winter wheat production under the high price scenario conditions. A reduction of the set aside area in favour of crop production can not be obtained.

Tillage system

Tillage intensity will be intensified gradually. This can be carried out by an additional tillage pass and/or increased working depth within the conservation tillage system. However, the feasibility of an additional cultivation pass is depending on the operation conditions in the respective year (harvest period, soil water content). As indicated above, panel participants refuse the reactivation of the plough. This leads to the following tillage system adjustments:

– Winter wheat (WRa): additional cultivation pass, working depth 20 cm, effect on tillage cost: +52 €/ha
– Winter wheat (WW): additional cultivation pass, working depth 13 cm, effect on tillage cost: +42 €/ha
– Winter wheat (SB): working depth of the second cultivation pass 18 cm, effect on tillage cost: +5 €/ha
– Winter rapeseed: no changes
– Sugarbeet: no changes

With regard to rising energy prices and consecutive further technological development of the tillage systems, panel participants reported first insights about strip tillage. In principle, strip tillage would already be rewarded in the reference scenario due to cost saving effects: Deep tillage (25 cm working depth) would take place only in form of strip tillage before rapeseed and sugarbeet since both can be planted as row crops. The tillage to the following wheat can be shallower. Both measures save fuel. It has moreover been assumed, that 15% of the farm's mineral potassium fertilisation can be saved with strip tillage since rapeseed has been identified the crop with the biggest K need (SCHNEIDER 2009).

It has to be considered, however, that the application of strip tillage might not work that smoothly. For example, planting winter rapeseed after strip tilled land after rain might not work (there is no winter in between to freeze up clotty soil). Moreover, it is not clear yet whether the said fertiliser savings are really possible under German high input farming conditions. The operating cost reductions with the application of strip tillage come at the cost of higher machinery depreciation for the existing tillage gear while further capital has to be deployed in the strip tillage cultivator and a precision seeder for row crops.

Finally, if further extensification of the tillage program such as strip tillage system compromises yields even slightly, it will cause net losses. Under the high price scenario conditions farmers are even less prepared to take over additional production uncertainty.

– No further extensification of the tillage program, no adaptation of strip tillage

Seed technology

The typical farm is oriented to take further advantage from conventional plant breeding progress. The expected price increase for improved genetics is already considered by a 20 % increase of seed prices applied to all crops in scenario S-0.

– No changes

For the time being and irrespective of price developments, panel farmers do not expect broadacre cultivation of GM crops in the investigation region. This position is consolidated since first attempts to grow GM corn (MON810) in Germany in 2008 failed because of legal requirements[32] and substantial social resistance.

Fertilisation intensity

Fertilisation intensity will gradually increase. Basic fertilisation will be carried out more sophistically in terms of distribution to cure potential undersupply of soils. Furthermore, nitrogen and phosphorus fertilisation is expected to increase slightly with selected crops.

– Increase of N and P fertilisation in winter wheat and rapeseed by 10 %.

---

[32] Mandatory coexistence rules as described in EUROPEAN COMMISSION (2009b).

Increasing share of organic fertilisers as a further adaptation strategy to substitute mineral fertilisers within the fertilisation regime has been discussed by the panel. However, certainty about the uniform development of organic fertiliser prices, additional logistic and spreading expenditures, the imprecise release of nutrients and the critical conformity of to prevailing legal framework[33] are among reasons, why the panel assessed this option not applicable.

– No further substitution of mineral fertilisers with nutrients from organic sources.

Plant protection intensity

Pesticide application is generally oriented towards economic damage thresholds. This principle evaluates the potential damage caused by weeds, pests or diseases against the costs of the control measure. Economic damage thresholds shift with rising product prices leading to increasing pesticide intensity. The panel participants agree on greater rates of active ingredients applied especially with fungicides and more complex mixtures of active ingredients to prevent further resistances. This means for practical use:

– Increase of plant protection expenditures by +20 % in all crops

– Standard fungicide application in winter wheat during flowering (BBCH 6)

Selling of wheat straw

A relevant effect for the gross income is the new market for straw for industrial purposes at prices of 60 €/t paid free harvester on field. Based on local studies and experience, panel farmers estimated that 30 % of the winter wheat straw can potentially be removed permanently from the system (without return of manure etc.) without long term negative effects on the soil fertility. The straw yield of wheat (4.9 t/ha) is assumed to be 60 % of the grain yield. Selling the straw would cause the average revenues per hectare to increase by 64 €/ha.

A critical factor for straw sales is the nutrient balance of the soils. The nutrients (not humus) exported with the straw have to be substituted with mineral fertilisers. The additional average costs would amount to 35 €/ha under high price conditions. As a result the farm's average gross margin per hectare increases from 1,199 €/ha to 1,228 €/ha (+2 %). Since the cost for straw handling (baling, transport and storage) would be covered by the customer, the individual straw selling enterprise would yield in 29 €/ha extra profit. Respective calculations are found in Table A20 in the Appendix.

Although the selling of straw is profitable from an economic point of view, the panel evaluates the operation divertingly. Since the straw harvesting commonly takes place

[33] German directive on sludge (AbfKlärV), fertiliser (DüngeV) and bio-waste (AbfBioV).

during the critical period of grain harvest and cultivation of winter rapeseed, disruptions e.g. caused by prolonged rainfall or technical disruptions lead to delayed sowing of the following crops and resulting yield penalties are not acceptable. This is especially true considering the underlying high prices for the main products. Farmers are not willing to take over additional production uncertainty under the scenario conditions.

– No selling of by-products from agricultural commodities (straw).

Management input

The described intensification of production also entails higher management input. The panel refers to the following areas of action: crop monitoring, operation management, market observation, accumulation of know how by agronomy and business management consulting and on farm efficiency analysis.

– Annual labour quantity by the farm manager increase by 400 h/a (total 2,200 h/a).

– Payment reserves for farm advisory services increase by 5,000 €/a (total 10,200 €/a).

Yield response to scenario S-1

In consideration of the prevailing slight positive yield development during the investigation period, the panel estimated further marginal yield development with the complex application of the outlined adaptation strategies. The yield increase is considered to be time-depended with a constant rate of **one percent per annum** based on the average yield in the reference scenario (B-0).

The average yield increase of all crops by +1 % in scenario S-1 results in the following yield figures (rounded) for simulation:

– Sugarbeet (quota) 59.2 t/ha

– Sugarbeet (ethanol) 59.2 t/ha

– Winter wheat (SB) 7.9 t/ha

– Winter wheat (WW) 8.1 t/ha

– Winter Rapeseed 4.1 t/ha

– Winter wheat (WRa) 8.7 t/ha

The estimated production output potential of DE 1300MB influenced by changes in acreage and yield under scenario S-1 conditions amounts to **+1 % for wheat and rapeseed**. A comparison of the production output potential is found in Table A45 in the Appendix.

Scenario S-2 – Adjustments referring to DE 1300MB

Farm size

The general agricultural restructuring process is expected to be slightly decelerated in the Magdeburger Börde under the conditions of the high price scenario. Significant farm growth or cooperation leading to

– further increase of the cultivated land is not expected by the panel.

Furthermore, the current farm size is assessed being adequate to realise economies of scale and must not necessarily be increased to enable the implementation of further technological improvements.

Machinery investments

Beside the previously mentioned increase of the direct and operating input intensity machinery will be upgraded separately. The panel approves the replacement of the following units as a direct response to the high price conditions.

Boomspray (6,000 l tank capacity, 36 m working width, variable rate technology (VRT)). The assumed purchase is 140,000 €. Annual utilisation increases according to an additional fungicide application in cereals (+500 ha) while other depreciation details remain ceteris paribus.

– Increased operation performance for optimal execution of scheduled pesticide applications
– Increase of chemical application cost by 0.70 €/ha (+10 %).

Fertiliser spreader (36 m working width, individually operating partial widths, air stream distribution of spreading material, site specific variable rate application in combination with GPS and crop sensor). Purchase price is assumed 130,000 €. Other depreciation details remain ceteris paribus with the actual machine.

– Increasing input efficiency of mineral fertilisers and more precise timing of application
– Increase of fertiliser application cost by 2.20 €/ha (+55 %).

Harvesting capacity is evaluated critically. Beside one own combine harvester, the basis scenario incorporates contracted harvest of grain crops (approximately 300 ha). Possible losses and cost due to delayed harvest are assessed substantial under scenario conditions. However, optimisation potential is restricted with regards to divisibility of large machinery units.

Further adaptation potential is detected with the seeding component. Here panel participants do anticipate investments in more efficient seed placement and underground fertilisation. The upgrade of the seeding equipment will take place once current machinery is completely written off and can not be associated with the price scenario directly.

– No changes of the remaining machinery configuration

Irrigation systems

As already outlined, occasionally (one out of five years) occurring pre-summer aridity causes yield depressions in field crops grown in the Magdeburger Börde. On a limited regional scale this is encountered by using irrigation systems, especially in vegetable and food potato cultivation. Therefore individual farms need water rights which is not the case on DE 1300MB at this stage.

– The installation of irrigation systems is assessed not feasible since 1) the average yield response of crops in the current crop portfolio do not justify investments in irrigation and 2) the release of new permissions for water removal from ground water or open sources is virtually suppressed by the prevailing legal framework.[34]

Yield response to scenario S-2

The yield increase associated with the adjustments confirmed under scenario S-2 is considered to follow the previously determined constant growing rate of **one percent per annum** based on the average yield in the reference scenario (B-0) however, the activation is expected with a considerable time delay (assumption for calculations: five years).

Thus, the yield potential of all crops resulting from scenario S-1 will be fixed at +5 % in the scenario S-2 results in the following yield figures (rounded) for simulation:

– Sugarbeet (quota)	61.5 t/ha
– Sugarbeet (ethanol)	61.5 t/ha
– Winter wheat (SB)	8.2 t/ha
– Winter wheat (WW)	8.4 t/ha
– Winter Rapeseed	4.2 t/ha
– Winter wheat (WRa)	9.0 t/ha

The estimated production output potential of DE 1300MB influenced by changes in acreage and yield under scenario S-2 conditions amounts to **+5 % for wheat and rapeseed**. A comparison of the production output potential is found in Table A45 in the Appendix.

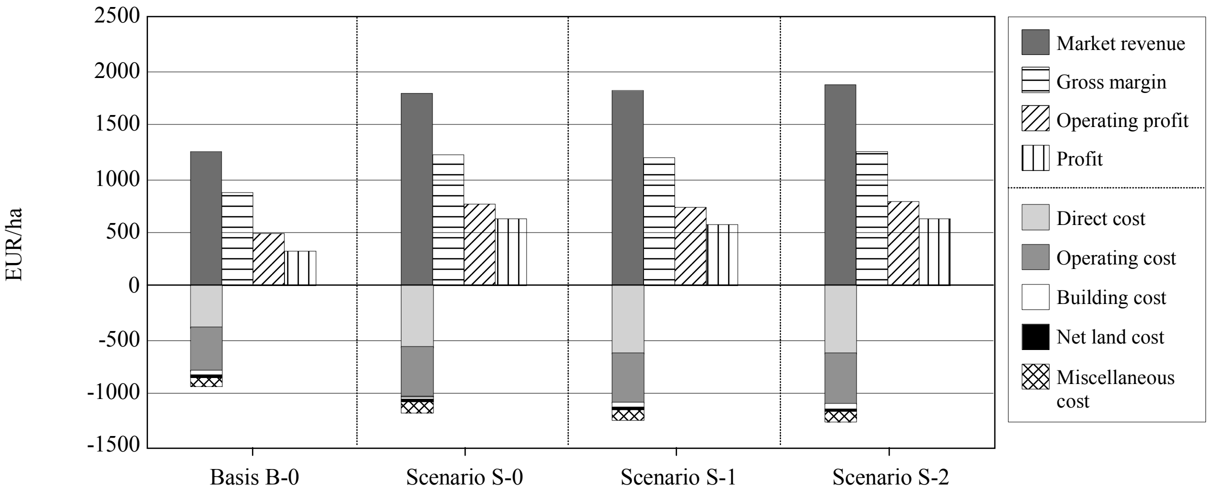
34 Legal framework: EU-Wasserrahmenrichtlinie (WRRL).

Farm level implications of adaptation strategies and perspective

The adaptation strategies and estimated yield developments have effects on the market returns, the cost structure of the production system and thus on the profitability of the typical farm. While detailed calculations can be found in Tables A17, A18 and A19 in the Appendix, key findings for the DE 1300MB are outlined in this section.

The following Figure 4.19 illustrates the development of key indicators of the typical farm DE 1300MB in the basis scenario (B-0) and under high price conditions (S-0 - S-2).

Figure 4.19: Cost, revenue and profitability indicators of the DE 1300MB cropping enterprise (€/ha) in the basis scenario (B-0) and under scenario conditions (S-0, S-1, S-2)



Source: Own calculation.

The high price scenario constitutes the largest dynamics in the farm performance when applied without adaptations (Scenario S-0).

Agronomical adjustments which are summarised in the scenario S-1 lead to increasing average production cost from 1,166 €/ha to 1,249 €/ha which is primarily due to increasing average direct cost (+53 €/ha) and fuel cost (+14 €/ha). Since adaptation measure lead to a rather marginal immediate yield increase, market revenues can not keep up with the cost and profitability indicators (gross margin, operating profit and farm profit) shrink. However, the total profit downturn from 610 €/ha to 565 €/ha can be evaluated vanishingly small, keeping the profit fluctuations in the investigation period in mind (Figure 4.16).

Structural upgrades executed in scenario S-2 lead to another marginal increase of operation cost by 14 €/ha compared to scenario S-1 which is predominantly caused by the specification of chemical and nutrient application. In the long run this trend is, however, rewarded by the yield increase and lead to an overall farm profit of 610 €/ha which is equal with the scenario S-0 without any adaptations.

For the typical farm in the Magdeburger Börde it can be concluded, that the high price scenario has significant positive effects on the profitability of the cropping enterprise. Possible adjustments incorporate a marginal yield increase of one percent per annum which rewards additional expenditures medium term.

The total costs of production per unit of output increase for wheat from 146 €/t in B-0 to 173 €/t in S-0 under high price conditions. The agronomical adjustments cause a further increase of average cost to 183 €/t in S-1 which can hardly be compensate to 177 €/t with the adjustments to the farm configuration in S-2. An analogue conclusion can be drawn for the production of rapeseed. Respective figures are displayed in Figure A26 and A27 in the Appendix. Hence, according to economic theory considerable doubt remains if all adjustment processes are carried out in the light of rising average cost.

Thus, adjustments carried out by the farm are net expenditures in the fertility and sustainability of the farms resources which are carried out in expectation of the long term profitability. However, the combination of agronomical and organisational adjustments causes increasing average total cost of 85 €/ha (+8 %) in the long run. Although this is presumably rewarded in an average year, the panel pointed out a prevailing production uncertainty with yield failures which might question the increased production intensity.

According to the panels expectations a further uncertainty must be considered in association with an aggregated high price level for commodities. This is caused by stronger price fluctuations for direct inputs and outputs threatening the profitability. Possible measure to deal with this are

– Consolidation of the farms storage facilities to store a) a certain share (approx. 25 %) of grain beyond the next harvest and b) a major share (approx. 50 %) of the amount of fertiliser applied per year.
– Augmented hedging of key input and output prices by means of respective instruments such as contracted production or futures trading.

Among the perspectives shared by the panel is also the strong transmission of the increasing profitability on regional land markets. The participating farmers expect an analogical response of land rents. Considering the high share of leased land (60 %) that implies a cash drain to the landowner reducing profit margins of the farming enterprise in the long run. Thus, the activation of cost saving potentials is key for the long term farm development strategy in the Magdeburger Börde.

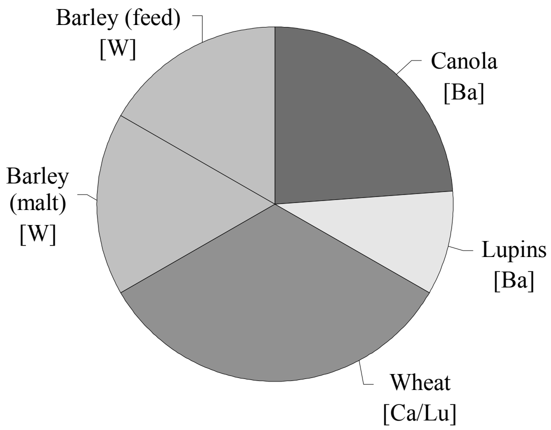
4.3 The West Australian typical farm on the South Coast

4.3.1 Status quo crop portfolio and production system

The cropping enterprise of the West Australian typical farm in the South Coast region is aligned on the production of cereals, oilseed and pulse. Figure 4.20 provides an overview about the acreage and percentage share of crops in the crop portfolio.

Figure 4.20 Acreage (ha), share in the crop portfolio (%) and yield (t/ha) of crops grown on AU 4500SC (Average 2005–2009)

Crop	Pre-crop	Acreage [ha]	Share [%]	Yield [t/ha]
Canola	Ba	1000	24	1.8
Lupins	Ba	400	10	1.6
Wheat	Ca/Lu	1400	33	2.7
Barley (malt)	W	700	17	3.0
Barley (feed)	W	700	17	3.0
Total acreage		4200	100	



Typical crop rotation:
Canola/Lupins -- Wheat -- Barley (3-year-cycle).
Note: Legend of diagram contains main crop name and the abbreviation of the pre-crop in square brackets.
Source: Own illustration.

The typical crop portfolio of typical farm AU 4500SC has a relatively fixed relation of 1/3 broadleaf crops (canola[35] and lupins) versus 2/3 cereals (wheat and barley). The typical crop rotation of these crops is the following:

Canola/Lupins – Wheat – Barley

according to the general rotation frame broadleaf – cereal – cereal.

Further insights about the cropping operations are found by focussing on the production system of the individual crops. This section will concentrate on the production of the major crops wheat and canola as these crops can also be found on the other typical farms in this comparison.

[35] The term “canola” refers to the Australian denomination for 00-rapeseed varieties (*Brassica napus* L.) which are low in erucic acid (below 2 %) and glucosinolates content. This term will be used for denominating Australian “double low” rapeseed in this thesis. Further information on canola is found in OGTR (2002).

Wheat production

Wheat is the dominating crop on AU 4500SC. The share of wheat in the cropping portfolio amounts 33 % referring to the diagram in Figure 4.20. Wheat is either grown on canola or lupins. However, the production system is not further differentiated due to the equal positive preceding crop value of both crops.[36] Respective fieldwork passes of the production system are illustrated in Figure 4.21.

Figure 4.21 Production system of wheat on AU 4500SC and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost [EUR/ha]	Operating cost [EUR/ha]
1	beg 01	Spraying	Total herbicide	6	4
2	mid 04	Spraying	Total herbicide	3	4
3	end 04	Spraying	Total herbicide	9	4
4	beg 05	Seeding NO-TILL	Airseeder (discs) + FlexiN (mineral) N22 + fungicide	36	26
	beg 05	Fertilizer	+ DAP (mineral) N10 P15	27	
5	end 05	Plant protection	Selective herbicide	9	4
6	mid 08	Fertilizer	Urea (mineral) N28	19	8
7	mid 09	Plant protection	Fungicide	6	4
8	mid 11	Harvest	Combine harvest		29
9	mid 11	Transport	On field transport (chaser bin)		8
10	mid 11	Transport	On road transport (truck)		8
			Total	115	82

Summary				
Crop		Winter wheat (following canola/lupins)		
Tillage		No-Till seeding		
Seed	kg/ha	80	14	EUR/ha
Fertilisation	Nutrient kg/ha	N60 P15 K0 CaO0 Mg0 S0	65	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (2), insecticide (0), other (0)	36	EUR/ha
Yield	t/ha	2.7		

Source: Own calculation.

The single fieldwork passes are categorised in the following sections. Hereby the production processes and agronomical causalities are explained in more detail before focussing on the economics of production.

No-Till seeding

No-Till production system incorporating direct seeding are widely adopted in Western Australia and well established especially in the South Coast region. The reasons given by growers for adopting no-tillage are soil conservation and improved sowing timeliness.

[36] Estimate for canola is found in Section 4.2.1; lupins accumulate nitrogen due to leguminous plant.

However, herbicide resistance and weed control issues are critical (D'EMDEN and LLEWELLYN; 2006).

Key operation of No-Till on AU 4500SC is the seeding pass at the beginning of May. Two components of fertiliser are applied: Liquid fertiliser (FlexiN 32 % N) and granulated DAP. Both are applied in the furrow opened by disc for minimum disturbance. Seed is placed on top of the fertiliser depot and incorporated with a soil effective fungicide. Integrative component of the No-Till technology is chemical weed control carried out before seeding (see below).

The optimal date for the start of the seeding season in Western Australia is determined by the beginning of the winter (wet season). In average years this is marked by sufficient rainfall (season break rainfall) creating optimal seedbed conditions. On the other hand, growing period of broadacre crops is limited to six month (Figure 4.20) and delayed seeding cause severe yield decline. In appreciation of this investment, the agronomical risk assessment incorporates two options:

1. seeding only after a sufficient rainfall to achieve optimal seedbed and germination conditions. This may involve overrunning the optimal seeding window and accepting yield decline or a change of the cropping program in favour of cereals.
2. seeding irrespective of the soil moisture in expectation of rainfall (dry seeding), the certain accomplishing of the seeding program with the thread of non-appearing rainfall inducing crops to germinate.

In consideration of relatively stabile rainfall distribution[37], the panel agreed on an average share of 50 % of all crops on AU 4500SC being seeded dry. During the investigation period there has been no complete failure of single crops due to late seeding or rainfall deficiency.

Since there is a relative certainty about the natural conditions at the beginning of the growing period, the typical farm AU 4500SC established a complex blend of crop inputs applied with the seeding pass leading to 63 €/ha direct cost which equals 55 % of the total direct cost of wheat production.

Fertilisation program

A sufficient amount of nitrogen and phosphorus is applied with the seeding pass as a start up application. While urea is predominantly used as the nitrogen source in the recent past, FlexiN (liquid urea and ammonium nitrate solution) has been established, mainly due to the more precise application and easier handling. (LOSS et al., 2001)

---

[37] Cp. Section 3.3.1.

A further top dress application with urea is carried out by mid August to supply nitrogen crops during flowering (BBCH 6). The total nutrient quantity is calculated in relation to crops nutrient absorption:[38] Due to the acidic and high acidic reaction of soils in the study region, principal lower rates of nutrients are available for plant uptake. Thus, the assumed factor for target fertilisation in wheat is 1.5 of crop's removal. Further leaf dressing is carried out occasionally with the fungicide application if favourable seasonal conditions prevail but is not considered to be typical.

Plant protection program

The plant protection program is strongly dominated by **herbicide** applications, in particular total herbicides before seeding. Total herbicides are applied on the seasonal fallow after harvest until seeding as a strategy to control weeds and emerging seeds to limit water losses (FREEBAIRN, 2010; BROWNE, 2011).

The high input intensity became relevant as a response to herbicide resistances developed by grass weeds. Perennial ryegrass (*Lolium rigidum G.*) has established the most critical herbicide resistance. Since first indications of resistances against common groups[39] of herbicides have been reported by GILL (1995) the situation has changed dramatically. According to the panel, ryegrass can actually not be controlled with any grass selective herbicides in cereals and broadleaf crops. This lead to different weed management strategies (LLEWELLYN and POWLES, 2000):

- Burning of crop residues – therefore chaff output from the combine is collected in rows brought to patches on field which are burned after harvest to destruct ryegrass seeds. However, this is seen critical due to collision with conservation farming practices and the inevitable loss of organic matter.
- Affected land is dedicated to perennial pasture (three to four years) and grazed with livestock to break resistances. While this is only applicable to mixed farming systems it can still be a profitable land use strategy since ryegrass has a decent nutritive value.
- Potential utilisation of herbicide tolerance crops to get independently from selective herbicides in the weed control regime
- Intensive total herbicide (glyphosate) regime incorporating several applications and high active substance input) to kill remaining ryegrass seeds before seeding.

The latter measure is still appropriate in the case of AU 4500SC. However, the region is actually considered to be moderately affected and further reinforcement of the herbicide

---

[38] Cp. Tables A10 and A11 in the Appendix.

[39] E.g. Chlorosulfuron (triazinylsulfonylurea herbicides) or Diclofop (aryloxyphenoxypropionic hebicides).

resistances of ryegrass and other grasses are expected. At the time of the investigation Brome grass varieties (*Bromus Sp.*) show first indications (PENFOLD, 2011).

Beside the pre-seed total herbicide, there is a further selective herbicide applied by end of May to control various broadleaf weeds.

Fungal disease pressure requires one optional flag leaf **fungicide** spray in September (BBCH 7) according to seasonal conditions. The following fungal leaf pathogens are of relevance: Septoria Leaf Blotch (*Septoria tritici*), Take-all (*Gaeumannomyces graminis* var. *tritici*) and Wheat stem rust (*Puccinia graminis* f.sp. *tritici*). Further information about these pathogens live cycle biology and yield damage potential is found in LOUGHMAN et al. (2000).

Harvest and handling

Wheat harvest usually takes place from end of November to beginning of January. Under the described production intensity a five-year-average crop yield of 2.66 t/ha is realised on AU 4500SC. The harvest operations listed in Figure 4.21 include the transport on field, short term storage[40] and on road transport to the cooperative storage facility.

The herewith introduced production system can in principle be generalised for the cereal production on the typical farm. Minor changes in the timing of single passes can be found in the production of **barley** for feed and malt equalling 1,400 ha (34 % of the arable land).

Remarkable difference is the greater yield performance of barley which averages 3.0 t/ha. Better adaptation to dry and warm conditions in September and the general disposition of lower protein contents of the grain in favour of vegetative growth are dominating among the estimates of the panel. The respective production system can be found in Figure A13 in the Appendix.

Production of canola

The dominating broadleaf crop by acreage is canola which is typically grown on 24 % of the arable land (grey body in Figure 4.20). On AU 4500SC canola is typically grown in a triennial frequency following barley to manage its self-intolerance.

After having some experience of canola production in the area, panel participants assessed the current share to be typical but not the maximum. There are farms in the district resigning from lupins and dedicating more land to canola.

---

[40] Cp. Section 4.1.4.

Due to the "virginity" of the land, negative yield effects due to rising disease pressure have are not reported yet. The panel assesses considerable expansion potential for the area planted with canola. The typical production system in the high rainfall South Coast region is illustrated in the following (Figure 4.22).

Figure 4.22 Production system of canola on AU 4500SC and physical direct inputs differentiated by month and type of operation

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost [EUR/ha]	Operating cost [EUR/ha]
1	mid 01	Soil testing			
2	beg 04	Spraying	Total herbicide	9	4
3	mid 04	Spraying	Total herbicide	8	4
4	end 04	Seeding NO-TILL	Airseeder (discs) + FlexiN (mineral) N16	15	26
		Fertilizer	+ DAP (mineral) N12 P20	35	
5	end 05	Plant protection	Selective herbicide + insecticide	15	4
6	end 08	Plant protection	Fungicide	6	4
7	end 08	Fertilizer	Blend of Urea (mineral) N37 +	26	8
		Fertilizer	NS-42 (mineral) N7 S2	6	
8	end 10	Swathing	Cut and windrowing of crop		22
9	mid 11	Harvest	Pick-up harvest		29
10	mid 11	Transport	On field transport (chaser bin)		8
11	mid 11	Transport	On road transport (truck)		8
			Total	120	49

Summary				
Crop		Canola (following barley)		
Tillage		No-Till seeding		
Seed	kg/ha	5	2	EUR/ha
Fertilisation	Nutrient kg/ha	N72 P20 K0 CaO0 Mg0 S2	80	EUR/ha
Chemicals	Applications	Herbicide (3), fungicide (1), insecticide (2), other (0)	39	EUR/ha
Yield	t/ha	1.8		

Source: Own calculation.

Production of canola principally incorporates the same fieldwork passes as of wheat. However minor changes can be found in the following sections:

No-Till seeding

Crop varieties planted in the reference scenario are line varieties and seed is most commonly reproduced and treated on farm. Breeding innovation is introduced by a small percentage of certified seed (5 %). This coincides with low seed cost observed with canola.

Fertilisation program

Fertilisation intensity tends to be higher compared to wheat due to the physiological demand of canola[41]. On top of the increased nitrogen and phosphorus input, top-up fertilisation contains a sulphur component to meet requirements of protein and glucosinolates synthesis.

Plant protection program

Common fungal diseases of canola in the South Coast area are Downy mildew (*Peronospora brassicae*) and Blackleg (*Leptosphaeria maculans*). While the latter one caused heavy damages in the past, both fungal diseases are not decrementing yield significantly due to **fungicide** application and blackleg resistant varieties (CSIRO, 2004).

Harvest and handling

Harvest of canola is split in two independent operations. The first pass is carried out to cut and windrow the crop in BBCH 84 – 86 when 40 to 60 percent of seeds in the main stem have changed colour and start ripening. After 3 weeks of further ripening and drying windrows are harvested using pickup-front mounted to a conventional combine harvester. Canola yields 1.8 t/ha on average.

Windrowing aims to balance crop seed maturity and even drying against the risk of pod shattering and seed loss as the crop matures. However, once the crop has been windrowed, there is limited opportunity for the seeds to develop which leaves the potential for further technical improvements. Trials carried out in various canola growing regions showed significant positive effects of delayed windrowing, desiccation and also direct harvest of the standing crop (NORWOOD, 2011):

Hence, reassessing the harvest operation of canola might be an option for further development of the canola production system on the typical farm.

A further broadleaf crop in the portfolio is **lupins** which accounts for 10 % of the total arable land (Figure 4.20). Due to a rather marginal fertiliser input, the production of lupins is less intensive compared to the previously introduced crops. The five-year-average crop yield is 1.6 t/ha. An illustration of the production system can be found in Figure A14 in the Appendix.

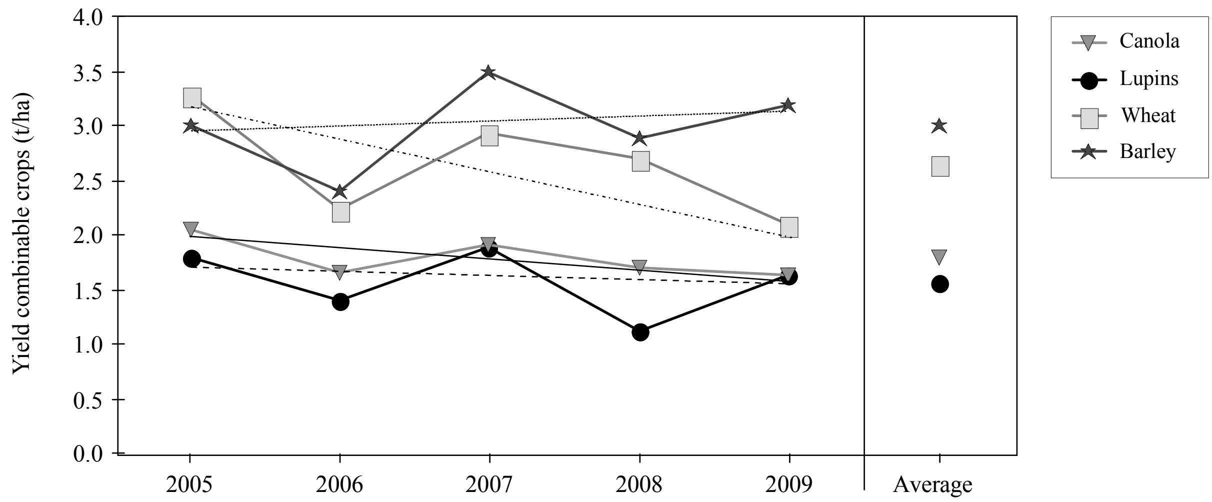
---

41 Fat synthesis requirements and typical fat acid pattern of rapeseed cp. SCHILLING (2000).

Evolution of crop yields and estimation of production uncertainty

The interaction of natural conditions in the South Coast region with the production systems resulted in the following crop yields of the typical farm in individual years. (Figure 4.23)

Figure 4.23: Evolution of crop yields (t/ha) and five year average (2005–2009) of AU 4500SC



Source: Own calculation.

Crop		Canola	Lupins	Wheat	Barley
Precrop		Barley	Barley	Canola/Lupins	Wheat
Ø 2005-2009	t/ha	1.80	1.58	2.66	3.00
Max[1)]	t/ha	2.05	1.90	3.30	3.50
Min[1)]	t/ha	1.65	1.13	2.10	2.40
CV[2)]		0.10	0.20	0.19	0.14

1) Maximum and minimum yields in the observed period.
2) Coefficient of variation.

The graph indicates the following properties of the crop yield pattern relevant for this investigation:

- Crop yields of wheat, canola and lupins appear to tend negatively (descending linear trend line) during the investigation period, whereas a positive indication can be observed with barley.
- Crop yields fluctuate differently compared to their respective yield level during the observed harvest years (cp. internal CV in Figure 4.23). These figures indicate a considerable production uncertainty especially with lupins respectively wheat and barley to a certain extend.

Acknowledging the limited explanatory power of the statistical indicators generalisation from this data are certainly not feasible. However, abovementioned indications regarding the agronomical performance influence the position of the panel participants and have to be considered when interpreting results.

4.3.2 Profitability analysis and production cost

The previously introduced detailed production systems of AU 4500SC cover the main agronomical framework. In the following section the focus is set on the profitability of production on the West Australian typical farm in the South Coast region.

The following Table 4.19 summarises the total cost account of single crops on a per hectare basis and ordered by the individual crop's gross margin contribution. The final column (grey shaded) refers to the average farm performance of the cropping enterprise of AU 4500SC per hectare cropped land computed by means of the acreage-weighted figures of single crops.

Market revenues of single crops are relatively even between the crops in the portfolio. The revenue of canola is the highest and ranges about 500 €/ha. Cereal revenues are between 400 €/ha and 470 €/ha and lupins follow at about 260 €/ha. The average farm revenue is in the range of wheat at 424 €/ha.

The highest net revenue over direct cost (gross margin) in the cropping portfolio is generated by canola followed by malting barley. Wheat and feed barley are almost equal in gross margins followed by lupins which perform with considerable distance to the other crops. However, a considerable preceding crop value is linked to the production of lupins justifying its further position as a risk management strategy to diversify the cropping portfolio. The average gross margin amounts to 295 €/ha.

In terms of operating profit the gap between canola and cereals narrows due to the relative intensive machinery input (harvest) and allocation of overhead labour cost to the higher returns of this crop. The average operating profit during the investigation period adds up to 172 €/ha.

Table 4.19: Profitability of single crops and farm average AU 4500SC (2005–2009)

Crop		Canola	Barley (malt)	Wheat	Barley (feed)	Lupins	Farm average
Previous Crop		Barley	Wheat	Canola	Wheat	Barley	
Acreage	ha	1,000	700	1,400	700	400	4,200
Crop yield	t/ha	1.8	3.0	2.7	3.0	1.6	
Output price	EUR/t	279	156	152	132	165	
Market revenue	**EUR/ha**	**502**	**468**	**405**	**397**	**261**	**424**
Seed	EUR/ha	2	10	14	10	19	10
Nitrogen (N)	EUR/ha	53	45	45	45	4	43
Phosphorus (P)	EUR/ha	26	21	21	21	13	21
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	1	0	0	0	0	0
Fertilizer (total)	EUR/ha	80	65	65	65	17	64
Herbicides	EUR/ha	24	27	27	27	30	26
Fungicides	EUR/ha	6	12	9	12	0	9
Insecticides	EUR/ha	9	0	0	0	7	3
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	39	39	36	39	37	38
Crop establishment cost	**EUR/ha**	**120**	**115**	**115**	**115**	**73**	**112**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	4	4	3	2	2	3
Other	EUR/ha	10	10	10	10	10	10
Finance field inventory	EUR/ha	4	4	4	4	2	4
Total direct cost	**EUR/ha**	**137**	**132**	**132**	**131**	**87**	**129**
Gross margin[1)]	**EUR/ha**	**365**	**336**	**274**	**266**	**174**	**295**
Labour	EUR/ha	28	26	26	26	24	26
Contractor	EUR/ha	3	2	2	2	2	2
Machinery	EUR/ha	88	72	72	72	66	75
Diesel	EUR/ha	18	17	17	17	15	17
Other	EUR/ha	3	2	2	2	1	2
Total operating cost	**EUR/ha**	**139**	**120**	**120**	**120**	**109**	**123**
Operating profit[2)]	**EUR/ha**	**226**	**216**	**154**	**146**	**65**	**172**
Building cost	EUR/ha	8	7	6	6	4	7
Total land cost	EUR/ha	60	60	60	60	60	60
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	60	60	60	60	60	60
Miscellaneous cost	EUR/ha	12	11	9	9	6	10
Total cost	**EUR/ha**	**356**	**330**	**327**	**326**	**266**	**329**
Profit[4)]	**EUR/ha**	**146**	**138**	**78**	**71**	**-5**	**95**

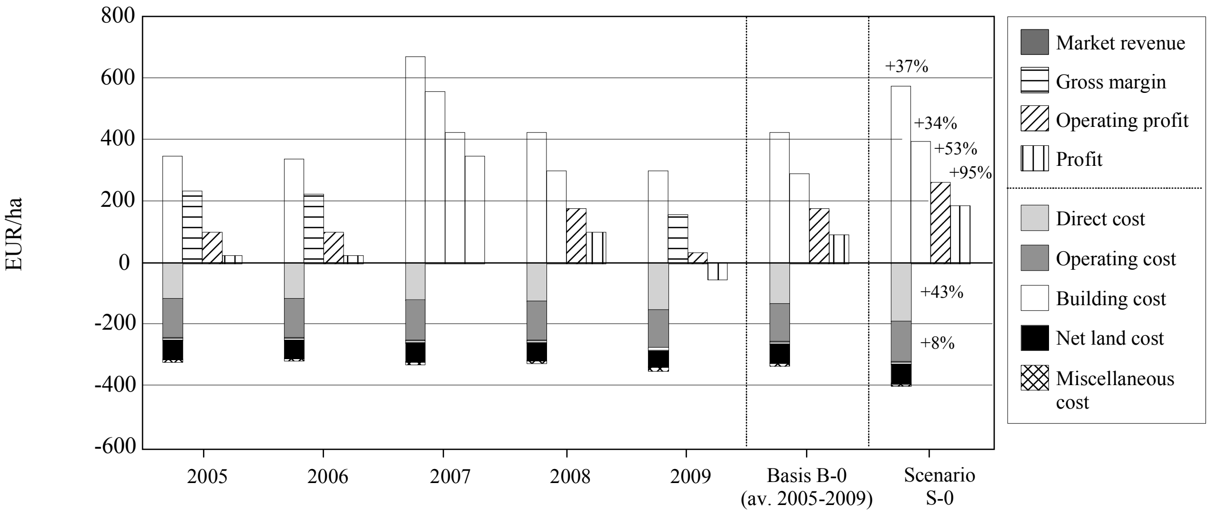
1) Gross margin = Net revenue over direct cost.
2) Operating profit = Net revenue over direct and operating cost.
3) Net land cost = Total land cost reduced by decoupled payments.
4) Profit = Net revenue over total cost.
Source: Own calculation.

The profit per hectare which is presented in the bottom line of Table 4.19 is computed considering net land cost (which corresponds to the total land cost due to the absence of any subsidies). It is concluded, that all cropping activities of the typical farm (except lupins) are profitable and cover their total cost, while canola and malting barley perform outstandingly compared to the remaining crops in the portfolio. The average profit of AU 4500SC is 95 €/ha. The typical farm averaged a profit margin[42] of 22 % during the investigation period from 2005 to 2009.

Based on these findings it is necessary to investigate further, how the economics of production developed in single years during this time period and how the high price scenario would influence the performance of the farm per se without any adaptations. The respective findings are described in the following by means of the Figure 4.24.

The underlying calculations are found in Table 4.19 and in Tables A21 to A26 in the Appendix.

Figure 4.24: Cost, revenue and profitability indicators of the AU 4500SC cropping enterprise (€/ha) in selected years, 5-year average (2005–2009) and under scenario conditions (Scenario S-0)



Note: 1) Net land cost calculation incorporates decoupled payments.
2) Percentage figures typify the increment (delta) of selected positions based on basis scenario B-0.
Source: Own calculation.

The figure illustrates selected economic indicators for the typical farm AU 4500SC in different temporal dimensions. Firstly, single years of the investigation period are displayed and based on this the following conclusions are drawn:

[42] Average profit margin (return on sales ROS respectively) = profit / market revenue.

– The typical farm is able to cover the total cost of the crop production enterprise in four out of five years in the investigation period. While 2005 and 2006 averaged approximately 25 €/ha, in 2007 substantial equity (350 €/ha profit) is gained. The latter effect is caused by both above average yields in all crops[43] and high commodity prices. High output prices also level average yields in 2008 resulting in an average profit of 100 €/ha. In the following year revenues are under pressure especially by poor crop performance of wheat and are cut back to the level of 2005 and 2007. The typical farm is not able to remunerate all factor cost and generated net losses of –42 €/ha.
– From 2005 to 2008 total cost of production and the cost structure is relative stabile at a level of 320 €/ha. In 2009 a moderate cost increase of 25 €/ha (+7 %) is observed which is assessed being a time delayed effect of the previous high commodity price period.

The basis scenario (B-0)[44] established using the five-year-average figures from 2005–2009 eliminates the individual price and yield bias. In the following section this provides the general reference farm situation for further analysis. In a first step the high price scenario[45] underlying for this study is adapted without any changes to the production system or farm configuration. The economic effect of this scenario (S-0) is also illustrated in Figure 4.24 and can be assessed as the following:

– The high price scenario results in a significant increase of the gross and net return figures. Although income indicators are significantly above the average of the last five years, margin and profit situation is below the exceptional harvest year 2007.
– The observed gap between market returns, gross margin and operating profit respectively is caused by a significant increase of production cost, in particular direct cost (+43 %). As in the previous case of the typical farm in the Magdeburger Börde this can be traced back to the increasing prices for energy related inputs, especially fertiliser and fuel.
– Building cost, net land cost (incl. decoupled payments) and miscellaneous cost do not vary between B-0 and S-0 since the reference farm setup is considered ceteris paribus.

With regard to the differentiating production systems incorporating varying direct and operational inputs (which have been described in greater detail in the previous section), the observations above lead to the assumption, that single crops performance might

43 Cp. Figure 4.23.

44 An overview over the specific scenario configurations can be found in Chapter 2.4.1 in Table 2.2.

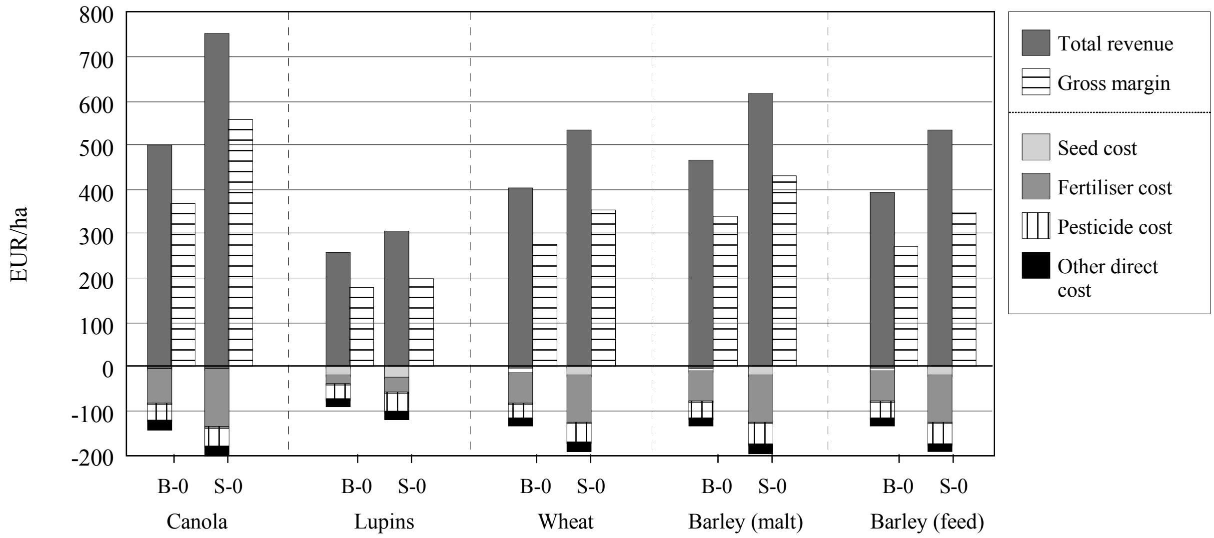
45 The relevant scenario prices for AU 4500SC can be found in Table A50 in the Appendix.

response differently to the high price scenario. This issue will be addressed in the following.

Direct cost and gross margin

The Figure 4.25 displays the single crops market revenues, direct cost and gross margins of AU 4500SC in the reference scenario (B-0) and under high price conditions (S-0). Respective calculations can be found in Table 4.19 and Table A26 in the Appendix.

Figure 4.25: Comparison of revenue, direct cost structure and gross margin (€/ha) of major crops on AU 4500SC, reference scenario (B-0) vs. high price scenario (S-0)



	Canola	Lupins	Wheat	Barley (malt)	Barley (feed)
Gross margin response	+52 %	+11 %	+28 %	+27 %	+29 %

Source: Own calculation.

All crops in the portfolio are able to gain significant increments in gross margins. The strongest response (+52 %) can be observed at canola which benefits from the strong price increase within the scenario compared to the other crops in the comparison. Hence, canola bears up the competitive position in the cropping portfolio and even widens the gap to wheat and barley. Gross margins of the latter ones respond relatively uniform (approx. +28 %).

Although production of lupins makes up ground under the high price scenario, its gross margin contribution remains on a low level. The gross margin gap to the alternative crop within the broadleaf segment (canola) increases from 191 €/ha to 364 €/ha. Thus, the preceding crop value and the acreage are to be critically evaluated in favour of canola when discussing adaptation strategies in the next section.

Operating cost and operating profit

Increasing operating cost are exclusively linked to rising prices for fuel and other energy sources under the high price scenario. Other cost positions (labour, machinery and contractor cost) are considered ceteris paribus.

Since production systems of the individual crops are identified being relatively uniform, the increase of operating cost shows no substantial differences between single crops (+8 % in each case). Hence, the relative on-farm competitiveness identified above is not thwarted by substantial differences in operating profits.

The respective illustration can be found in Figure A15 in the Appendix.

4.3.3 Analysis and assessment of adaptation strategies

The following section presents adaptation strategies of the typical farm AU 4500SC to cope with the effects of the high price scenario discussed in the previous section. They refer to the estimation of the respective farmer panel held in the South Coast region of Western Australia and are categorised in:

1. agronomical adjustments of the cropping program under high price conditions (scenario S-1)
2. adjustments to the general farm configuration under high price conditions (scenario S-2)

Scenario S-1 – Adjustments referring to AU 4500SC

Crop portfolio adjustments

The application of the high price scenario to the typical farm (scenario S-0) resulted in a shift of gross margin relations. While cereal production would remain relatively stabile, gross margins of canola developed disproportionally strong to the detriment of lupins which are already identified being the weakest crop in the reference scenario (B-0) in terms of gross margin. Given the latter two crops are broadleaf and can possibly substitute each other in the cropping rotation, an adjustment of the cropping rotation in favour of canola can be assumed according to economic theory.

Yet, the panel shared the opinion that an increase of canola is feasible. Under scenario conditions a short term extension of the canola acreage would be anticipated. The following modifications are assessed feasible:

- Increase of land planted to canola from 1,000 ha to 1,100 ha (+10 %). Thereof 500 ha switched from line varieties to hybrid canola of which 100 ha are planted to GM Roundup Ready canola (see below).

- Decrease of land planted to lupins from 400 ha to 300 ha (-25 %).
- Wheat and barley acreage ceteris paribus to basis scenario (B-0).

In the long run rotation would be switched back to initial setup. The timely restriction is not foreseeable at this stage and linked to possible yield losses due to the self intolerance of canola.

Tillage system

The No-Till system and direct seeding are proven reliable on AU 4500SC. The Panel does not anticipate any adjustments with the existing machinery configuration under scenario S-1 conditions.

- No changes.

Seed technology

Given the substantial performance of canola, the panel agrees on a certain share of hybrid varieties planted and acknowledges higher seed cost.

- Planting of hybrid canola varieties on 50 % of the land dedicated to canola in S-0 (500 ha) and increase of seed cost on this land from 2 €/ha to 46 €/ha due to external purchase obligation.

However, since the WA government announced an exemption to its GM crop moratoria legislation in early 2010 to allow GM canola traits planted commercially, GM canola acreage has skyrocket in the first year totalling 70,000 ha (8 % of total canola acreage) to be harvested in the same year (FITZGERALD, 2010).

Farmers in the panel see significant benefits from GM canola for weed resistance management and would anticipate growing GM canola varieties where hybrid varieties proof substantial yield improvement. A minimum of +0.2 t/ha would remunerate for technology fee (2.2 €/kg seed) and endpoint royalty (8 €/t output) of GM varieties.

- A percentage share of 20 % of the hybrid canola (see above) would be Roundup Ready canola. However the adaptation of GM crops is **not** linked to the potential price scenario underlying for this study but also a tactic to manage herbicide resistant weeds under reference conditions (B-0).

The expected price increase for cereal and lupins seeds has already been considered by a 20 % increase of seed prices applied to all crops in scenario S-0.

- Seeding configuration of cereals and lupins ceteris paribus.

Fertilisation intensity

The simulation of direct cost under S-0 scenario conditions discloses a significant vulnerability of the cropping enterprise. Hence, efforts concentrate on increasing efficiency of mineral fertilisation instead of increasing fertiliser rates.

– Fertiliser application in cereals: substitute granulated urea (1.07 €/kgN) in top-dress application with liquid Flexi-N (1.30 €/kgN) in combination with preventative fungicide; remove spreading pass (-8 €/ha operating cost).
– Fertiliser application in broadleaf crops ceteris paribus.
– Payment reserves for plant and soil analytic measures (soil testing, nitrogen leaf tests, 'N rich' strips[46]): 2,000 €/a.

Plant protection intensity

Pesticide applications on AU 4500SC are generally curative measures carried out if crops show indications of infection. Under scenario conditions strategy will also incorporate preventative tactics. The panel agrees on the following:

– Plant protection in cereals: substitute optional flag leaf application in September with standard preventive fungicide sprayed with nitrogen top-dress at beginning of August during flowering (BBCH 6, see above), fungicide cost 10 €/ha.
– More effort to control weeds in summer fallow and increase water use efficiency: One more total herbicide application prior to conventional canola, herbicide cost 10 €/ha.
– Pesticide benefit of Roundup Ready canola amounts to 15 €/ha.
– Greater rates of active ingredients applied especially with herbicides and more complex mixtures of active ingredients to control resistances. Increase of existing selective herbicide expenditures by +20 % in all crops.

Selling of wheat straw/oaten hay

Increasing removal of organic matter from paddocks is not feasible due to fragile soil structures in relative proximity to the coast and the potential loss of long term nutrient depot (soil organic matter). Furthermore, the panel does not see an emerging market for industrial use of straw.

Oaten hay export to Asian countries became relevant in Western Australia. However, hay is primarily sourced in the more marginal wheat/sheep zone in the Central Wheatbelt[47] and is not expected to shift in the high rainfall South Coast.

– No selling of by-products from agricultural commodities (straw) or oaten hay.

---

[46] "N rich" strips is a decision-support tool for in-season nitrogen applications cp. D'EMDEN (2010).

[47] Cp. Typical farm AU 4000WB.

Management input

The described intensification of production also entails higher management input. The panel refers primarily to crop monitoring and agronomy advisory.

– Annual labour quantity by the farm manager increase by 200 h/a (total 2,200 h/a).
– Agronomy service is accounted for with payment reserves for plant analytics.

With regard to the increasing operational input, the existing machinery set may restrict carrying out time sensitive operations on schedule. To prevent efficiency losses, selected operation are sourced out to contractors. This may adumbrate crop spraying (partly by aeroplane), windrowing of canola, transport and logistic.

– For the simulation various contractor services are budgeted at 5 €/ha in canola and cereals.

Yield response to scenario S-1

In consideration of the prevailing yield level during the investigation period the panel estimated a marginal yield improvement with the complex application of the outlined adaptation strategies. The yield increase **under average climate conditions** is considered to be 0.1 t/ha in conventional canola (+5 %), 0.3 t/ha in hybrid canola (+17 %), 0.25 t/ha in cereals (+9 %) and nil in lupins based on the average yield in the reference scenario (B-0).

These results in the following yield figures for the simulation of scenario S-1:

– Canola 1.90 t/ha
– Canola (hybrid) 2.10 t/ha
– Lupins 1.60 t/ha
– Wheat 2.95 t/ha
– Barley 3.25 t/ha (no shift in ratio of feed versus malt)

The estimated production output potential of AU 4500SC influenced by changes in acreage and yield under scenario S-1 conditions amounts to **+11 % for wheat**, **+22 % for rapeseed** and **+8 % for barley** to the detriment of pulses (-24 %). A comparison of the production output potential is found in Table A45 in the Appendix.

Scenario S-2: Adjustments referring to AU 4500SC

Farm size

The panel considers the farm size to remain constant as in the reference situation (B-0).

Crop portfolio adjustments

The panel shared the opinion that an increase of canola is feasible short term. However, under scenario S-2 conditions the rotation is switched back to the initial setup to prevent negative impacts on the crop performance of canola being the main supporting pillar of the cropping enterprise of AU 4500SC:

– Shift back to initial crop rotation set up: 1,000 ha of canola (cp. B-0) however, incorporating 400 ha of hybrid canola and further 100 ha of GM Roundup Ready canola.
– Area of land planted to lupins is 400 ha (cp. B-0).
– Wheat and barley acreage ceteris paribus to basis scenario (cp. B-0).

Machinery investments

Beside the previously mentioned adjustments of the direct and operating input intensity machinery will be upgraded separately. The panel approves the replacement of the following units as a direct response to the high price conditions:

Airseeder – 18 m working width, variable rate technology (VRT) for site specific application of seed and two separate fertilisers, deep blade system (DBS) replacing the currently utilised disc seeding unit.[48] At the heart of the DBS is a precision seeding three slot system. The first slot breaks through hardpans to create moisture and air pathways, the second slot sees the seed placed at a precise depth in disturbed but stabilised soil, while the third slot is more commonly described as the water harvesting trench. The slot is finally closed by a press wheel (AUSPLOW, 2011).

This system is actually favoured by the panel farmers since they see a yield benefit with a slightly deeper cultivation (+2 cm). The Airseeder comes with a tow behind three component seedcart. The assumed purchase price for this unit is 280,000 €. All other depreciation details remain ceteris paribus with the current machine.

– Considerable intensification of the tillage program by increasing working depth of the seeding pass by +2 cm. Fuel consumption of the seeding pass 10 l/ha instead of 8 l/ha, and increased acreage performance (+20 %) results in increasing operation cost of the seeding pass by 2.70 €/ha
– VRT increases fertiliser application efficiency and enables saving of 5 kgP/ha.

[48] Cp. Section 4.1.3.2.

Tractor – With the seeder usually the towing unit is changed over. Farmers assess a caterpillar tractor on tracks in the largest horsepower category to be adequate with the new Airseeder.

– Tractor upgrade to a 600 hp caterpillar tractor, GPS auto steering, ISO bus application. Purchase price is assumed 230,000 €. Other depreciation details remain ceteris paribus with the actual machine.

No further changes of the remaining machinery configuration.

Land improvement

Under high price conditions farmer do consider long term investments to secure sustainable production. Appropriate measures would be

– Payment reserve for drainage of land tending to water logging of 2,000 €/a.

– Increase effort of lime (85 %CaO) spreading to support soil structure and lift soil pH of light land (input 2 t lime per hectare at 7 €/t; logistic and spreading done by contractor costing 45 €/ha; estimated acreage approximately 200 ha/a totals 12,000 €/a). The investment is considered being a long term land improvement, lifting soil pH on treated land by 0.4 depending on current status.

Management and labour input

The described intensification of production also entails higher labour and off-farm services input. The panel refers primarily to machinery operation and upgrade of necessary digital farm information for VRT implementation and marketing support.

– More off farm labour (additional 200 h input from seasonal labour) to release farm manager.

– Payment reserve for on farm data services (4,000 €/a) to facilitate precision agronomics such as EM38 soil scanning, soil testing and yield mapping.

– Employ professional off-farm grain marketing service at 6,000 €/a.

Farm buildings

The farm’s building configuration will be extended by a bunker storage facility to host approximately 750 t of grain. The panel does not anticipate storing grains long term but during harvest as a reloading point to blend batches according to required quality and to overcome delivery shortages at the local grain bin to keep up with combine output.

– Single investment of 60,000 € in flat roofed bunker silo, depreciation period 30 years.

Yield response to scenario S-2

In consideration of the adjustments, relevant for yield performance the panel estimated a marginal yield improvement with the complex application of the outlined adaptation strategies. The yield increase **under average climate conditions** is considered to be 0.15 t/ha in conventional canola (+8 %), 0.35 t/ha with planting of hybrid canola (+19 %), 0.3 t/ha in cereals (+10 %) and nil in lupins based on the average yield in the reference scenario (B-0).

This results in the following yield figures for the simulation of scenario S-2:

– Canola 1.95 t/ha
– Canola (hybrid) 2.15 t/ha
– Lupins 1.60 t/ha
– Wheat 3.00 t/ha
– Barley 3.30 t/ha (no shift in ratio of feed versus malt)

The estimated production output potential of AU 4500SC influenced by changes in acreage and yield under scenario S-2 conditions amounts to **+13 % for wheat**, **+14 % for rapeseed**, **+10 % for barley**. Pulses recover to the level of B-0. A comparison of the production output potential is found in Table A45 in the Appendix.

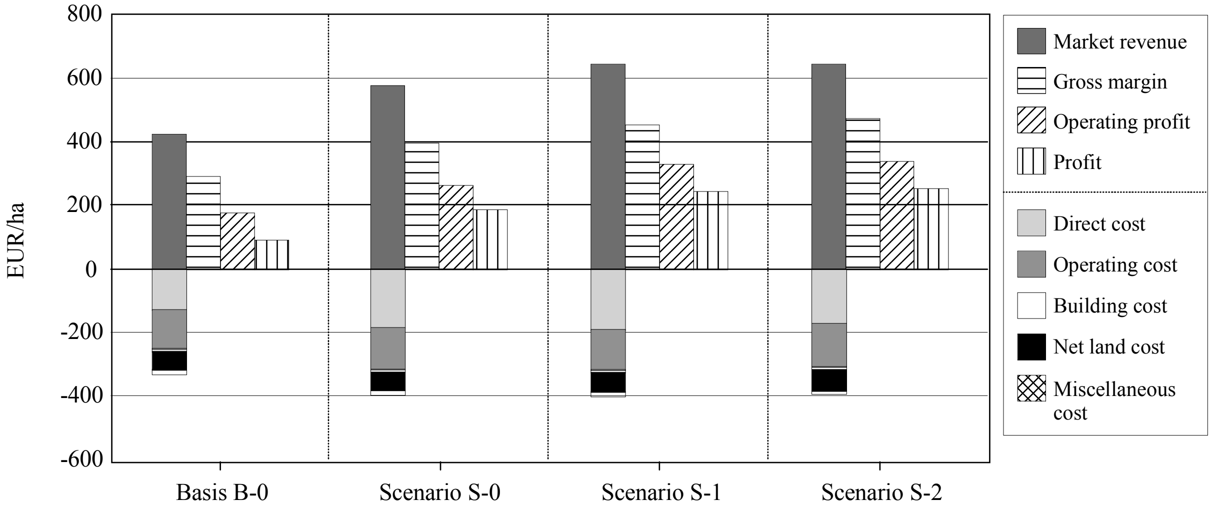
Farm level implications of adaptation strategies and perspectives of AU 4500SC

The adaptation strategies and estimated yield developments have effects on the market returns, the cost structure of the production system and thus on the profitability of the typical farm. While detailed calculations can be found in Tables 4.19 and Tables A26, A27 and A28 in the Appendix, key findings for the typical farm AU 4500SC are outlined in this section.

The following Figure 4.26 illustrates the development of key indicators of the typical farm AU 4500SC in the basis scenario (B-0), under high price conditions and under the previously analysed adjustments regarding agronomy (S-1) and farm configuration (S-2).

The broad comparison of the price and adaptation scenarios with the reference situation shows a positive effect of the high prices on the overall farm performance. While a significant profit increase can already be observed in scenario S-0, the farm is further able to increase profits by adjusting agronomy of production (S-1) and also by reconsidering the general farm setup (S-2).

Figure 4.26: Cost, revenue and profitability indicators of the AU 4500SC cropping enterprise (€/ha) in the basis scenario (B-0) and under scenario conditions (S-0, S-1, S-2)



Source: Own calculation.

Agronomical adjustments which are summarised in S-1 lead to different effects. Firstly, expanding canola production, incorporating hybrid varieties and advantageous yield improvements caused market revenues increase substantially from 580 €/ha to 647 €/ha (+12 %). At the same time total cost increased less strongly from 386 €/ha to 403 €/ha (+4 %) which states short term rationalisations being effective to offset the higher direct cost load linked to canola production, especially seed cost of the new hybrids. Both effects accumulate and profitability indicators (gross margin, operating profit and farm profit) increase. The total profit upturn from 186 €/ha to 244 €/ha (+30 %) constitutes a strong dynamic and adaptation potential of the agronomy of production on the South Coast of Western Australia.

The reset of the area planted with canola and lupins anticipated as a precaution measure to maintain the physical performance of canola is considered in the scenario S-2. However, the marginal yield increase proven as a response to the more sophisticated site specific application of direct crop inputs[49] is able to offset the declining return contribution of canola and stabilised average market revenues at 647 €/ha. The furthermore analysed efficiency upgrades to the typical farm (VRT-Airseeder with greater acreage performance) simulated in scenario S-2 lead to a decrease of direct cost by 23 €/ha. This can be seen as a prime example how to offset energy dependency with

[49] Cp. BAXTER (2011).

application efficiency. Finally, compared to scenario S-1 the overall farm profit increased further by 10 €/ha (+4 %) leading to an overall farm profit of 254 €/ha.

The total costs of production per unit of output increase for wheat from 123 €/t in B-0 to 148 €/t in S-0 under high price conditions. However, the yield increase in response to agronomical adjustments cause a decrease of average cost to 131 €/t in S-1 which can further be pushed to 126 €/t with the adjustments to the farm configuration in S-2. Analogue conclusions can be drawn for the production of rapeseed and barley. Respective figures are displayed in Figure A26, A27 and A28 in the Appendix. Hence, according to economic theory the typical farm is encouraged to run the adjustment process thru in the light of decreasing average cost. With the full range of adjustments, the production intensity moves towards the optimal specific level of intensity.

The increasing profitability of the cropping enterprise leads to a substantial equity gain for the entrepreneur. Considering only the price effect, the income would increase by 380,000 €/a while an adjustment of the farm configuration (S-2) would lead to a further 285,000 €/a (total increase by 665,000 €/a).

For the typical farm in the South Coast region in Western Australia it can thus be concluded, that the implementation of a high price scenario has per se a significant positive effect on the profitability of the cropping enterprise and the adaptation strategies evaluated by the panel would further maximise profitability.

The investment in efficient technology and thus the reduction of total cost in this context is of special importance since it is an acknowledgement of the outlined production uncertainty.

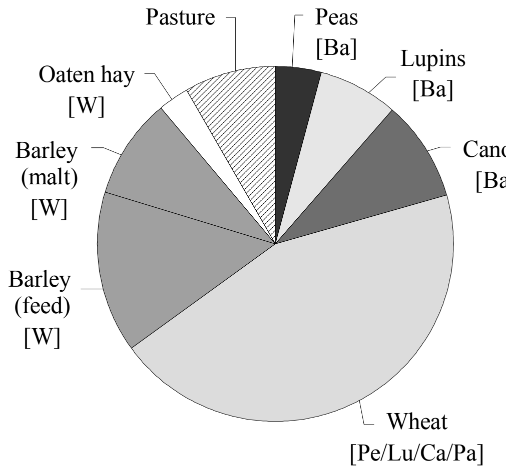
4.4 The West Australian typical farm in the Wheatbelt

4.4.1 Cropping portfolio and type of production system

The mixed farming system of the West Australian typical farm in the Wheatbelt region differs from the previously discussed land use systems. The cropping portfolio is comprised of a greater number of individual crops and besides that, a certain share of the arable land is dedicated to livestock production (sheep). Figure 4.27 provides an overview about the acreage and percentage share of crops in the crop portfolio.

Figure 4.27 Cropping area (ha), share in the crop portfolio (%) and yield (t/ha) of crops grown on farm AU 4000WB (Average 2005–2009)

Crop	Pre-crop	Acreage [ha]	Share [%]	Yield [t/ha]
Peas	Ba	150	4	0.76
Lupins	Ba	260	7	1.04
Canola	Ba	330	9	0.95
Wheat	Pe/Lu/Ca/Pa	1600	44	1.90
Barley (feed)	W	530	15	2.11
Barley (malt)	W	330	9	2.11
Oaten hay	W	100	3	3.82
Pasture	--	300	8	--
Total acreage		3600	100	



Typical crop rotations:
1) Peas/Lupins/Canola -- Wheat -- Wheat/Barley/Oaten hay (3-year-cycle).
2) Pasture -- Pasture -- Pasture -- Wheat (4-year-cycle).
Note: Legend of diagram contains main crop name and the abbreviation of the pre-crop in square brackets.
Source: Own illustration.

The typical farm AU 4000WB runs two different crop rotations. The first one is a permanent cropping rotation while the second one incorporates a permanent pasture which is used for grazing sheep. Nevertheless, cereals (wheat in particular) account for the predominating share of the arable land.

Rotation 1) Cropping rotation

The permanent cropping rotation includes legumes, oilseed and cereals in a general **broadleaf – cereal – cereal** frame. With regards to economical forces discussed in the next section, diversity of crops and the respective acreage is determined by the following constraints:

– Late or non-appearing season break rainfall leads to a delayed sowing which can cause severe yield penalty. Beside shifted flowering window and shorter vegetation period, crops react sensitive on temperature differences, vernalisation to switch from vegetative to reproduction stage and day lengths. As a rule of thumb, late sowing yield penalty amounts to 25 kg/ha/day in the central Wheatbelt region (ZAICOU-KUNESCH et al., 2005; GRDC, 2011).

  The crop most sensitive to delayed sowing is canola. Assessed by the panel being an opportunity crop, canola is only grown in three to four years with favourable conditions out of five.

– Additionally to the season break rainfall uncertainty, the central Wheatbelt region is distinguished by fluctuating growing season rainfall which can result in periodical drought. Water shortages during the yield establishment of crops, in particular when crops finish off, leads to adverse yield performance and quality issues. On AU 4000WB poor growing season rainfall resulted in severe yield failure (2006) and rededication of malting barley to feed (2006 and 2008).

– The occurrence of frost during crop maturing period (July – September) restricts yield performance drastically. Frost damage is determined by a combination of factors such as temperature, humidity, wind, topography, soil type, crop and variety and considered being a significant thread to production in the Central Wheatbelt (White, 2000; Rebbeck and Knell, 2007; GRDC, 2009). The general susceptibility of individual crops to frost is illustrated in Figure 4.28.

Figure 4.28: Crop susceptibility to frost damage

	Susceptibility to frost				
Crops	MOST				LEAST
Cereals	Triticale	Wheat	Barley	Cereal rye	Oats
Broadleaf crops	Peas	Canola Lentils	Chickpea	Faba beans	Lupins

Source: GRDC (2009) and WHITE (2000), own illustration.

– The crops grown on the typical farm AU 4000WB reveal to diverting susceptibility to frost. The higher crop diversity compared to the farm on the South Coast is assessed as being a risk management strategy to even out single crop failures on farm level. However, frost caused perceptible yield damage in 2005 in peas, lupins and wheat (Figure 4.31).

– Herbicide resistant weeds in particular Annual ryegrass (*Lolium rigidum* G.) and Wild radish (*Raphanus raphanistrum* L.) are major determining factors for the paddock management in the Wheatbelt. Since acquired resistances have progressed further compared to the previous region, chemical treatments often prove ineffective. Therefore the most affected paddocks are taken out of crop production and brought into a grazing pasture for a period of 3–5 years.

Rotation 2) Pasture rotation

Once established to provide grazing area for livestock and to accumulate soil moisture and nutrients, rotational pasture has proven to be an effective management tool to control herbicide resistant weeds (Gorddard et al., 1995).

The pasture rotation on AU 4000WB usually involves the paddocks of arable land taken out of crop production. They are either planted into perennial legume pasture (lucerne, clover or seradella) or natural growth is kept considering the feedstock requirements to graze the sheep flock. With natural growth farmers can make a virtue out of necessity since ryegrass has a considerable nutritive value. After a period of typically three years, pasture paddocks are reclaimed and integrated back into the cropping regime by planting wheat. The pasture rotation follows the general frame **pasture – pasture – pasture – wheat**.

Several years of intensive investigation of integrated pasture system there has been found evidence that perennial pastures can increase profitability of mixed farming system and acquired resistances of Annual ryegrass and Wild radish break down or the onset is delayed after with intensive grazing and absence of chemical weed control measures (MONJARDINO et al., 2004).

Further details about the land use system are provided by discussing production systems of individual crops and the pasture management. The following section will concentrate on the production of the major crops such as wheat and canola as these crops can also be found on the other typical farms in this comparison and the livestock enterprise.

Production of cereals

Wheat is the major crop on the typical farm AU 4000WB. The share of wheat in the cropping portfolio amounts 44 % referring to the diagram in Figure 4.27. The major share of wheat (1500 ha) is grown following canola or legumes while a minor share (100 ha) is pioneering after pasture. However, the production system is not further differentiated. Respective fieldwork passes of the production system are illustrated in Figure 4.29.

Figure 4.29: Production system of wheat on AU 4000WB and direct physical inputs differentiated by month and type of operation (Average from 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost [EUR/ha]	Operating cost [EUR/ha]
1	end 02	Spreading	Lime on light land CaO1		7
2	beg 04	Spraying	Total herbicide	6	4
3	mid 05	Spraying	Total herbicide	21	4
4	mid 05	Seeding NO-TILL	Airseeder (tines) + DAP (mineral) N8 P9	28	21
	mid 05	Fertilizer	+ Urea (mineral) N14	10	
	mid 05	Fertilizer	+ MoP (mineral) K20	20	
5	mid 07	Fertilizer	Urea (mineral) N14	10	4
6	end 07	Spraying	Selective herbicide	9	4
7	end 11	Harvest	Combine harvest		13
8	end 11	Transport	On field transport (chaser bin)		7
9	end 11	Transport	On road transport (truck)		7
			Total	105	57

Summary				
Crop		Wheat (following peas/lupins/canola/pasture)		
Tillage		No-Till seeding		
Seed	kg/ha	55	9	EUR/ha
Fertilisation	Nutrient kg/ha	N36 P9 K20 CaO1 Mg0 S0	59	EUR/ha
Chemicals	Applications	Herbicide (3), fungicide (0), insecticide (0), other (0)	37	EUR/ha
Yield	t/ha	1.9		

Source: Own calculation.

The agronomical production processes are explained in the following section in more detail before discussing the economics of production.

No-Till seeding

No-Till incorporates direct seeding is also firmly established as the state of the art cultivation practice in the Wheatbelt region (D'EMDEN and LLEWELLYN, 2006).

Key expenditure of the No-Till production on AU 4000WB is the seeding pass in the middle of May. Deviating from the operation discussed in the previous section, the typical farm AU 4000WB utilises a tine seeding implement for more intense soil cultivation and water accumulation.[50] With the seeding pass three components (N, P and K) of granulated fertiliser are applied: diammonphosphate (DAP), urea and muriate of potash (MoP). They are applied deeper into the soil profile as a depot and seed is placed on top. Integrative component of the No-Till technology is chemical weed control carried out before seeding (see below).

[50] Cp. Section 4.1.3.2.

In consideration of a higher variability of the rainfall distribution[51], the panel assessed all crops to be seeded after major rainfall events. Dry seeding is typically not feasible.

Fertilisation program

A sufficient amount of nitrogen and phosphorus is applied with the seeding pass as a start up application. Urea is predominantly used as the single nutrient fertiliser for nitrogen and also applied as a top-dress in mid/end July to supply nitrogen crops during flowering (BBCH 6).

An application of lime on the lighter land does typically take place prior to wheat to stabilise soil reaction further. Due to the overall moderate reaction of soils closer to crops pH optimum in the study region, principal higher rates of nutrients are available for plant uptake compared to the South Coast region. Thus, target fertilisation in wheat and other crops equal crop's removal.[52]

Plant protection program

As in the South coast region, the plant protection program is strongly dominated by **herbicide** applications. On average one pre-seeding total herbicide application can be cancelled however, due to lower summer rainfall initiating less weeds and losses to germinate on the fallow between harvest and seeding.

Annual ryegrass and wild radish have established critical resistances which outreach the situation in the South Coast region. Some populations can not be controlled with chemicals at all. Beside the abovementioned grazing pasture which has proven successful, burning of crop stubbles is still common practice in the Wheatbelt but is critically discussed by the panel farmers. The typical farm does not burn crop residues.

Harvest and handling

Wheat harvest usually takes place from end of November to beginning of January. Under the described production intensity a five-year-average crop yield of 1.9 t/ha is realised on AU 4000WB. The harvest operations listed in Figure 4.21 include the transport on field, short term storage[53] and on road transport to the cooperate storage facility.

The herewith introduced production system can in principle be generalised for the cereal production on the typical farm. Minor changes in the timing of single passes can be found in the production of **barley** for feed and malt equalling 860 ha (24 % of the arable land).

---

[51] Cp. section 3.3.1.

[52] Cp. Table A10 and A11 in the Appendix.

[53] Cp. Section 4.1.4.

Remarkable difference is the slightly better yield performance of barley which averages 2.11 t/ha. Determinants for the rating between malting barley and feed barley are quality measures, especially screening and protein. Both are strongly depending on finishing rainfall and are thus more variable in the Wheatbelt compared to the South Coast region. In 2006 and 2008 the typical farm is not able to harvest any barley for malting consumption.

One fungicide application is carried out as protenctant in barley to target Powdery mildew (*Blumeria graminis* f.sp. *hordei*). Powdery mildew is one of the major diseases of barley in WA affecting leaves, stems, and ears. It is specific to barley and does not affect other crops (THOMAS et al., 2011).

The respective production system is not generally differentiated between the qualities and are found in Figure A18 in Appendix. Oats are another cereal cultivated on the typical farm. In contrast to wheat and barley oats are, however, not harvested for grain but whole plant for hay. Field work passes for crop establishment and cropping intensity are close to wheat. However, harvest operations of **oaten hay** imply cutting, baling respective logistics and are entirely carried out by a contractor. The harvestable yield of oaten hay amounts to an average of 3.8 t/ha tradable product. The respective production system is illustrated in Figure A19 in Appendix.

Production of broadleaf crops

The dominating broadleaf crop by acreage is canola which is typically grown on 330 ha (9 % of the arable land). Due to this small share various paddock combinations are chosen within the four-year cycle to manage its self-intolerance. The cultivation of canola is, however, a rather unreliable option in the Wheatbelt due to its vulnerability to late seeding. As mentioned above, canola is considered being an ‘opportunity crop’. The typical production system in the low rainfall Wheatbelt region is described in the following Figure 4.30.

Figure 4.30 Production system of canola on AU 4000WB and direct physical inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost [EUR/ha]	Operating cost [EUR/ha]
1	beg 05	Spraying	Total herbicide	6	4
2	mid 05	Spraying	Total herbicide	6	4
3	mid 05	Seeding NO-TILL	Airseeder (tines) + DAP (mineral) N9 P10 S1	22	21
	mid 05	Fertilizer	+ Urea (mineral) N18	14	
4	end 05	Spraying	Selective herbicide	6	4
5	mid 07	Fertilizer	Urea (mineral) N14	10	4
6	end 07	Spraying	Insecticide	3	4
7	end 08	Spraying	Selective herbicide	19	4
8	end 11	Harvest	Combine harvest		13
9	end 11	Transport	On field transport (chaser bin)		7
10	end 11	Transport	On road transport (truck)		7
			Total	86	59

Summary				
Crop		Canola (following wheat/barley/oaten hay)		
Tillage		No-Till seeding		
Seed	kg/ha	4	1	EUR/ha
Fertilisation	Nutrient kg/ha	N41 P10 K0 CaO0 Mg0 S1	44	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (0), insecticide (1), other (0)	41	EUR/ha
Yield	t/ha	0.95		

Source: Own calculation.

Production of canola in terms of fieldwork passes is relatively similar to wheat. However, minor changes are found in the intensity of direct crop inputs.

Fertilisation program

Fertilisation intensity of nitrogen, phosphorus and traces of sulphur is marginal higher compared to wheat due to the physiological demand of canola.[54] Potassium fertilisation is typically neglected.

Plant protection program

Due to the relatively low crop density, the economic damage of fungal diseases is minimal and therefore not controlled with fungicides. An additional **insecticide** is sprayed in July to control a broad range of aphids.

[54] Fat synthesis requirements and typical fat acid pattern of rapeseed cp. SCHILLING (2000).

Harvest and handling

Unlike on the previous farm, canola is harvested in a one pass operation using a conventional combine harvester. This is possible since density and ramification of crops are much lower compared to the South Coast region. Additionally, pod shattering in the maturing crop is less likely because the region is not permanently exposed to strong winds during early summer. Canola yields averaged 0.95 t/ha during the investigation period.

Further broadleaf crops in the portfolio include **peas** which account for 150 ha (4 % of the total arable land) and **lupins** accounting 260 ha (7 %). Due to a rather marginal fertiliser input, the production of legumes is less intensive compared to the previously introduced crops. The five-year-average crop yield of peas is 0.76 t/ha and 1.04 t/ha of lupins respectively, which are both substantial damaged by frost damage at the beginning of the investigation period. An illustration of the respective production system can be found in Figure A16 and A17 in the Appendix.

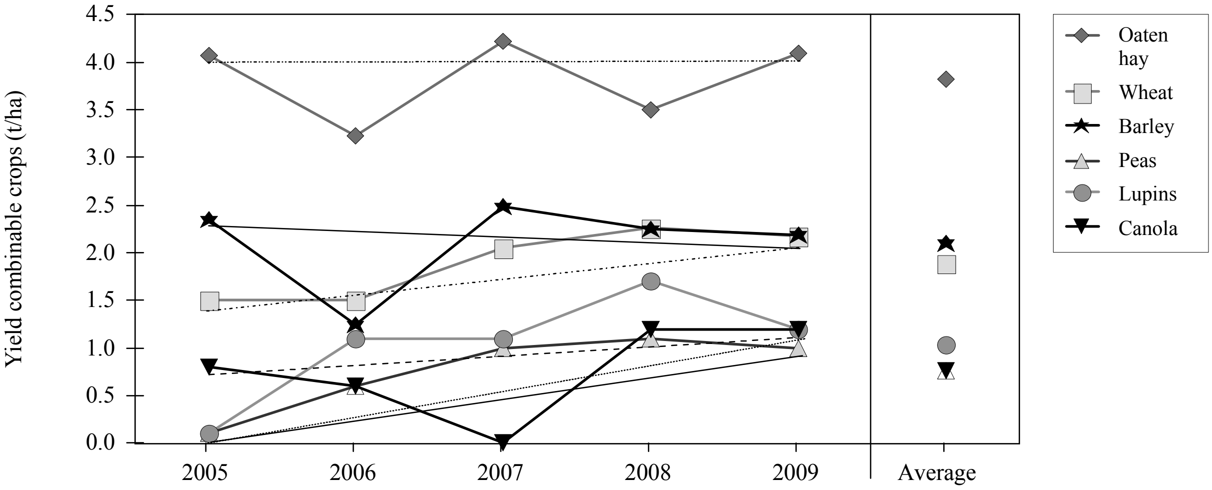
Evolution of crop yields and estimation of production uncertainty

The interaction of natural conditions in the Wheatbelt region with the production systems resulted in the following crop yields on the typical farm for individual years (Figure 4.31).

The peculiarities of crop yields in single years are predominantly caused by characteristic natural conditions:

- In 2005 wheat and broadleaf crops are severely damaged by frost. In particular lupins and peas are almost entirely wiped out.
- In the following year 2006 below average growing season rainfall caused significant yield decline in cereals and the failure of barley qualities grown for malt.
- In 2007 late season break rainfall prevented farmers from planting a canola crop while all other crops yielded at or above average.
- Apart from forfeiting malting barley quality and oaten hay depression in 2008, conditions are quite favourable in that and the following year for above average grain yields.

Figure 4.31: Evolution of crop yields (t/ha) and five year average (2005–2009) of AU 4000WB



Source: Own calculation.

Crop		Peas	Lupins	Canola	Wheat	Barley	Oaten hay
Precrop		W/Ba/Oh	W/Ba/Oh	W/Ba/Oh	Pe/Ca/Lu/Pa	W	W
Ø 2005-2009	t/ha	0.76	1.04	0.76	1.90	2.11	3.82
Max[1)]	t/ha	1.10	1.70	1.20	2.26	2.49	4.22
Min[1)]	t/ha	0.10	0.10	0.00	1.50	1.25	3.23
CV[2)]		0.55	0.56	0.66	0.19	0.23	0.11

1) Maximum and minimum yields in the observed period.
2) Coefficient of variation.

Apart from the annual information, the graph indicates the following properties of the crop yield pattern relevant for this investigation:

– Crop yields fluctuate differently compared to their respective yield level during the observed harvest years (cp. internal CV in Figure 4.23). These figures indicate a high production uncertainty especially with broadleaf crops but also wheat and barley.

– Yields of crops harvested for grain (wheat and broadleaf crops in particular) appear to trend positive (ascending linear trend line) during the short term investigation period and hence counter the long term negative trend identified on the respective regional scale. (Figure 3.7).

Acknowledging the limited explanatory power of the statistical indicators due to the limited number of observations, generalisations from this data are certainly not feasible. However, the indications in regards to the yield performance for the recent years (fluctuation and trend) influence the confidence of the panel participants about the prospective development in their cropping region. They are only considered as ‘mind-measurement’ when interpreting the results and not useful to replace broader statistical observations.

Pasture management involving livestock

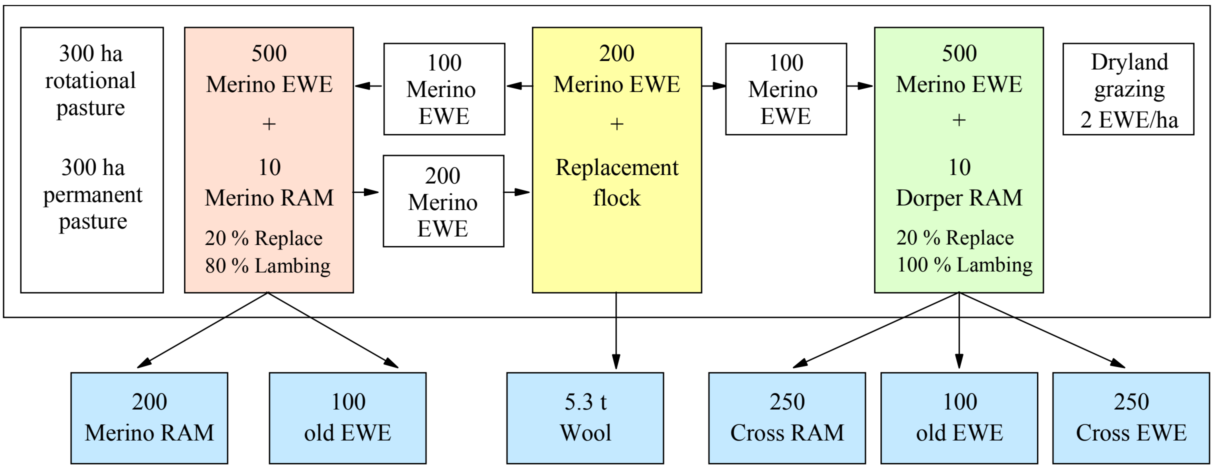
The livestock enterprise on AU 4000WB in the Western Australian Wheatbelt involves a first cross self-replacing Merino-Dorper operation, which concentrates on meat and wool production from sheep. Two main sheep breeds are of importance to the sheep enterprise: **Merino** and **Dorper**.

The Merino is a breed of sheep prized for its wool. Merinos are regarded as having some of the finest and softest wool of any sheep. The Dorpers are a valuable breed, because of their improved feed utilisation and conversion into carcase weight. They don't require shearing, crutching and mulesing and they are robust. The Dorper sheep has the ability to thrive in harsh conditions and is one of the most fertile sheep breeds.

Production system

The typical production system for meat and wool is illustrated and described by means of the following Figure 4.32.

Figure 4.32: Production system of self-replacing first cross Merino-Dorper operation on AU 4000WB



Source: Own illustration.

Central elements of the self replacing Merino/Dorper operation are two Merino ewe flocks with 500 heads each. All figures refer to one production year.

The first flock (left block) is paired by Merino ram. Considering a lambing rate of 80 % this results in 200 Merino ram traded to market for meat and 200 Merino ewes transferred into the replacement flock, where ewes grow to sexual maturity (middle block). From there 100 matured ewes (16–18 month old) are shifted back to replace 20 % of old ewes in the initial Merino*Merino flock which are traded to market.

Another 100 Merino ewes are shifted from the ‘teenager flock’ to the Merino*Dorper flock (right block) to replace 20 % of the old ewes. The ewes in this flock are paired with Dorper rams to crossbred lambs for prime meat production. Considering a typical lambing rate of 100 % this amounts to 500 lambs traded to market each year.

All ewes and merino rams are shorn for wool averaging 6.2 kg greasy wool/head totalling 5,300 kg of clean wool marketed each year. Details about wool classification and deductions are found in Figure A20 in the Appendix.

The grazing intensity mainly depends on the growth of natural or seeded pasture and the rainfall distribution. In this part of Western Australia the typical livestock intensity is two ewes per hectare on average over the year.

The stock are kept outside throughout the whole year. This is of advantage as investments in stables or housing infrastructure are relatively low. Farms usually have no other building dedicated to the livestock enterprise except a shearing shed. On the other hand the simplicity of the production system does rarely allow any form of mechanisation. Thus running livestock as described requires a lot of manual work, often under very unfavourable conditions (merciless heat, dust, flies). On AU 4000WB half of the working capacity of a full time labour unit is dedicated to the sheep enterprise (1,000 h/year).

To utilise the land more efficiently, all fields are fenced off with reasonable kinds of steel-wire fences, most commonly with layers of barb wire or electric fence. That allows managing changing diets, intensive grazing and recovering fields. The diet typically consists of:

– Permanent pastures or rotational pastures during the growing period (April – November)
– Perennial grasses or bushes on the moderately affected land with hay as a supplement feed (April–November)
– Grain stubbles, grain losses, weed seeds and germinated seeds on the harvested arable land (November–April)

Troughs and watering places are installed in favourable locations on the farm. Most commonly surface water is collected over a downhill grade in artificial dams without ground water connection. The water is used here directly for livestock watering or pumped into tanks higher elevated in the profile by the characteristic windmills or solar driven pumps. These tanks gravity feed troughs for watering and secure a relatively constant water supply in remote areas of the farm.

The investigation of the mixed farm enterprise stated a solid position of the livestock enterprise on AU 4000WB for the following reasons:

- Sheep are an integrated part of the land use system processing natural growth of pasture on arable land, permanent pasture and salt affected land. Especially the latter one would be entirely lost for production without sheep farming.
- Intensive grazing is a recommended weed management strategy to control herbicide resistances in Annual ryegrass.
- The market revenues from meat and wool are generating approximately 10 % of the gross revenue of the farm.

The economic performance of the sheep enterprise is of particular interest for the research question of this study whether more land is brought into production at the expense of the land dependent livestock farming. To achieve comparability of the two enterprises in the following section, cost and revenue positions of the sheep enterprise will refer on the occupied arable land (rotational pasture) as the reference unit which competes directly with the cropping enterprise.

4.4.2 Profitability analysis and production cost

The previously discussed production systems of crops and livestock on AU 4000WB cover the main agronomical and operational framework of the typical farm. In the following section the focus is set on the profitability of production on the West Australian typical farm in the Wheatbelt region.

The following Table 4.20 summarises the total cost account of single crops and rotational pasture (sheep) on a per hectare basis, structured by the individual crop's operating profit contribution. The final column (grey shaded) refers to the average farm performance of the farming enterprise of AU 4000WB per hectare cropped land computed by means of the acreage-weighted figures of single crops.

Market revenues of single operations vary by a factor of 2.5 between the crops in the portfolio. The revenue of oaten hay is the highest and ranges about 416 €/ha. Cereal revenues are between 260 €/ha and 310 €/ha and broadleaf crops follow between 130 €/ha and 260 €/ha. The sheep enterprise generates 186 €/ha return. The average farm revenue ranges between wheat and barley at 266 €/ha.

The highest net revenue over direct costs (gross margin) in the cropping portfolio is generated by oaten hay followed by malting barley. With considerable distance wheat, feed barley, canola and sheep are almost equal in gross margins (170–180 €/ha). The lowest gross margin is contributed by legumes which perform with distance to the other crops. However, a considerable preceding crop value is linked to the production of legumes justifying its position in the crop portfolio. The average gross margin amounts to 177 €/ha.

In terms of operating profit the gap narrows due to the relative intensive machinery input to oaten hay and labour input to the sheep operation. The average operating profit during the investigation period adds up to 85 €/ha.

Table 4.20: Profitability of single crops and farm average AU 4000WB (2005–2009)

Crop		Barley (malt)	Oaten hay	Pasture	Wheat	Wheat	Barley (feed)	Canola	Lupins	Peas	Farm average
Previous Crop		Wheat	Wheat	Sheep	Pa	Pe/Lu/Ca	Wheat	Barley	Barley	Barley	
Acreage	ha	330	100	300	100	1,500	530	330	260	150	3,600
Crop yield	t/ha	2.1	3.8		1.9	1.9	2.1	1.0	1.0	0.8	
Output price	EUR/t	147	109		155	155	122	275	154	167	
Market revenue	**EUR/ha**	**310**	**416**	**186**	**295**	**295**	**258**	**262**	**160**	**127**	**266**
Seed	EUR/ha	9	18	0	9	9	9	1	13	15	9
Nitrogen (N)	EUR/ha	19	26	2	26	26	19	30	0	0	20
Phosphorus (P)	EUR/ha	13	13	4	13	13	13	14	15	15	12
Potassium (K)	EUR/ha	0	20	0	20	20	0	0	0	0	9
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	32	59	6	59	59	32	44	15	15	42
Herbicides	EUR/ha	28	37	6	37	37	28	37	28	28	31
Fungicides	EUR/ha	6	0	0	0	0	6	0	0	0	1
Insecticides	EUR/ha	0	0	0	0	0	0	3	1	6	1
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Pesticides (total)	EUR/ha	34	37	6	37	37	34	41	29	34	33
Crop establishment cost	**EUR/ha**	**75**	**114**	**12**	**105**	**105**	**75**	**86**	**57**	**64**	**84**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	2	1	0	2	2	2	2	1	1	2
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Finance field inventory	EUR/ha	3	4	0	4	4	3	3	2	2	3
Total direct cost	**EUR/ha**	**80**	**119**	**13**	**111**	**111**	**80**	**91**	**60**	**67**	**88**
Gross margin[1)]	**EUR/ha**	**230**	**297**	**173**	**184**	**184**	**178**	**170**	**100**	**60**	**177**
Labour	EUR/ha	29	11	47	26	26	29	31	28	31	29
Contractor	EUR/ha	4	152	9	11	11	4	4	0	0	11
Machinery	EUR/ha	44	25	18	42	42	44	47	44	47	41
Diesel	EUR/ha	11	5	3	10	10	11	12	11	12	10
Other	EUR/ha	2	2	1	2	2	1	2	1	1	2
Total operating cost	**EUR/ha**	**91**	**195**	**79**	**91**	**91**	**90**	**95**	**85**	**90**	**93**
Operating profit[2)]	**EUR/ha**	**139**	**102**	**95**	**93**	**93**	**88**	**75**	**15**	**-31**	**85**
Building cost	EUR/ha	7	10	4	7	7	6	6	4	3	6
Total land cost	EUR/ha	61	61	60	61	61	60	60	60	60	60
Decoupled payments	EUR/ha	0	0	0	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	61	61	60	61	61	60	60	60	60	60
Miscellaneous cost	EUR/ha	16	21	10	15	15	13	13	8	7	14
Total cost	**EUR/ha**	**255**	**407**	**166**	**285**	**285**	**250**	**267**	**217**	**227**	**261**
Profit[4)]	**EUR/ha**	**55**	**10**	**20**	**11**	**11**	**8**	**-5**	**-57**	**-100**	**4**

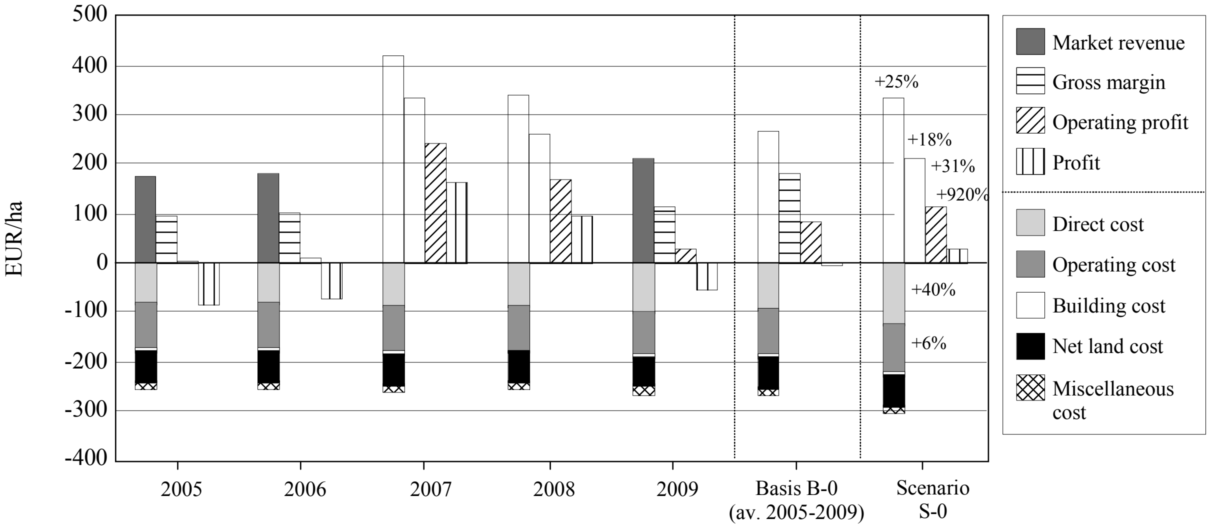
1) Gross margin = Net revenue over direct cost.
2) Operating profit = Net revenue over direct and operating cost.
3) Net land cost = Total land cost reduced by decoupled payments.
4) Profit = Net revenue over total cost.
Source: Own calculation.

The profit per hectare which is presented in the bottom line of Table 4.20 is computed considering net land cost (which corresponds to the total land cost in this case due to the absence of any subsidies). It can be concluded, that the majority of operation in terms of acreage are profitable and cover their total cost. The average profit of AU 4000WB is 4 €/ha in the long run. Especially oaten hay, malting barley and the sheep enterprise perform substantially above average compared to the remaining crops in the portfolio. However, the typical farm averaged a profit margin[55] of 2 % during the investigation period from 2005 to 2009.

Based on these findings it is necessary to investigate further how the economics of production developed in single years during this time period and how the high price scenario would influence the performance of the farm per se without any adaptations. The respective findings are described in the following Figure 4.33.

The underlying calculations are found in Table 4.20 and in Tables A29 to A34 in the Appendix.

Figure 4.33: Cost, revenue and profitability indicators of the AU 4000WB cropping enterprise (€/ha) in selected years, 5-year average (2005–2009) and under scenario conditions (Scenario S-0)



Note: 1) Net land cost calculation incorporates decoupled payments.
2) Percentage figures typify the increment (delta) of selected positions based on basis scenario B-0.
Source: Own calculation.

55 Average profit margin (return on sales ROS respectively) = profit / market revenue.

The Figure 4.3.3 illustrates selected economic indicators for the typical farm AU 4000WB in different temporal dimensions. Firstly, single years of the investigation period are displayed and based on these results the following conclusions are drawn:

– In three out of the five years the typical farm is not able to cover the total cost of production. In three out of five years, the operation on the typical farm generated substantial capital losses. This is due to disastrous yields and low commodity prices (2005 and 2006) and particular low output prices in 2009. In contrast to this, substantial equity is gained in the remaining years (160 €/ha profit in 2007 and 90 €/ha in 2008). The latter effect is caused by high commodity prices while yields are in proximity to the 5-year average for all crops.[56]

– During the whole investigation period total cost of production and the cost structure is relative stabile at a level of 250 €/ha with a marginal increase in direct cost (+10 €/ha) in 2009. In comparison with the previously discussed typical farms, this is an indication for the effect of a lower energy related direct crop input intensity and its response to rising energy prices.

The basis scenario (B-0)[57] established using the five-year-average figures from 2005–2009 eliminates the individual year's price and yield bias. In the following section, this provides the general reference farm situation for further analysis. In a first step, the high price scenario[58] underlying for this study is adapted without any changes to the production system and farm configuration. The economic effect of this scenario (S-0) is also illustrated in Figure 4.33 and can be interpreted as the following:

– The high price scenario results in a significant increase of the gross and net return figures. Although income indicators are significantly above the average of the last five years, the margin and profit situation is below the harvest years 2007 and 2008.

– The observed gap between market returns, gross margin and operating profit respectively is mainly caused by an increase of direct cost (+40 %).

– Building cost, land cost and miscellaneous cost do not vary between B-0 and S-0 since the reference farm setup is considered ceteris paribus.

While the production of combinable crops is found being relatively uniform, the typical farm runs further enterprises which vary significantly in terms of direct and operational expenditure. Particular noteworthy are oaten hay and the livestock enterprise which have been described in greater detail in the previous section. The comparison of the S-0 scenario versus the farm average (B-0) lead to the assumption that single operations

---

[56] Cp. Figure 4.31.

[57] An overview over the specific scenario configurations can be found in Section 2.4.1 in Table 2.2.

[58] The relevant scenario prices for AU 4000WB can be found in Table A51 in the Appendix.

performance might response differently to the high price scenario. This is especially true since wool and meat prices are kept separately and ceteris paribus from the crude oil price derivation. According to the panel, this procedure does reflect the price development during 2007/08 where arable prices soared and the meat prices remained untouched at break even level for nearly two years. This issue will be addressed in the following

Direct cost and gross margin

The mentioned diverting requirements of enterprises regarding farm's resources, direct cost and gross margin comparisons are not convincing enough to explain the on-farms competitiveness. However, an important conclusion regarding the energy dependency can be drawn from the direct cost comparison illustrated in Figure A21 in the Appendix, displaying the single crops market revenues, direct cost and gross margins of AU 4000WB under the reference scenario (B-0) and under high price conditions (S-0):

– Wheat, canola and oaten hay are most prone to energy price changes since their cultivation requires the highest fertiliser input.
– Direct cost of maintaining rotational pastures are marginal and do rarely respond to the high price scenario.
– Within the group of combinable crops, the canola gross margin does respond mostly (+56 %) since canola seed price corresponds disproportionally high to the rising oil price underlying for the scenario used in this study.

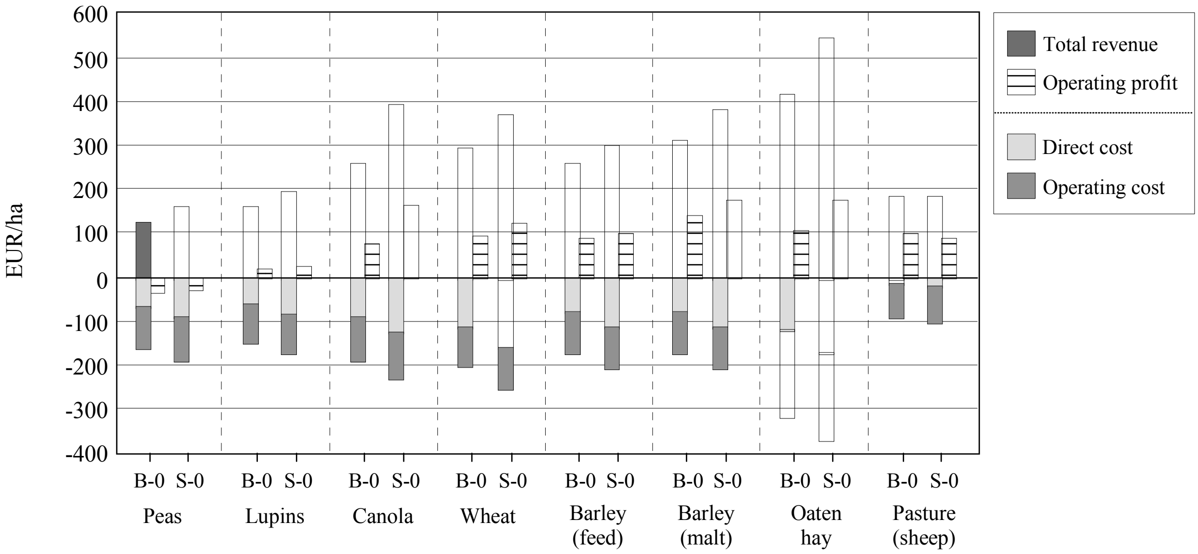
The detailed calculation regarding gross margins can be found in Table 4.20 and Table A34 in the Appendix.

Operating cost and operating profit

More information about the relation between single crops and cropping versus livestock in the basis scenario and under high price conditions are gained when focussing on the operating profit (Figure 4.34).

The calculation accounts market revenues reduced by total direct cost and total operating cost. While the linkage between direct cost and energy prices has already been discussed, operating cost variability is exclusively linked to rising prices for fuel and other energy sources under the high price scenario. Other cost positions (labour, machinery and contractor cost) are considered ceteris paribus.

Figure 4.34: Comparison of revenue, direct cost, operating cost and operating profit (€/ha) of cropping and livestock on AU 4000WB, reference scenario (B-0) vs. high price scenario (S-0)



	Peas	Lupins	Canola	Wheat	Barley (feed)	Barley (malt)	Oaten hay	Pasture (sheep)
Operating profit response	+9 %	+47 %	+118 %	+27 %	+8 %	+25 %	+72 %	-7 %

Source: Own calculation.

Average figures for the investigation period show a relative uniform operation profit contribution from canola, wheat, feed barley and the livestock enterprise of approximately 90 €/ha. A surplus is generated by malting barley (139 €/ha) and oaten hay (102 €/ha) whereas direct and operating cost are not covered in peas and lupins hardly break even.

When applying the high price scenario to the farming system some changes to the exposition can be observed. In fact, the cropping enterprise does respond positively to rising prices. Canola is the greatest profiteer in terms of operating profit and able to more than double the net return over direct and operating cost. A further strong benefit can be observed with oaten hay and malting barley. The position of legumes remains critical.

A small loss of operating profit under S-0 conditions is monitored at the livestock enterprise. Since market revenues are assumed ceteris paribus with the simulation, the profit decline (-7 %) is caused by rising production cost. However, this shift is evaluated to be marginal given the cost response of the cropping operation.

The shift in operating profit relations promts another question, whether the production portfolio might change in favour of single operations (crops) which are identified as being more profitable. Therefore it is prerequisite to uncover further considerations of the panel participants in the West Australian Wheatbelt region. The contesting options are derived from Figure 4.34 and discussed in the next section.

4.4.3 Analysis and assessment of adaptation strategies

The following section presents adaptation strategies for the typical farm AU 4000WB to cope with the effects of the high price scenario as discussed in the previous section. They refer to the estimation of the respective farmer panel held in the Wheatbelt region of Western Australia and are categorised in:

1. agronomical adjustments of the cropping program under high price conditions (scenario S-1)
2. adjustments to the general farm configuration under high price conditions (scenario S-2)

Scenario S-1 – Adjustments referring to AU 4000WB

Crop portfolio adjustments

The application of the high price scenario for this typical farm (scenario S-0) resulted in a shift of operating profit relations. While cereal production would remain relatively stabile, operating profits of the canola, oaten hay and malting barley developed disproportionally strong compared to the possible detriment of the sheep and legume operation. The latter one is already identified being the weakest operationin the reference scenario (B-0). The possibility to substitute each other in the land use system is evaluated in the following section.

Sheep enterprise – The following pros/cons are exchanged by the panel participants and lead to more insights of a mixed farming enterprise beyond plain profitability:

1. The sheep enterprise is identified as being a reliable source of income in a rather uncertain farming environment with significant yield fluctuations. In other words: 'If there isn't any wheat, you still got a sheep.' Hence, farms evaluate livestock as a risk management strategy to diversify the production portfolio.

2. The integrated pasture with intensive grazing has been proven as an effective weed and herbicide resistance management tool. Neither increased herbicide input nor burning of crop residues is found adequate for this region to entirely substitute the pasture strategy. Further positive effects are the disease break in the cereal dominated rotation and considerable nitrogen carry-over.

3. The discussed self replacing first cross Merino-Dorper operation is a matured production system. The replacement cycle and flock maintenance requires long time

periods and fixed stock numbers. Short term increase or decline of the flock does not coincide with the self-replacing strategy and erases the advantage of producing own offspring.

4. Running sheep is still very hand-labour intensive and involves strong personal commitment. The technical improvements here are entirely not comparable with the cropping industry. This is a prominent reason for the decline of total sheep numbers in Australia keeping the labour shortages in remote areas in mind.

5. However, the characteristics of the sheep operation (low degree of mechanisation, low energy input and independence of processed feedstock) turns out to be a protective advantage when it comes to rising energy and commodity prices.

Acknowledging these arguments, the decision to keep or abort the livestock enterprise on the typical farm is not induced by a contemporary productivity advantage of the cropping enterprise as first assumed in this study, in particular under consideration of production risk.

Furthermore, a short term reduction of animal numbers to expand cropping is not feasible due to the systematic cycle of the operation and path dependency of equipment (shearing shed, fences, water supply etc.). This means either sticking to sheep or going out completely. However, once livestock is ceased, re-entering is unlikely even more since this decision is often made with the succession of the farm.

In summary, running a sound performing sheep enterprise on a farm similar to AU 4000WB is very much linked to the personal preferences of the entrepreneur and his family and less influenced by shifting on farm competitiveness. Thus, the panel agreed on

– keeping the acreage dedicated to livestock and sheep numbers ceteris paribus to basis situation (B-0)

Oaten hay is a high value arable product specialised to Western Australia. About 800,000 t are exported annually into the growing market for animal and pet supplies in Asia, in particular Japan. Therefore it is sourced within a 400 km radius inland from the export terminal in Perth, blended and resized to high compressed bales and shipped in sea containers. The market is dominated by 5 key processors carrying out the processing (WINFIELD et al., 2007).

From the panel farmer's perspective the operation merges the following risks. Oaten hay is not an internationally standardised product but with high quality requirements. However, these quality requirements are subject to negotiation and vary between the individual processors. This implies considerable marketing uncertainties and price fluctuations.

Although production system is common practice, substantial drop of quality (e.g. colour, dry matter composition, digestive value, fibre content and moisture) can be caused by rainfall at a late crop stage or after cutting. Thus, a substantial production uncertainty must be considered since production incorporates high expenditures regarding logistic, storage and off-farm contractor services which are cash cost and must be rewarded even if quality fails. Acknowledging these facts, the panel jointly concluded

– not extend the acreage dedicated to oaten hay. (Ceteris paribus B-0).

Malting barley is the most profitable crop in the reference scenario (B-0) and maintains a good position under high price conditions (S-0). An extension of the barley acreage targeting malt would theoretically be advisable but not be realistic since non-reliable rainfall may restrict the development of the required quality as it happened in two out of the five years of the investigation period. In that case profitability would fall back to feed barley which is below the level of wheat. Yet, the share of wheat in the rotation is constrained by the current level of herbicide resistance.

– share of cereals in the cropping rotation to remain ceteris paribus to B-0.

Broadleaf crops can show significant shifts of individual on-farm competitiveness. Legume production can makes up some ground under the high price scenario. However its operating profit contribution remains on an overall low level while peas still yield negatively. The operating profit gap to the alternative crop within the broadleaf segment (canola) increases from approximately 80 €/ha to 160 €/ha. Thus, the acreage is yet to be critically evaluated in favour of canola.

The panel shared the opinion that an increase of canola is feasible. Under scenario conditions a short term extension of the canola acreage would be anticipated. However, the poor position of legumes from an agronomical point of view would be offset since the nutrient carry-over is estimated at 40–60 kgN/ha. The following modifications are assessed feasible:

– Increase of land planted to canola from 330 ha to 400 ha (+20 %).

– Decrease of land planted to peas from 150 ha to 80 ha (-46 %).

– All other crops acreage ceteris paribus to basis scenario (B-0).

In the long run rotation would be switched back to initial setup. The timely restriction is not foreseeable at this stage and linked to possible yield losses due to the self intolerance of canola or the lack of legume fixed nitrogen.

Tillage system

The No-Till system and direct seeding with tine implements has been proven reliable on AU 4000WB. The Panel does not anticipate any adjustments with the existing machinery configuration under scenario S-1 conditions.

– No changes.

Seed technology

Given the recent uncertainty with canola due to season break rainfall occurrence and frost damage, the panel does not estimate an implementation of hybrid varieties or GM Roundup Ready canola. Accompanying this estimate, the panel does not expect the required substantial yield increase of at least 0.2 t/ha to offset technology fee and endpoint royalty of GM varieties.

– Seed configuration of all crops ceteris paribus.

Fertilisation intensity

The modelling of direct cost under S-0 scenario conditions discloses vulnerability of the cropping enterprise to energy. However, farmers see a yield benefit of increasing fertiliser rates in cereals on the premise of average or above average weather conditions (primarily sufficient rainfall) in the respective year. Increasing efficiency of mineral fertilisation is further anticipated but not feasible with the current machinery. Respective measures will be discussed in scenario S-2.

– Increasing top-up fertilisation in cereals harvested for grain by +20 kgN/ha in the form of urea.

Plant protection intensity

With the rising product value economic damage thresholds of fungal diseases become relevant. While wheat production in the reference scenario does not typically incorporate a fungicide spray, this will be carried out under high price conditions. The panel agrees on the following:

– Wheat pesticide strategy: optional flag leaf fungicide application in August (BBCH 7), fungicide cost 10 €/ha.

Selling of wheat straw/oaten hay

Further removal of organic matter from paddocks (in B-0 oaten hay and some wheat straw for on-farm consumption) is not feasible due to the potential loss of long term nutrient depots. The soil organic matter is already anticipated to increase since it is prone to the former practice of stubble burning.

– No further selling of by-products from agricultural commodities (straw) or increasing productions of oaten hay.

Management input

The described intensification does not necessarily require higher management input. With regard to the increasing operational input, the existing machinery set may restrict carrying out time sensitive operations on schedule. The additional fieldwork passes will be carried out by a spraying contractor. The panel refers to

- Labour configuration to remain ceteris paribus.
- Off-farm contractor services for fungicide application budgeted at 3 €/ha in wheat.

Yield response to scenario S-1

In consideration of the prevailing yield level during the investigation period, the panel estimated a yield improvement with the adaptation of the outlined measures. The yield increase **under average climate conditions** is considered to be 0.2 t/ha in cereals harvested for grain (~ +10 %) and nil in broadleaf crops and oaten hay based on the average yield in the reference scenario (B-0).

This results in the following yield figures for the simulation of scenario S-1:

- Peas 0.76 t/ha
- Lupins 1.04 t/ha
- Canola 0.95 t/ha
- Wheat 2.10 t/ha
- Barley 2.31 t/ha (no shift in ratio of feed versus malt)
- Oaten hay 3.82 t/ha

The estimated production output potential of AU 4000WB influenced by changes in acreage and yield under scenario S-1 conditions amounts to **+11 % for wheat**, **+21 % for rapeseed**, **+9 % for barley** however, to the detriment of pulses (-14 %). A comparison of the production output potential is found in Table A45 in the Appendix.

Scenario S-2: Adjustments referring to AU 4000WB

Farm size

The panel considers the farm size to remain constant as in the reference situation (B-0).

Crop portfolio adjustments

The panel shared the opinion that short term increase of canola is feasible. However, under scenario S-2 conditions the rotation is switched back to the initial setup.

- Shift back to initial crop rotation set up: 330 ha of canola (cp. B-0).
- Area of land planted to peas is 150 ha (cp. B-0).
- All other crops and pasture ceteris paribus to basis scenario (cp. B-0).

Fertilisation and pesticide intensity

First positive experience with the application of Flexi-N as the single nitrogen source makes panel participants confident to substitute urea in the production system. Main advantages are seen in increasing nitrogen efficiency, fine tuning of grain quality (protein) and logistical advantages. Furthermore, the decision to utilise liquid fertilisers increases the year-to-year flexibility and creates an opportunity for further plant protection measures or trace element fertilisation (PFEIFFER, 2010).

The panel confirms the following adjustments of the fertilisation strategy on the premise of average or above average growing season conditions:

– Substitute granulated urea (1.07 €/kgN) in sowing application and top-dress application with liquid Flexi-N (1.30 €/kgN); further increase of total nitrogen rate by 10 kgN/ha split equally on the two passes in cereals harvested for grain.
– Top-dress application in cereals in combination with fungicide and timed in late July or beginning of August; remove spreading pass (-4 €/ha operating cost).
– Application of micro nutrients (copper on light land, zinc on heavy land) in cereals harvested for grain with fertilisation/fungicide pass; trace element cost 2 €/ha.
– All other crops remain ceteris paribus to S-1.

Machinery investments

The increase of flexibility by splitting nutrients (N, P, and K) and improvements in efficiency do require adjustments of the equipment. The following technical measures accompanying the fertiliser strategy are approved by the panel:

Upgrade to utilise Flexi-N – Airseeder and seedcart modification of the existing machine (liquid fertiliser tank, tubes and tine implement upgrade): 15,300 €; setup of on farm site specific analysis appliances (EM38, soil sampling, mapping software): 18,000 €; tank for on-farm storage: 10,000 € (20 years depreciation period); cart for on-farm transport: 7,000 € (20 years depreciation period);

– Total upgrade volume: 50,300 €; all further depreciation details remain ceteris paribus.

The implementation of the variable rate technology in the seeding system is basically intended. However, the replacement of the seeding equipment including VRT will take place once current machinery is completely written off and can not be associated with the price scenario directly.

– No changes of the remaining machinery configuration.

Land improvement

Under the high price conditions farmers do consider long term investments to secure sustainable production such as drainage and recultivation (establishment of bush plantations) of land subject to degradation by salt. Appropriate measures would be a

– payment reserve of 4,000 €/a.

Management and labour input

The discussed utilisation of liquid fertiliser offers a logistical advantage. The panel estimates that the farm manager and the full time worker can manage the seeding program without the help of a seasonal worker. Further savings are obtained by combining fertiliser and fungicide passes. The measures contain the following:

– Less off-farm labour (reduction of input from seasonal labour by -300 h/a).
– Payment reserve for on-farm data and external advisory services (2,000 €/a) to facilitate precision agronomics.
– Spare contractor cost for spreading fertiliser (-4.50 €/ha).

Yield response to scenario S-2

The panel participants estimate a further yield improvement on the **better graded arable land** acknowledging the improved utilisation of direct crop inputs and plant protection effort. Assuming an equal share of high and low quality land, the increase **under average climate conditions** is considered to be +0.1 t/ha in cereals (+5 %) and nil in broadleaf crops and oaten hay based on the cropping adjustments in scenario S-1.

This results in the following yield figures for the simulation of scenario S-2:

– Peas 0.76 t/ha
– Lupins 1.04 t/ha
– Canola 0.95 t/ha
– Wheat 2.20 t/ha
– Barley 2.41 t/ha (no shift in ratio of feed versus malt)
– Oaten hay 3.82 t/ha

The estimated production output potential of AU 4000WB influenced by changes in acreage and yield under scenario S-2 conditions amounts to **+16 % for wheat** and **+14 % for barley**. Pulses and canola retreat to the level of B-0. A comparison of the production output potential is found in Table A45 in the Appendix.

Farm level implications of adaptation strategies and perspectives of AU 4000WB

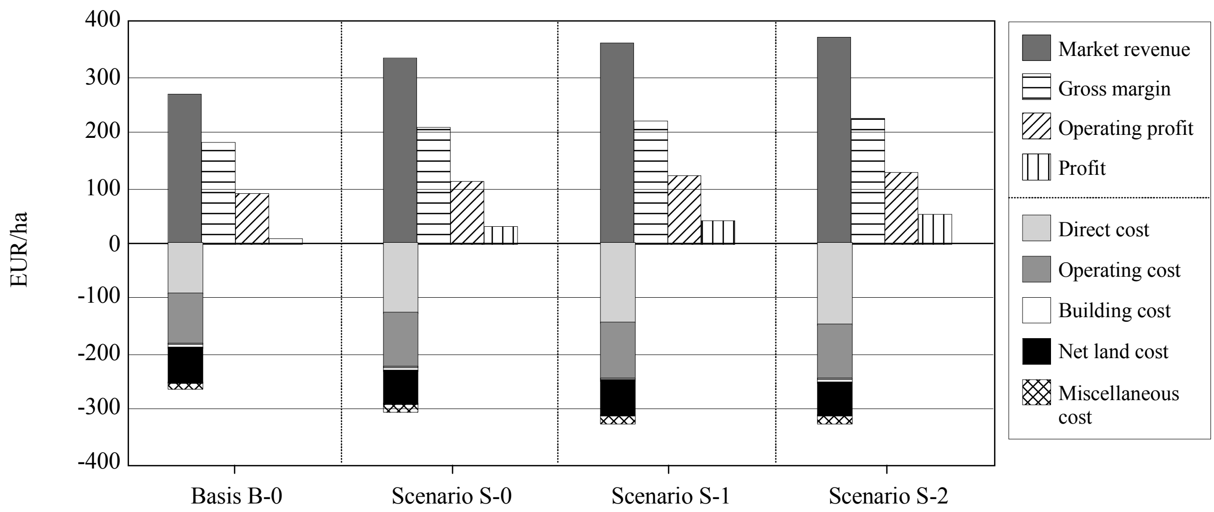
The adaptation strategies and estimated yield developments have effects on the market returns, the cost structure of the production system and thus on the profitability of the typical farm. While detailed calculations for individual crops are shown in Tables 4.20 and Tables A34, A35 and A36 in the Appendix, key findings for the typical farm in the West Australian Wheatbelt are outlined in this section.

The following Figure 4.35 illustrates the development of key indicators of the typical farm AU 4000WB in the basis scenario (B-0), under high price conditions and under the previously analysed adjustments regarding agronomy (S-1) and farm configuration (S-2).

The broad comparison of the price and adaptation scenarios with the reference situation shows a positive effect of the high prices on the overall farm performance. While a significant profit increase can already be observed in scenario S-0, the farm is further able to increase profits by adjusting agronomy of production (S-1) and also by reconsidering the general farm setup (S-2).

Agronomical adjustments which are summarised in S-1 lead to different effects. Firstly, expanding canola production, advantageous yield improvements in cereals harvested for grain caused market revenues increase substantially from 332 €/ha to 361 €/ha (+8 %).

Figure 4.35: Cost, revenue and profitability indicators of the AU 4000WB cropping enterprise (€/ha) in the basis scenario (B-0) and under scenario conditions (S-0, S-1, S-2)



Source: Own calculation.

At the same time, total cost increased less strongly from 302 €/ha to 321 €/ha (+6 %). That means agronomical adjustments undertaken as an adaptation to higher product prices are effective to generate a growth in return which can offset the higher direct cost load, especially fertiliser cost in cereals. This effects profitability indicators positively (gross margin, operating profit and farm profit). The total profit upturn from 30 €/ha to 40 €/ha (+33 %) constitutes a strong dynamic and adaptation potential of the agronomy of production in the Wheatbelt of Western Australia.

The reset of the area planted with canola and peas anticipated as a precaution measure to maintain the physical performance of canola and the legume N-fixation is considered in the scenario S-2. But the further yield increase in cereals proven as a response to a further increased nitrogen fertilisation, switch to more efficient nitrogen sources and fungicide application is not only able to offset the declining return contribution of canola but also increase average market revenues by 8 €/ha. The discussed consolidation of the production system and labour retrenchments which are the most interfering in scenario S-2, lead to a decrease of operating cost by 4 €/ha while higher direct cost are generated. Compared to scenario S-1 the overall farm profit increased further by 6 €/ha (+15 %) leading to an overall farm profit of 46 €/ha. For the typical farm in the Western Australian Wheatbelt it can be concluded, that both agronomical and strategic adjustments carried out to cope with higher prices proof fruitful to increase the profitability of the land use system.

In other words, production uncertainty in the Wheatbelt constraints top managed mixed farming systems to exploit the full production potential under reference price conditions but if the value of the output increases a considerably higher risk is taken.

The total costs of production per unit of output increase for wheat from 149 €/t in B-0 to 176 €/t in S-0 under high price conditions. However, the yield increase in response to agronomical adjustments cause a marginal decrease of average cost to 174 €/t in S-1 which can further be pushed to 167 €/t with the adjustments to the farm configuration in S-2. Analogue conclusions are drawn for the production of rapeseed and barley. Respective figures are displayed in Figure A26, A27 and A28 in the Appendix. Hence, according to economic theory the typical farm is encouraged to run the adjustment process thru in the light of decreasing average cost. With the full range of adjustments, the production intensity moves towards the optimal specific level of intensity under high price conditions.

Nevertheless, this result is only feasible assuming favourable weather conditions. Production uncertainties which are defined throughout various sections in this thesis are prevailing and can cause the loss of single top performing crops which reverts the substantial adaptation response extracted in the investigation of this typical farm.

The increasing profitability of the land use system is a substantial economic incentive and can lead to equity gains for the entrepreneur running a business like AU 4000WB. Considering only the price effect, the income could increase by 93,000 €/a while the described adjustment of the farm configuration (S-2) could lead to a further 57,000 €/a (total increase by 150,000 €/a).

4.5 The typical farm in Central West New South Wales

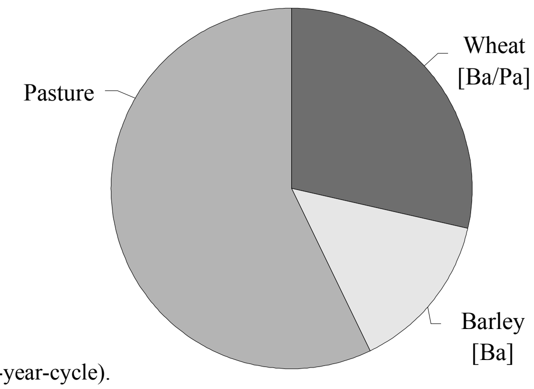
4.5.1 Cropping portfolio and type of production system

Mixed farming systems presented by the example of the typical farm in the Central West region of New South Wales differs significantly from the previously discussed land use systems. While all enterprises discussed so far are predominantly aligned on the production of cash crops, this farm is generating 45 % of the market revenues with its livestock enterprise and dedicates a large share of the productive farm land to extensive grazing.

The cropping operation is per se a well established enterprise and concentrates on the production of cereals. However, the performance is severely hit by disastrous weather conditions during the investigation period. This should be kept in mind when focussing on the results of the panel in New South Wales in the following section. An overview about the acreage and percentage share of crops in the crop portfolio is presented in Figure 4.36.

Figure 4.36 Cropping area (ha), share in the crop portfolio (%) and yield (t/ha) of crops grown on farm AU 2800CW (Average 2005–2009)

Crop	Pre-crop	Acreage [ha]	Share [%]	Yield [t/ha]
Wheat	Ba/Pa	600	29	1.66
Barley	Ba	300	14	1.80
Pasture	--	1200	57	--
Total acreage		2100	100	



Typical crop rotation:
Wheat -- Barley -- Wheat -- Pasture -- Pasture -- Pasture -- Pasture (7-year-cycle).
Note: Legend of diagram contains main crop name and the abbreviation of the pre-crop in square brackets.
Source: Own illustration.

Out of the 2,800 ha total farm land of AU 2800CW about 2,100 ha are categorised to be suitable for arable production. Out of the arable land 900 ha are dedicated to crops while the major share is occupied by pasture.

The cropping program does not include any broadleaf crops. To maintain a reasonable alternation, the cereal block is followed by typically three to seven years of pasture following a general **cereal – cereal – cereal – pasture (4-years)** frame.

One of the most important constraint for this land use system is the rainfall pattern. Differentiating from the previously discussed Western Australian regions, rainfall distribution in the Central West is summer dominated.[59] During the last decade more than half of the total available rain fell in the fallow period between harvest and seeding. The cropping performance does thus rely to a major extend on accumulated soil moisture.

The pasture in this system functions to reproduce soil moisture evaded by crops. Due to the permanent ground cover the pasture provides an open pored surface allowing rainfall to infiltrate and limit runoff during the very few heavy rainfall events, which are typical for summer rainfall. The growth of the natural or seeded legume pasture supplies fodder to run livestock which is sheep in the case of the typical farm AU 2800CW.

However, the current land use system is under heavy pressure to develop strategies to increase efficiency of soil moisture storage since trends of a) further shifts of rainfall from winter to summer b) severe droughts are observed with the investigation of long term rainfall data.[60]

Further details about the land use system are provided by discussing production systems of individual crops and the pasture management. Due to the absence of broadleaf crops, this section will concentrate on the production of wheat and it can also be found on the other typical farms in this comparison and the livestock enterprise.

Production of cereals

The share of cereals in the land use system amounts to approximately 45 %. They are grown in three different configurations:

1. Wheat following pasture
2. Barley following wheat
3. Wheat following barley
4. Wheat (dual purpose) following pasture or barley

Wheat following pasture is the first crop grownafter the 4 years grazing period. Respective fieldwork passes of the production system are illustrated in Figure 4.37.

---

[59] Cp. Section 3.3.1.4 and 3.3.2.

[60] Cp. Figure 3.13.

Figure 4.37 Production system of wheat following pasture on AU 2800CW and direct physical inputs differentiated by month and type of operation (Average from 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost [EUR/ha]	Operating cost [EUR/ha]
1	mid 12	Stubble tillage	Disc harrow, working depth 5cm		26
2	end 02	Seedbed preparation	Disc harrow, working depth 9cm		26
3	beg 05	Seeding	Airseeder (tines) + MAP (mineral) N10 P21	52	27
4	mid 07	Spraying	Selective herbicide	15	4
5	mid 08	Spraying	Selective herbicide	12	4
6	beg 12	Harvest	Combine harvest		22
7	beg 12	Transport	On road transport (truck)		4
			Total	80	113
Summary					
Crop			Wheat (following pasture)		
Tillage			Soil cultivation and mulch seed		
Seed		kg/ha	38	12	EUR/ha
Fertilisation		Nutrient kg/ha	N10 P21 K0 CaO0 Mg0 S0	41	EUR/ha
Chemicals		Applications	Herbicide (2), fungicide (0), insecticide (0), other (0)	28	EUR/ha
Yield		t/ha	1.66		

Source: Own calculation.

Tillage program and seeding

Soils in the study region tend to compact during long term pasture and under repeated grazing. To bring land back into cropping tillage is assessed to be necessary for recultivation and weed control.

On AU 2800CW two disc cultivation passes with five and nine centimetres working depth are carried out in December and February before seeding. Key expenditure of the production system is the seeding pass in the middle of May. The typical farm utilises a tine seeding implement with press-wheel to achieve reasonable seedbed conditions.[61]

With the seeding pass a double component (N and P) granulated fertiliser is applied: Monoammonphosphate (MAP). Due to the mechanical weed control of tillage there are no herbicides are applied before seeding.

Differentiating from dual-purpose wheat discussed in the next section, seeding is not determined by rainfall events but are required for germination.

[61] Cp. Section 4.1.3.3.

Fertilisation program

All fertilisation is carried out with the seeding pass. Top-dress fertilisations with nitrogen are prevalent under average conditions but were not observed in the investigation period.

Due to the moderate reaction of soils closer to crops pH optimum in the Central West region and the proportional rate of nutrient availability for plant uptake, target fertilisation would principally equal crop's removal. However, due to the nutrient accumulation of pasture, in particular legume pasture, target fertiliser rates are cut back to factor 0.8 of removal.[62]

Plant protection program

In wheat following pasture, plant protection efforts are restricted to post-seeding selective herbicides. Fungicide applications are held as top-dress with urea and were not appropriate during the years from 2005 to 2009.

Low chemical inputs, tillage, long term grazing, rotational pastures and burning of crop stubbles are common measures of the land use system in Central West NSW and a reason for relatively low pressure of specific weeds or potential resistances. However, this issue is critically discussed by the panel farmers especially in the light of interstate quarantine restrictions.

Harvest and handling

Wheat harvest usually takes place from end of November to beginning of December using a second hand conventional combine. Since tonnages per hour are relatively low, there is no on-field transport necessary and the combine unloads directly into provided trucks or field bins.

With the described production intensity the typical farm generated a five-year-average crop yield of 1.66 t/ha. However, it must be acknowledged that yield performance is adversely influenced by drought during the investigation period. Figure 4.38 will further extend this issue.

The herewith introduced production system can in principle be generalised for the cereal production on the typical farm AU 2800CW. Minor changes in the timing of single passes are found in the production of cereals in the remaining configurations.

Barley following wheat and **wheat following barley** are seeded no-till. The tillage passes are substituted by two total herbicide applications while all other passes remain the same. Barley yielded slightly higher at 1.8 t/ha while wheat following wheat remain equal

62 Cp. Tables A10 and A11 in the Appendix.

to the pioneering wheat after pasture. An illustration of the production system can be found in Figures A22 and A23 in the Appendix.

Ideally, proportion of the wheat crop is planted as **dual purpose wheat.** Beside harvested for grain, this wheat has the potential to benefit sheep by grazing at intervals during late stages of leaf development, tillering and early stages of stem elongation (BBCH 15–33). Grazing grasses in these stages does stimulate tillering and vegetative growth and does not influence grain yields if growing conditions are favourable. Advantages of dual purpose are spreading of extreme climatic risk (frost, drought, waterlogging), provision of high nutritive grazing in late autumn and early winter and taking advantage of early sowing opportunities to better utilise favourable seasons (AMJAD and CURTIS, 2006).

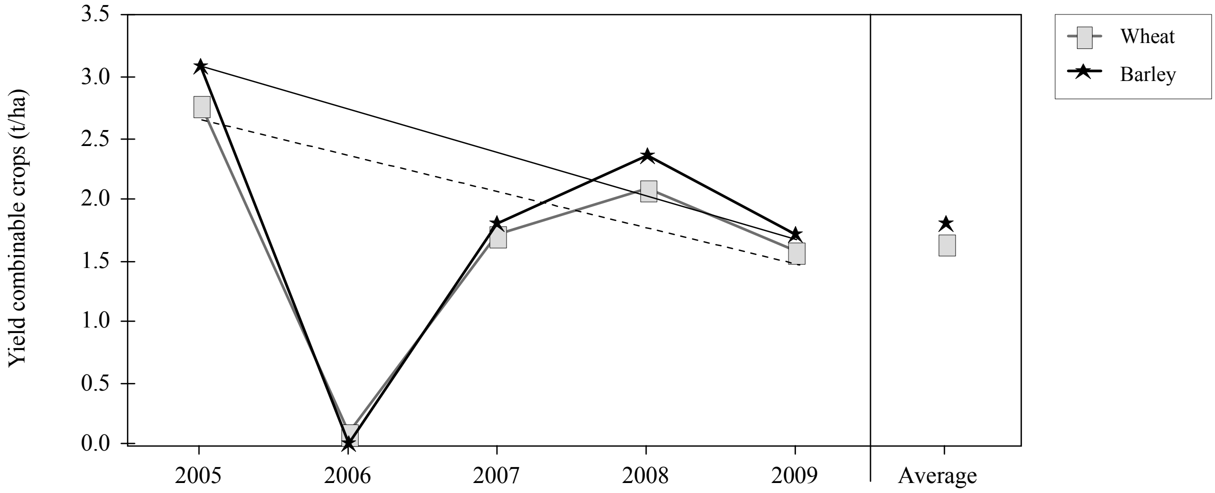
On the typical farm dual purpose wheat is seeded on the premise of sufficient rainfall in February and grazed for approximately ten weeks intensively with six to seven sheep per hectare. Thereby paddocks are alternated to allow crops to recover. Yet, grazed crops are stocked off in August at the latest to allow grain yield accumulation. The panel does report same yields in dual-purpose wheat seeded in February compared to wheat seeded in May. The monetary benefit of the grazing wheat is valued 21 €/ha and included in market returns. However, since rainfall conditions are poor during the investigation period, there is very little opportunity to graze.

The respective production system of dual purpose wheat does not vary substantially between the assignments and is illustrated in Figure A24 in the Appendix.

Evolution of crop yields and estimation of production uncertainty

The interaction of natural conditions in the Central West region in New South Wales with the production systems resulted in the following crop yields of the typical farm in individual years. (Figure 4.38)

Figure 4.38: Evolution of crop yields (t/ha) and five year average (2005–2009) of AU 2800CW



Source: Own calculation.

Crop		Wheat	Barley
Precrop		Pa/Ba	Wheat
Ø 2005-2009	t/ha	1.66	1.80
Max[1)]	t/ha	2.78	3.08
Min[1)]	t/ha	0.10	0.00
CV[2)]		0.60	0.64

1) Maximum and minimum yields in the observed period.
2) Coefficient of variation.

The yields of wheat and barley in the single years are closely linked to the natural conditions, in particular growing season rainfall in the respective year (Figure 3.14):

– In 2005 growing season rainfall outreached the 35-year average by 40 mm. Wheat and barley crops performed outstanding well above the five year average. According to the panel, this year gives an indication for the yield potential in the Central West region.

– The year 2006 is marked by severe drought conditions throughout the eastern states of Australia. In the study region growing season rainfall of 111 mm fell which is less than half of the long term average. This was leading to a total wipe out of barley crops and allowed only patches of wheat maturing to grain and to be harvested.

– Further water deficiency was observed from 2007 to 2009 with growing season rainfall at 2/3 of the long term average.

Apart from the annual information, the graph indicates the following properties of the crop yield pattern relevant for this investigation:

– Since wheat and barley yields fluctuate homogeneously compared to their respective yield level during the observed harvest years (cp. internal CV in Figure 4.38). These figures indicate an extreme production uncertainty.
– Cereal yields appear to trend negatively (descending linear trend line) during the short term investigation period. This observation corresponds to the long term negative trend identified on the respective regional scale. (Figure 3.7)

Acknowledging the limited explanatory power of the statistical indicators due to the limited number of observations, generalisations from this data are certainly not feasible. However, the indications regarding the yield performance in the recent past (fluctuation and trend) influence the confidence of the panel participants about the prospective development in their cropping region.

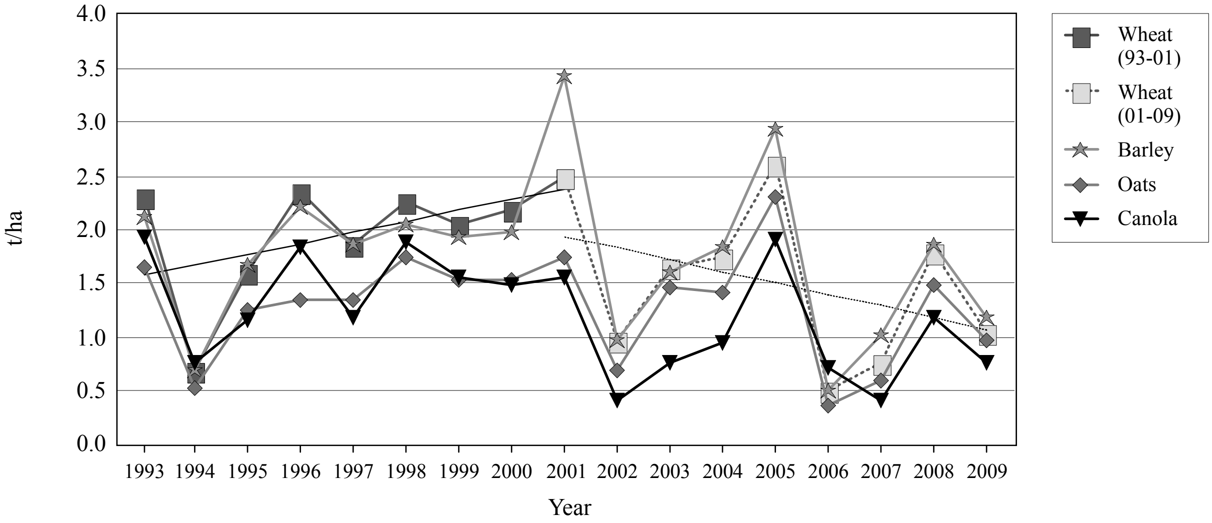
The statements regarding the crop performance of the typical farm AU 2800CW are outstanding in proportion to the other farms in this comparison. To further elaborate whether the tremendous development of yields during the investigation period in this special case is rather a 'farm-specific' observation of AU 2800CW or fundamental for the investigation region, a higher aggregated level is chosen: Long term small scale statistical yield data of major crops exclusively available on shire level in NSW.

The following Figure 4.39 illustrates the yield evolution of wheat, barley, oats and canola in the Central West region compiled for the shires of Wellington, Forbes, Parkes and Condobilin from 1993 to 2009.

During the years from 1993 to 2001 annual yields developed relatively steady. With the only exception of 1994, yields of wheat and barley level even around 2 t/ha, oats and canola yields are around 1.5 t/ha. From 2001 onwards yield fluctuations accelerated significantly and yields decline. Within nine years, cereals yielded below 1.2 t/ha in four years and canola below 1 t/ha in six years.

By means of wheat, which is the most dominating crop in terms of acreage, a significant break can be observed after 2001. While annual wheat yields increased and averaged 2 t/ha until that year they declined substantially in the second period after 2001 and cut back to 1.38 t/ha on average due to a degradation of rainfall pattern for cropping.

Figure 4.39: Evolution of yields of selected crops (t/ha) in the Central West region[1)] of New South Wales (1993–2009)



1) Shire of Wellington, Forbes, Parkes and Condobolin, statistical data.
Source: Scott (2009), own illustration.

These yield records show that not only the typical farm but the cropping operations in the whole region of Central West is facing substantial threads to production and is under pressure to risk manage low return situations caused by extreme yield fluctuations.

However, crop failures in selected years is also evaluated by the panel as being chained to a lack of conservation farming technologies. One participant of the panel observed better moisture storage in soils on his farm with diversified rotation and thus higher yields in the last 15 years (KNOWLES, 2010).

Another land use strategy established on several properties in Central West NSW is called 'Pasture Cropping'. This tactic involves seeding arable crops into natural perennial pastures to achieve 100% ground cover throughout the year, provision of grazing for livestock on cropland immediate after harvest and a risk managed crop establishment (SEIS et al., 2009).

Seeding into perennial pasture after intensive grazing gives the opportunity to grow a profitable grain crop but still high quality grazing in case a lack of rainfall does not provide enough soil moisture to allow cereals to mature. Within the scope of this study investigation of pasture cropping is undertaken as a case study on a farm in the region but it is not suitable to be considered when establishing the typical farm (MAURICE, 2010).

Pasture management involving livestock

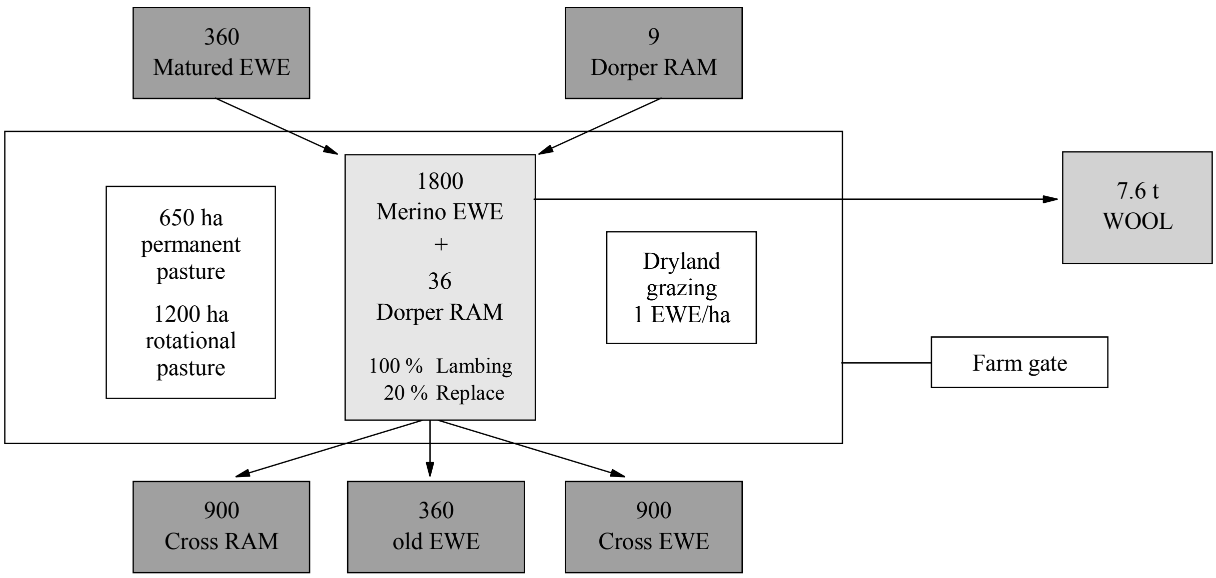
Given the return instability of the cropping in the last ten years, the sheep enterprise on AU 2800CW in Central West NSW has a high importance to the farm performance:

– Market returns from meat and wool are generating one third of the total farm return and operating profit in average years.
– About 60 % of the total farmland is dedicated to the sheep enterprise **and** the major share of that is potential cropland included in the cropping rotation.

As in the previous example, **Merino** and **Dorper** sheep breeds are of importance to the sheep enterprise. Once also established as a self replacing operation with production of own offspring ewes, the replacing flocks had to be reduced due to the harsh drought conditions during the investigation period.

The typical production system is illustrated in the following Figure 4.40.

Figure 4.40: Production system of first cross Merino-Dorper operation on AU 2800CW



Source: Own illustration.

The central element is a 1,800 head Merino ewe flock which is paired with Dorper rams grazing on the rotational and permanent pasture. The grazing intensity is largely dependant on the growth of natural or seeded pasture. In this part of New South Wales the typical livestock intensity is one ewe per hectare on average throughout the year.

Stock management is carried out similar to the previous example. On the typical farm AU 2800CW the work capacity of the senior family member is dedicated to the sheep enterprise (1,100 h/year). At times when handwork on the sheep (marking, trenching, crutching or shearing) is not carried out husbandry mainly comprises field and diet management. In the presence of the abovementioned cropping system the diet typically consists of:

– Natural grass or lucerne pastures during the growing period (April–November)
– Grain stubbles, grain losses, weed seeds and germinated seeds (November–April)
– Dual purpose grains, most commonly wheat is used. Crops are grazed intensively until August in favourable years with decent early season rainfall which allows early seeding.

Legume or grass cover crops (e.g. cowpeas, millet or sorghum) are a reasonable source of fodder when seeded after harvest of cash crops. However, they are not very commonly to grown at the moment. Research is concluded are undertaken to elaborate the introduction of cover crops into the crop portfolio to support soil moisture accumulation for the following wheat and/or to provide fodder during summer (McNee, 2011).

Under these conditions the Merino flock is maintained to reach a typical replacement rate of 20%. That means 360 old ewes (6–7 years) are sold and must be replaced by matured ewes every year. These matured ewes and also the rams are bought from other breeders and not produced on farm.

The typical **lambing rate** of first cross lambs is 100%. That means every ewe is raising one sellable lamb per year. Thus, from the typical flock ideally 900 first-cross rams and 900 first-cross ewes are born and sold after the grazing period of six months.

In this typical farm situation it can be assumed that the lambs are cleared completely to market after this period and the ewes are recovering before being paired again.

The co-product to sheep meat is **wool** which is solely produced by the Merino ewe flock. The flock is usually shorn by a shearing contractor once a year in January or February. The rams and lambs are not getting shorn. Due to their breed the wool does not contribute in terms of production and output.

During their productive time on farm a single the ewe produces 4.2 kg of clean high quality wool (21 Micron) on average per year. Considering the last five years average price of 5.80 €/kg kg of clean wool, the ewe generates approximately 25 € return per year from wool.

When the ewe is going to be replaced after five lambing periods, the animal reaches 55 kg average live weight. Thereof 22 kg is the typical dressed carcase weight which has been valued with 1.15 €/kg on average in the last five years. Taking into account an additional

1.25 € premium per skin, the ewe generates another 26 € return at the end of its production period.

On top of the ewe's individual productivity it produces one lamb per year. After the lambing period in May/June, it takes about six weeks to raise marketable lambs of approximately 40 kg live weight. Considering a dressing percentage of 49 % for first cross lambs this equals a carcase weight of 19.4 kg. The pricing for lambs follows the same scheme as with the ewes. The price for weaned lambs in the investigation period averaged 2.20 €/kg carcase weight. This average is based on figures of the strong **domestic market** of the east coast of Australia.

The **export market**, in particular the live export of lambs to the Middle East, has gone up significantly in volume in the recent past and is becoming more and more important for marketing in Western Australia. The export market tends to pay off better for the producer here but has special requirements regarding breed, weight and quality.

On top of the carcase value there is also a premium paid on the skin of 3.10 € per head. Summing this up, a single lamb is generating approximately 45 €/ha return.

The **total return of the sheep enterprise** considering the settings of the introduced typical production system in AU 2800CW in Central West NSW equals to:

– 74 € per ewe per year (wool, lamb and ewe at the end of productive live)

When considering the productivity on a per hectare base to be comparable to crop production, it can be assumed that sheep production contends with cropping. Therefore, it is common to allocate the entire sheep production to the potential crop land. Given this assumption, the total return would add up to:

– 116 € per cropable hectare dedicated to rotational pasture

The operating cost items of the sheep enterprise in the typical farm situation in Central West NSW are listed in the following table 4.21.

The economic performance of the sheep enterprise is of particular interest for the research question of this study whether more land is brought into production at the expense of the land dependent livestock farming.

To achieve comparability of the two enterprises in the following section, accumulated cost and revenue positions of the sheep enterprise will be transferred into TYPICROP and refer on the occupied arable land (rotational pasture) as the reference unit which competes directly with the cropping enterprise.

Table 4.21: Profitability of the sheep enterprise on AU 2800CW (2005–2009)

Stock numbers		**Stocking rates**	
Merino ewes	1,800	DSE[1)] per ewe	3.5
Dorper rams	36	Lambing	100 %
Wether lambs	900	Replacement	20 %
Ewe lambs	900	Ewe per arable ha	1.5
Total flock size	3,636	Arable land	1,200 ha

Item	**Factor**	**EUR per Ewe**	**EUR per ha**
Wool [kg/head]	4.22	24	36
Lambs to market	100 %	48	72
Old ewes	20 %	5	8
Market revenue		**78**	**116**
Production cost			
Husbandry		1.7	2
Feeding		2.6	4
Crutch		1.1	2
Shearing		3.3	5
Deaths	4 %	2.6	4
Replacement ewe	20 %	9.2	14
Transport ewe		0.5	1
Rams	9	1.5	2
Marking and husbandry		1.0	2
Transport lamb		1.5	2
Fertilizer cost		0.6	1
Direct cost		**28**	**39**
Gross margin		**50**	77
Labour		8.7	13
Machinery		2.7	4
Other	5 %	2.4	5
Operating cost		**40**	**21**
Operating profit		**38**	**57**

1) DSE = Dry sheep equivalent.
Source: Own calculation.

4.5.2 Profitability analysis and production cost

The previously discussed production systems of crops and livestock on AU 2800CW cover the main agronomical and operational framework. In the following section the focus is set on the profitability of production in the Central West region of New South Wales.

The following Table 4.22 presents the total cost account of single crops and rotational pasture (sheep) on a per hectare basis ordered by the individual crop's operating profit contribution. The final column (grey shaded) refers to the average farm performance of AU 2800CW per hectare cropped land computed by means of the acreage-weighted figures of single crops.

Market revenues of single operations vary very little between the crops in the portfolio. The revenue of dual purpose wheat is higher since it includes an allowance of 22 €/ha for the grazing benefit. The average farm revenue ranges at 180 €/ha.

The highest net revenue over direct cost (gross margin) in the cropping portfolio is generated by wheat following pasture caused by lower chemical cost. However, the tillage program to offset the weed control is considered in operating cost. The average gross margin amounts to 118 €/ha.

When focussing on operating efforts, the configuration of this typical farm shows competitive disadvantage in terms of labour cost and machinery cost compared to the other Australian farms in this study. For example labour cost are approximately 10 €/ha higher[63] in the no-till operations. Since input intensity in No-Till systems is comparable, this indicates structural deficiencies of AU 2800CW. The average operating profit during the investigation period adds up to 47 €/ha.

As shown in the bottom line of Table 4.22 the operations of the typical farm during the investigation period are not able to cover their total cost. The farm generates a net loss of -28 €/ha. With regards to the financial sustainability it must be considered that the total cost approach in this thesis does incorporate all calculated opportunity cost for own capital, labour and land. In the short and medium range, the farm can withstand this situation of not remunerating these factors.

---

63 Cp. Table 4.20.

Table 4.22: Profitability of single crops and farm average AU 2800CW (2005–2009)

Crop		Wheat dual	Pasture	Wheat	Barley (feed)	Wheat	Farm average
Previous Crop		Barley	Sheep	Barley	Wheat	Pasture	
Acreage	ha	100	1,200	200	300	300	2,100
Crop yield	t/ha	1.7		1.7	1.8	1.7	
Output price	EUR/t	157		157	142	157	
Market revenue	**EUR/ha**	**283**	**116**	**261**	**256**	**261**	**179**
Seed	EUR/ha	7	0	7	7	7	3
Nitrogen (N)	EUR/ha	9	0	8	8	8	3
Phosphorus (P)	EUR/ha	40	1	33	33	33	15
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	50	1	41	41	41	19
Herbicides	EUR/ha	45	0	45	45	28	17
Fungicides	EUR/ha	0	0	0	0	0	0
Insecticides	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	45	0	45	45	28	17
Crop establishment cost	**EUR/ha**	**102**	**1**	**93**	**93**	**75**	**39**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	37	0	0	0	21
Finance field inventory	EUR/ha	3	1	2	2	2	1
Total direct cost	**EUR/ha**	**105**	**39**	**95**	**95**	**77**	**61**
Gross margin[1)]	**EUR/ha**	**178**	**77**	**166**	**160**	**184**	**118**
Labour	EUR/ha	38	13	37	38	50	26
Contractor	EUR/ha	0	2	0	0	0	1
Machinery	EUR/ha	67	4	66	67	101	36
Diesel	EUR/ha	11	1	11	11	21	7
Other	EUR/ha	2	1	1	1	1	1
Total operating cost	**EUR/ha**	**118**	**21**	**115**	**118**	**174**	**70**
Operating profit[2)]	**EUR/ha**	**60**	**56**	**50**	**42**	**10**	**47**
Building cost	EUR/ha	19	8	18	17	18	12
Total land cost	EUR/ha	50	49	50	50	50	50
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	50	49	50	50	50	50
Miscellaneous cost	EUR/ha	22	9	20	20	20	14
Total cost	**EUR/ha**	**314**	**126**	**299**	**301**	**339**	**207**
Profit[4)]	**EUR/ha**	**-31**	**-10**	**-37**	**-45**	**-78**	**-28**

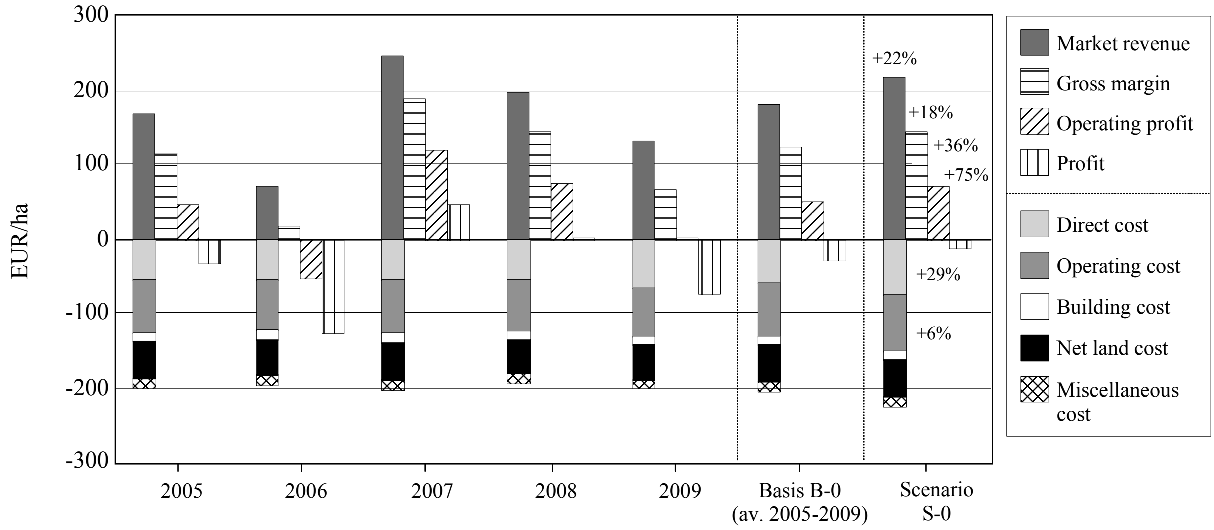
1) Gross margin = Net revenue over direct cost.
2) Operating profit = Net revenue over direct and operating cost.
3) Net land cost = Total land cost reduced by decoupled payments.
4) Profit = Net revenue over total cost.
Source: Own calculation.

The figure shows furthermore that the sheep enterprise is generating the smallest total loss of all enterprises on that farm. The argument of the panel that sheep is stabilising the overall performance although not fully profitable, is confirmed keeping in mind the disastrous yield performance mentioned above.

Based on these findings it is necessary to investigate further how the economics of production developed in single years during this time period and how the high price scenario would influence the performance of the farm per se without any adaptations. The respective findings are described in the following Figure 4.41.

The underlying calculations are found in Table 4.22 and in Tables A37 to A42 in the Appendix.

Figure 4.41: Cost, revenue and profitability indicators of the AU 2800CW cropping enterprise (€/ha) in selected years, 5-year average (2005–2009) and under scenario conditions (Scenario S-0)



Note: 1) Net land cost calculation incorporates decoupled payments.
2) Percentage figures typify the increment (delta) of selected positions based on basis scenario B-0.
Source: Own calculation.

The figure illustrates selected economic indicators for the typical farm AU 2800CW in different temporal dimensions. Firstly, single years of the investigation period are displayed and based on this the following conclusions are drawn:

– In three out of the five years investigated the typical farm is not able to cover the total cost of production. In these years, the operation on the typical farm generated substantial capital losses. Particularly in 2006 the yield failure in cereals caused a serious economic situation in which even operating cost are not covered (cash loss). The income situation in 2005 and 2009 is however mastered by low output prices. In contrast to this reasonable equity is gained in 2007 (44 €/ha profit). The latter effect is caused by high commodity prices while yields are in proximity to the 5-year average in all crops.[64]

– During the whole investigation period total cost of production and the cost structure is relative stabile at a level of 200 €/ha. In comparison with the previously discussed typical farms this demonstrates once again the effect of a low cost strategy and its response to rising energy prices.

The basis scenario (B-0)[65] established using the five-year-average figures from 2005–2009 eliminates the individual price and yield bias. In the following section, this provides the general reference farm situation for further analysis. In a first step, the high price scenario[66] underlying for this study is adapted without any changes to the production system and farm configuration. The economic effect of this scenario (S-0) is also illustrated in Figure 4.41 and can be interpreted as the following:

– The high price scenario results in an increase of the gross and net return figures. Although income indicators are above the average of the last five years, the margin and profit situation is below the harvest years 2007 and 2008.
– Even under high price conditions conducted by the scenario assumptions the land use system as discussed in this chapter would not be able to cover expenses for all production factors and generate a marginal loss when accounting total cost.

While the production of no-till crops is found being relatively uniform, wheat following pasture and the sheep enterprise differentiates in terms of direct and operational expenditure. Especially the large acreage contribution of the sheep enterprise can potentially be restrictive for the overall farm profitability to participate from rising commodity prices. This is especially true since wool and meat prices are kept separately from the crude oil price derivation and ceteris paribus.

Supporting the message from the Wheatbelt panel, the participants in the Central West confirmed that this procedure does reflect the price development during 2007/08 where arable prices soared and the meat prices remained untouched at break even level for nearly two years. This issue will be addressed in the following

64 Cp. Figure 4.38.

65 An overview over the specific scenario configurations can be found in Section 2.4.1 in Table 2.2.

66 The relevant scenario prices for AU 2800CW can be found in Table A52 in the Appendix.

Direct cost and gross margin

Due to the mentioned diverting requirements of enterprises regarding farm's resources direct cost and gross margin comparisons are not convincing enough to explain the on-farm competitiveness. However, an important conclusion regarding the energy dependency can be drawn from the direct cost comparison illustrated in Figure A23 in the Appendix, displaying the single crops market revenues, direct cost and gross margins of AU 2800CW in the reference scenario (B-0) and under high price conditions (S-0):

– The slight higher fertiliser input to dual-purpose wheat makes this crop more vulnerable to energy price hikes.
– Direct cost of maintaining rotational pastures are marginal and do rarely respond to the high price scenario.
– Wheat after pasture has a marginal advantage in terms absolute gross margin. This might be an indication why tillage is still commonly practiced: Cultivation with long term depreciated machines carried out by a family member is advantageous with regard to cash cost in the reference situation (B-0): 5 €/ha tillage (diesel) vs. 8 €/ha spraying (herbicide and diesel).

The detailed calculation regarding gross margins is found in Table 4.22 and Table A43 in the Appendix.

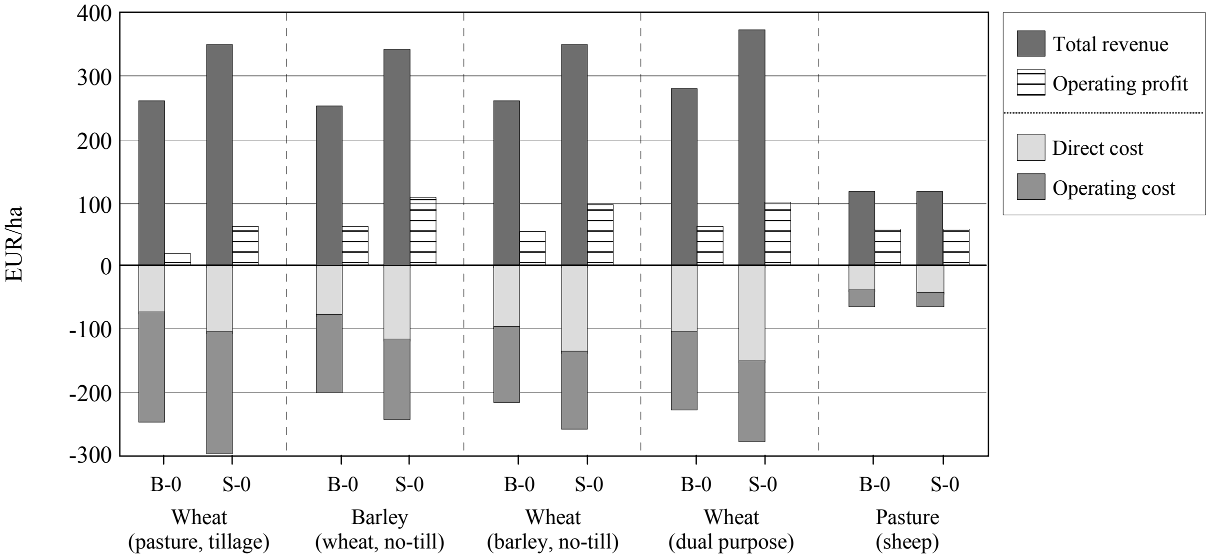
Operating cost and operating profit

More information about the relation between single crops and cropping versus livestock in the basis scenario and under high price conditions are gained when focussing on the operating profit.

The calculation accounts market revenues reduced by total direct cost and total operating cost. While the linkage between direct cost and energy prices has already been discussed operating cost variability is exclusively linked to rising prices for fuel and other energy sources under the high price scenario. Other costs are considered ceteris paribus.

The abovementioned minor advantage of wheat sown after soil cultivation shrinks when focussing on the operating profit. The first wheat crop after pasture in the prevailing production system shows the poorest performance in the basis scenario and No-Till sown crops show a better performance. Average operating profit figures during the investigation period (B-0) are uniform to livestock at approximately 60 €/ha.

Figure 4.42: Comparison of revenue, direct cost, operating cost and operating profit (€/ha) of cropping and livestock on AU 2800CW, reference scenario (B-0) vs. high price scenario (S-0)



Operating profit response	+274 %	+79 %	+89 %	+65 %	-3 %

Source: Own calculation.

When applying the high price scenario on the No-Till system some changes to the exposition can be observed. In fact, direct sown crops do respond positively to rising prices.

A small loss of operating profit under S-0 conditions is monitored at the livestock enterprise. Since market revenues are assumed ceteris paribus with the simulation, the profit decline (-3 %) is caused by rising production cost. However, this shift is evaluated to be marginal given the cost response of the cropping operation.

The shift in operating profit relations suggests the further question, whether the seeding system might change in favour of No-Till which is identified being more profitable under high price conditions on AU 2800CW. The research showed that the position of tillage on the farm is critical. This wheat reaches hardly the level of the sheep enterprise under high price conditions. Therefore it is prerequisite to uncover further considerations of the panel participants in the Central West region of New South Wales.

4.5.3 Analysis and assessment of adaptation strategies

The following section presents adaptation strategies of the typical farm AU 2800CW to cope with the effects of the high price scenario discussed in the previous section. They refer to the estimation of the respective farmer panel held in the Central West region of New South Wales and are categorised in:

– agronomical adjustments of the cropping program under high price conditions (scenario S-1)
– adjustments to the general farm configuration under high price conditions (scenario S-2)

Scenario S-1 – Adjustments referring to AU 2800CW

The land use system of the typical farm in the Central West region of New South Wales is under pressure of extreme weather risk. As highlighted in the previous sections, the overall performance of the typical farm in the investigation period suffered from few years with yield failure in crops pulling down five year average figures to an economically unsustainable level. This has two basic dimensions with regards to agronomical adjustments feasible in the short run:

1. Liquid funds to enable proactive business development and production adjustments are nonexistent. The economic survival of many farms in the recent past is supported by interest-subsidised short term loans to finance direct inputs.
2. High production uncertainty caused by unforeseeable weather extremes constraints farmers to increase investment in the cropping enterprise.

Hence, risk balancing between different enterprises especially taking livestock into account has first priority. In other words: ‘Have your eggs in more than one basket.’

Management adjustments

For the cropping operation the panel anticipates to further maintain the low cost strategy in the short run to be able to redeem benefits from high return situations building up equity and capital surplus for potential upcoming drought conditions. This includes the following measures:

– Become flexible to take manageable risk to implement innovation and advantage of upcoming cropping trends if feasible:
  – Payment reserve for farm consulting (4500 €/a)
  – Conduct own trials and/or develop farm individual tactics to manage soil moisture e.g. cover crops or pasture cropping. However, these tactics may fit into existing farming practices but positive effects can not be generalised at this stage (NEHRING and MCNEE, 2011).

– Maintain and monitor soil moisture as the basis for good plant growth and potentially neglect seeding of crops.

Further changes or investments are not anticipated in a short term period in order to prevent loss of equity. The panel agreed on ceteris paribus to the reference scenario under S-1 conditions without any influence on yield and total farm output.

– Change nothing.

Yield response to scenario S-1

– None.

The estimated production output potential of AU 2800CW influenced by changes in acreage and yield under scenario S-1 is analogue to the reference scenario. A comparison of the production output potential is found in Table A45 in the Appendix.

Scenario S-2 – Adjustments referring to AU 2800CW

Given the identified weaknesses of the current land use system of the typical farm in the Central West of New South Wales, conditions of scenario S-2 and the long term outlook of high commodity prices encouraged panel participants to reassess the general setup of AU 2800CW. Since failure in selected years is identified due to a lack of conservation farming technologies, a general change of management practices is anticipated. The outcome is presented in the following section.

Farm size and land use structure

Structural deficiencies are considered with regard to economics of scale (machinery utilisation and application of latest technologies. The panel reported land on the market from farm being judged insolvent but restructuring or extension is hardly ever possible for existing farms. The panel considers the farm size to remain constant as in the reference situation (B-0).

However more land will be dedicated to crop production (45–60 %):

– Extension of land area under crops 1,200 ha (58 %)

– Reduction of rotational pasture to 900 ha (42 %)

– Decrease stock numbers to 1350 ewes to fit grazing potential of the pasture. Hand feed sheep to substitute the loss of grazing area is not feasible. Stocking intensity, production system and utilisation of permanent pasture are assumed ceteris paribus.

– Shift to 100 % No-Till operation

Crop portfolio adjustments

The panel shared the opinion that a diversified rotation support long term sustainability of the land use system and maintain a higher level of productivity. Under scenario S-2 conditions, the rotation will be complemented by a broadleaf crop. The cropping rotation will thus be:

– Wheat – Canola – Barley – Wheat – Pasture – Pasture – Pasture

following a general **cereal – broadleaf – cereal – cereal – pasture (3-years)** frame. The individual crop's share in the production portfolio is determined to be:

– Wheat 600 ha, thereof 100 ha dual purpose wheat (±0 %)
– Barley 300 ha (±0 %)
– Canola 300 ha (new in rotation)
– Rotational pasture 900 ha (-25 %)

Seed technology

The panel does not estimate an implementation of hybrid varieties or GM Roundup Ready canola to the typical farm's crop portfolio. Furthermore, the panel does not expect a substantial yield advantage to offset technology fee, endpoint royalty of GM varieties and higher handling logistic cost due to longer distance to local freight terminal (3–6 €/t). The only driver would be weed control in combination with herbicide resistance. As mentioned above, this has been no issue so far.

– Seed configuration of all crops ceteris paribus.

Fertilisation intensity

On the premise of good or average growing conditions an intensification of the fertilisation regime is anticipated by means of a top-dress application of 20–40 kgN/ha in cereals. For S-2 simulation the following is assumed:

– Wheat and barley top-dress 30 kgN/ha in form of urea in September (BBCH 6) spread by contractor (5 €/ha).

Pesticide intensity

Assuming average or good growing conditions an intensification of the pesticide programme is aspired due to lower economic damage thresholds of fungal diseases by means of a fungicide application in cereals. For simulation is assumed:

– Wheat and barley fungicide spray in August (BBCH 5); fungicide cost 5 €/ha.

Machinery investments

The shift from rotational cultivation to 100 % No-Till requires technical measures:

- Airseeder (used) with disc implements including two tank seedcart (granulated fertiliser and seed), 12 m working width. Purchase price 153,000 €, all other depreciation details ceteris paribus. Increasing fuel efficiency: consumption with disc-seeding (2.5 l/ha) is lower compared to the current tine machine (6.5 l/ha).
- Implementation of GPS precision agriculture technology: parallel tracking application to existing 4WD tractor: 9,000 € one time upgrade cost.

Risk management

To risk manage the vulnerability of the farm to yield fluctuations is a major concern expressed by the panel. Therefore a higher equity rate is anticipated and the cash-out of tangible assets to risk cash liquidity only.

- Sell out and cash tillage gear, tine Airseeder and harvester. Increase equity from 65 % to 70 % to improve bank evaluation. An equity share of 65 % in farm assets is considered to be the minimum requirement of the finance institution.
- Get contractor for spreading urea and harvest (30 €/ha average harvest cost in diversified rotation) to remunerate harvesting expenditures only in applicable years and transfer capital risk off-farm.
- Avoid casual labour and cash labour cost (no casual worker due to more off-farm services including operator).
- No respond to deploy marketing tools as volatile prices has always been reality in export oriented ag industry.
- No incentive to invest in on-farm storage.
- Irrigation not feasible

Management and labour input

The panel estimates the farm manager to intensify supervision of operations and farm management (paddock selection, soil moisture measurements). All operations under S-2 scenario conditions carried out without the help of a seasonal worker. The measures contain the following:

- Elimination of off-farm labour (no casual required).
- Payment reserve for on-farm data and external advisory services (2000 €/a) to facilitate precision agronomics.
- Increased management input by farm owner (+150 h/a).

Yield response to scenario S-2

The panel participants estimate a yield improvement acknowledging the diversified crop rotation and intensification of direct crop inputs as well as plant protection effort in the longer run. Assuming **average or good climate conditions** the increase is considered to be +20 % in all crops based on the average yields in the reference scenario B-0.

This results in the following yield figures for the simulation in the scenario S-2:

– Wheat 2.00 t/ha
– Canola 1.48 t/ha
– Barley 2.16 t/ha (assumed 100 % feed quality)

The estimated production output potential of AU 2800CW influenced by changes in acreage and yield under scenario S-2 conditions on the premise of good or average climate conditions amounts to **+20 % for wheat** and **barley, rapeseed is established new**. A comparison of the production output potential is found in Table A45 in the Appendix.

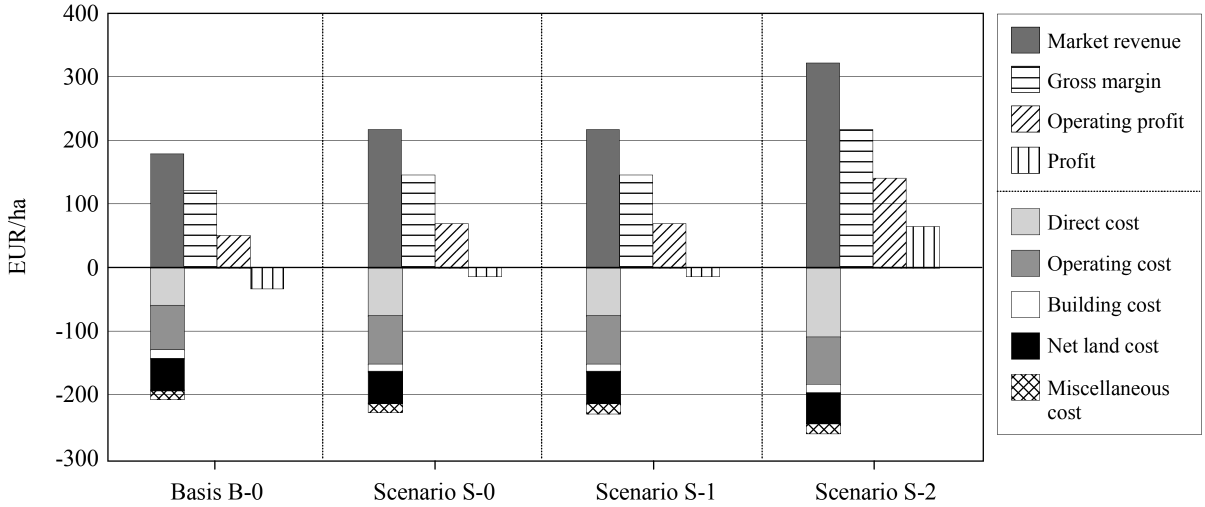
Farm level implications of adaptation strategies and perspectives of AU 2800CW

While adjustments under scenario S-1 conditions remained constant, the corrections to the general farm setup and estimated yield developments simulated in scenario S-2 have effects on the market performance of the cropping portfolio, the cost structure of the production system and thus on the profitability. The detailed calculations for individual crops are shown in Tables 4.22 and Tables A42, A43 and A44 in the Appendix. The key findings for the typical farm in the Central West region of New South Wales are outlined in this section.

The following Figure 4.43 illustrates the development of key indicators of the typical farm AU 2800CW in the basis scenario (B-0), under high price conditions and under the previously analysed adjustments regarding agronomy (S-1) and farm configuration (S-2).

The comparison of the 3 scenarios with the reference situation shows an ambivalent effect of the high prices on the overall farm performance. On the one hand the negative profit detected in the total cost account of the reference scenario B-0 is reduced with the application of the high price scenario. But in contrast to the previously discussed farms, AU 2800CW would not even under high price conditions be able to run a profitable production program. This perspective, the financial hardship caused by the yield performance in the investigation period and a predominant production uncertainty for the nearest future lead participants to fully reject from any short term agronomical adjustments in the frame of scenario S-1.

Figure 4.43: Cost, revenue and profitability indicators of the AU 2800CW cropping enterprise (€/ha) in the basis scenario (B-0) and under scenario conditions (S-0, S-1, S-2)



Source: Own calculation.

On the other hand, a substantial increase of the farm's profitability is observed under scenario S-2 conditions in which the panel participants announced major changes to the farm setup (intensification, assets vs. liquidity) assuming a) sustainable prices at the level introduced with the high price assumptions within this thesis and b) more confidence regarding their prospective productivity.

The changes under S-2 conditions adumbrate a major shift in the land use system in favour of cropping, the admission of canola to the production program which turned out to be very profitable, the intensification in cereal production and a lifted yield level. This inevitably entails a significant profit increase which is highlighted by:

– Increasing market returns by 105 €/ha (+50 %)
– Increasing total cost of production by 33 €/ha which is mainly due to intensified application of direct crop inputs.
– Compared to scenario S-0 the farm profit increases by 73 €/ha leading to an overall farm profit of 65 €/ha.

Based on the figures presented in Figure 4.43 it can be concluded that the Central West region has a considerable production and income potential for farms represented by AU 2800CW but the prevailing production uncertainty immediately restricts the exploitation. In the short run, farmers do rather favour being eventually not rewarded for full factor cost than exposing themselves to greater financial risk.

This attitude changes with the prospect of having favourable output prices in a longer range enabling a strategic directive for the farm development. In this case substantial interferences in the production are realised which increase cost but also increase flexibility to react immediately if conditions deteriorate. Nevertheless, this result is only feasible assuming average or favourable weather conditions. Production uncertainties which are defined throughout various sections in this thesis are prevailing and can cause the loss of single top performing crops which reverts the substantial adaptation response extracted in the investigation of this typical farm.

With regard to the total cost of production per unit of output, an increase for wheat from 191 €/t in B-0 to 221 €/t in S-0 under high price conditions is observed. Due to the absence of any agronomical adjustments under S-1 conditions the farm continues to produce highest average cost of wheat in this comparison. Only by inducing changes to the farm configuration as outlined in this section production cost of wheat can be pushed back to 179 €/t in S-2. Respective figures are displayed in Figure A26 in the Appendix. Hence, measures advisable according to economic theory could increase the overall competitiveness of wheat production in Central West NSW. Disregarding the climate conditions the typical farm is strongly encouraged to run the adjustment process thru in the light of decreasing average cost.

The increasing profitability of the land use system under scenario S-2 conditions is a substantial economic incentive and leads to equity gains of 136,000 €/a for the entrepreneur running a business like AU 2800CW.

It suggests the further question how this capital would be deployed within the business and which external effects are to be expected. This issue will be addressed in the following chapter in comparison with the results of the other farms participating in this investigation.

5 Conclusions

Conclusions from the analysis of land use systems in selected locations in Germany and Australia can be drawn regarding farm level implications, adaptation strategies and potentials of high commodity prices (Section 5.1), the application of focus groups (Section 5.2) and the application of the calculation tool TYPICROP (Section 5.3).

5.1 Farm level implications of high commodity prices

This thesis is concentrated on four selected regions in Germany and Australia. With the selection of these regions it is aimed to illustrate a gradient of intensity in land use systems and respective adaptation potentials to cope with rising prices for agricultural commodities. During the investigation several natural measures (temperature, rainfall pattern, land characteristics) and physical indicators (tillage intensity, fertiliser input, plant protection effort and yield level) were evaluated to improve the understanding of the respective production system. With the investigation of this natural farming environment also different degrees of production uncertainty are identified a) in reverse correlation to the prevailing gradient of intensity and b) as a latent constraint for the farm development.

5.1.1 Production systems

The typical farms established in the investigation regions cascade these factors and show substantial structural differences. Strong relations to the gradient of intensity are found in the land use system: While the typical farms in the Magdeburger Börde region in Germany and the South Coast region in Western Australia are entirely focussed on cash crop production, acreage depending livestock farming is relevant for the production program in the rather extensive regions as a diversification measure to manage increasing production uncertainty.

Further, operations on the land dedicated to arable production are in the focus of investigation. Substantial differences are found in the current productivity: For example, five year average yields of wheat which is the most dominating crop in the portfolio of all farms in this comparison, varies between 8.6 t/ha and 1.6 t/ha. This implies a specific degree of intensity of the production system based on agronomical causalities and profitability in each region. The research uncovered for example nitrogen input to wheat to vary between 190 kgN/ha in the Magdeburger Börde and 10 kgN/ha in Central West New South Wales, total chemical input to vary between 11 and 2 applications and working depth of tillage to vary between 25 and 3 cm. However, the production systems are also under pressure to cope with recent challenges: chemical resistances, precipitation patterns, soil salinity and limited biodiversity are identified to be restrictive in the current typical farm situations.

Exploiting the potentials of the land necessitates the utilisation of production factors. Beside the abovementioned direct inputs this involves labour and capital fixed in machinery and buildings: With regard to labour the investigation lead to the conclusion that labour input to the production is also strongly related to the intensity. In the Magdeburger Börde approximately 9 h/ha are spend to production whereas the low input systems in Australia require roughly 1.2 h/ha. Furthermore, the source of labour varies between the analysed typical farms: While production in the Magdeburger Börde and on the South Coast of Western Australia is primarily aligned to hired labour (cash cost), growing uncertainty in production forces typical farms in the Wheatbelt and Central West New South Wales to concentrate on family labour whose remuneration demand is substantially lower in the short run.

Similar findings are obtained with the analysis of the capital structure. Current values of machinery cover a span from 560 €/ha to 120 €/ha which is beside operational requirements also explained by the depreciation strategy. High annual utilisation of machines in intensive production systems (e.g. >1,000 tractor engine hours per annum) leading to shorter amortisation compared to low input production were the majority of machines is utilised only one month within the whole year. While the first strategy involves higher capital investments and enables immediate participation from technological advancements, the second strategy is less capital intensive but less effective in terms of energy efficiency, labour efficiency and reliability. Prime examples are detected with fertiliser application and site specific variable rate technology. On the other hand, the fixation of capital in machinery is becoming more critical with increasing production uncertainty since it limits the availability of liquid funds to overcome tight economic situations. This opens an area of tension for entrepreneurs especially on the prospect of high energy prices in the long run.

Finally, major differences in the farm setup and risk position of the farming system are found with the analysis of the ownership structure and financial situation of the typical farms: Firstly, the share of own land differentiates substantially between the typical farm in the Magdeburger Börde where 60 % of the farm land is rented and Australia where the major share of the farm land is owned by the entrepreneur. In the latter cases the typical farm’s share of own land increases from 75 % on the South Coast of WA to 95 % in Central West NSW. It was thus found in the comparison of the typical farms that the share of own land increases with the instability of production causing less cash cost for land and providing a financial security for debts.

Secondly, differences in the financial pattern were elaborated in relation to the production uncertainty. While an equity share of 50 % is considered being typical for a top performing farm in the Magdeburger Börde, the panel stated significantly higher requirements of financial institutions in Australia. An equity rate of 65 % was considered being the limit to sustain the business. In the case of the typical farm in the Central West NSW this credit line is fully exploited during the investigation period due to the tough financial situation after several drought seasons. Hence, equity is a major risk buffer and in this comparison higher shares were identified with rising production uncertainty.

In the cause of the investigation, the abovementioned production patterns are elaborated and monetary valued based on engineering and price data of individual years from 2005 to 2009. During this period significant differences of the farm profitability are detected between the selected regions and in single years. While the overall profitability remained relatively stable on the typical farm in the Magdeburger Börde, it is subject to increasing fluctuation on the Australian typical farms in the order AU 4500SC, AU 4000WB and AU 2800CW. The latter case is assessed as an extreme example with one year out of five in which substantial profit is achieved. Beside the price effect this can predominantly be reduced on adverse yield development due to a disastrous lack of growing season rainfall.

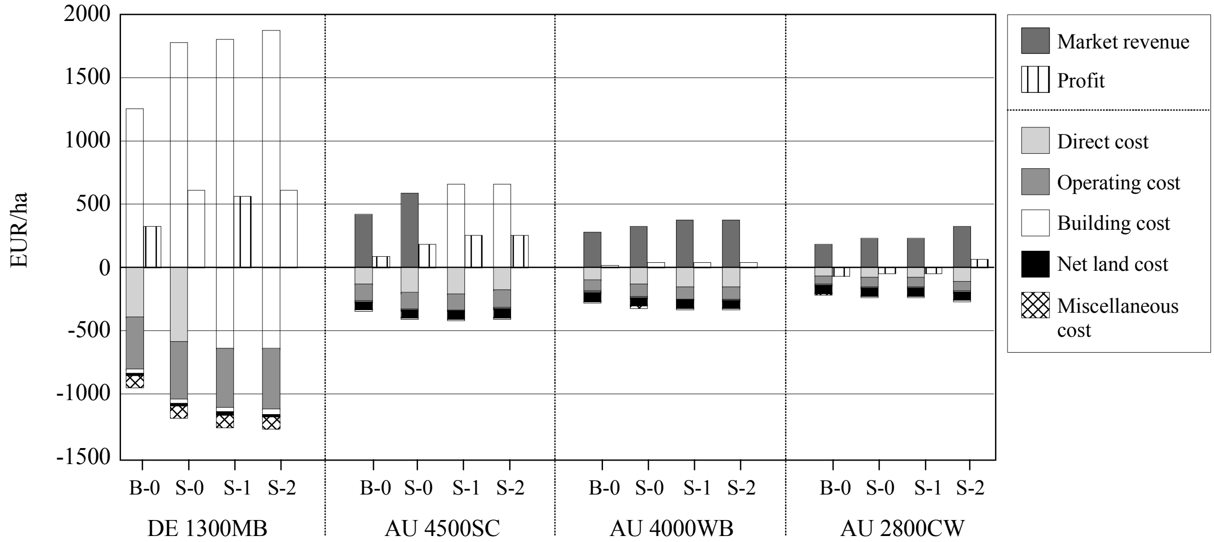
5.1.2 Adaptation strategies and potentials

To increase the confidence in results of the whole investigation and in particular the effects of a high price situation it is defined not to focus on one single year for reference but on the five year average from 2005 to 2009 (**B-0**) to evaluate the current status of the typical farm results. Based on this reference situation three scenarios are structured to describe the farm level implications of high commodity prices derived from the EIA oil price projection:

– **Scenario S-0:** Application of the high price scenario without any changes to the production program or farm setup (ceteris paribus B-0).
– **Scenario S-1:** Agronomical adjustments of the cropping program under high price conditions: land dedicated to arable production, crop rotation and production system of single crops.
– **Scenario S-2:** Organisational adjustments to the farm set up under high price conditions: general farm configuration, land, labour, tangible assets and finance.

The following Figure 5.1 illustrates the accumulated impacts of adjustments carried out within the scenario cascade on average revenue, cost and profitability of typical farm situations in the comparison. The acreage is chosen for reference to demonstrate the latitude of the underlying intensity levels and the value creation on the scare factor land.

Figure 5.1: Implications of high commodity prices on average revenue, cost and profitability of typical farms (€/ha)



Note: Net land cost = Total land cost reduced by decoupled payments
Source: Own illustration.

High prices for agricultural commodities and energy support the profitability of the land use system of the typical farms in this comparison. This is true even without any adaptation.

This positive effect on the income of the typical farms is a fundamental economic incentive to further adjust production. At this point substantial strategic differences are identified in the adaptation potential in the investigation regions with regards to the intensity level and production uncertainty.

The typical farm in the **Magdeburger Börde** region in **Germany** shows the greatest response to the high price scenario without any adaptations. The profitability of the wheat dominated land use system incorporating high natural yields and relatively low production uncertainty almost doubles.

This effect counteracts current considerations to expand the production portfolio towards alternative crops grown for energy production. Corn for biogas or sugarbeet for ethanol production, which have a land remuneration advantage in the reference situation become less attractive in a high price environment. The politically induced force to shift to arable energy production in the Magdeburger Börde is slowed down under the assumption of high commodity prices. The current production patterns are principally strengthened and farmers can participate from a bullish bioenergy sector even without growing energy crops or investing into technical infrastructure.

It is furthermore a matter of how sugar will react in this production-price-structure of the typical farm. Given prices are tied with the EU sugar regime at the current level in the long run, sugarbeet which is the most profitable crop in the reference scenario will lose on-farm competitive advantage in favour of winter wheat and winter rapeseed to a certain extent which are the profiteers of the price scenario.

Agronomical adjustments in context of scenario S-1 adumbrate a slight increase of the production system intensity (tillage working depth, fertiliser, plant protection, management) mainly with the intention to secure yield performance and sustainability of the land use system. However, the additional efforts can hardly be offset by increasing yields leading to a consolidation in profitability. Additional investments carried out under S-2 scenario assumptions focussing on efficiency gains in fertiliser and chemical applications. Major changes in the cropping program such as tillage technology (plough vs. conservation tillage vs. strip tillage) or further sources of income (straw sales) are not expected. Conversely, the anticipated adaptation strategies in both scenario categories do not result in significant yield and production output potential increases. The panel estimates yields, which are already on a high level and will continue on the marginal positive long term trend identified in cultivated crops.[1]

Acknowledging these findings it is concluded that the high price scenario has a great dynamic effect on the profitability of the typical farm in the Magdeburger Börde. Potential adjustments only have an increasing effect on crop establishment cost in the first instance, consolidate the machinery status in the second instance but do not lead to substantial further profit and production output.

Since significant re-investments in operational farm assets are not anticipated, the further question is suggested, how equity gains are positioned within the economic framework of the business. The panel is confident that under current low production uncertainty the additional profit is rather used to secure scarce production factors in the current ownership structure of the typical farm.

The scarcest factor for production in the Magdeburger Börde before labour and capital is arable land. Increasing profitability does thus have an influence on land issues: Own land increases in value. This consolidates the asset value of the farm. The utilisation costs of rented land are demand driven and determined by the profitability of the operation under due consideration of external revenues. Experiences from farm advisory group show that a constant share of the profit (40–60 %) is transferred into land rent irrespective of the commodity price level (DEEKE, 2010). This does immediately influence land rents to increase as observed in 2007/08. Furthermore, purchase prices for land in transition from

[1] Cp. Table A45 in the Appendix.

rented to own land are expected to increase with rising profitability and the occurrence of additional demand. This increases the pressure on the liquidity management and obligations to banks with further land purchase intentions.

Additional to the rent, utilisation costs of land consist of ground tax and official duties paid by the entrepreneur. Growing margins have a further influence on the design of these payment schemes. Furthermore, higher profitability will be a clear signal to policy makers that a higher share of farm income is generated by market returns and therefore less direct payments are necessary to secure income. This influences the discussion about the continuation and perspective structure of subsidy payments within the framework of the EU Common agricultural policy (CAP). Shrinking grants are to be expected in the long run due to the demanding public interest.

Acknowledging these findings it can be concluded for the **high input farming systems** that high commodity prices 1) do not induce significant changes to the farm configuration; 2) will lead to slightly higher cost of production which are not immediately rewarded by increasing yields and 3) have a strong economic effect on profits in the short run which will, however, be used up to remunerate the land utilisation in the longer perspective.

The typical farm in the **South Coast** region in **Western Australia** was identified being a high performing specialised cash crop farm in the high rainfall zone. The ceteris paribus adaptation of the high price scenario brought a doubling of profits in scenario S-0 as in the previous example.

However, agronomical adjustments in scenario S-1 most prominent the extension of the land area dedicated canola to the detriment of lupins, the cultivation of hybrid varieties of canola and the increased nitrogen fertilisation brought a significant increase in yields in canola and cereals while production cost are kept on almost the same level as in S-0. The increased productivity generated a significant boost in profitability beyond the plain adaptation of higher prices.

In the second step of adjustment under S-2 conditions investments in major cost drivers are anticipated. Most important is the stimulus for a new acquisition of the seeding technology which accompanied by a slight increase of the working depth and site specific direct input application. The increased efficiency of direct crop inputs does reduce total cost of production whilst the increasing output has the potential to offset the reduction of canola to the initial acreage. High prices in the long run which facilitate investments in farm assets are thus a reasonable incentive to 'Making every hectare a winning one' considering the further increasing average farm profitability.

The greatest profiteer of the crops on this typical farm is canola. Sufficient output advancements are due to the admission of hybrid varieties and the increasing share in the cultivated land. The production output increases by +22 % in the scenario S-1 to the detriment of lupins. Driven by concerns about the crop health status this will however, diminish to +14 % considering the adjustment of the farm setup in the long run (S-2). The wheat production output has the potential to increase by approximately +12 %.

When estimating the long term effects of high prices it must be kept in mind that the South Coast region has shifted from a livestock dominated region towards cropping only a few decades ago. Especially canola is performing well due to this virginity and might react sensitively on the high share in the cropping rotation in the future. Furthermore, it is not predictable at this stage how resistances develop and might restrict the pattern of solely cash crop farming systems. If canola suffers from any of these challenges, the elaborated adaptation strategies are limited significantly.

Rising profitability of cash crop enterprises started a restructuring process during the last bull market for agricultural commodities. This lead farms grow to units up to double the size of the typical farm. In some cases land was rededicated from extensive livestock production for crop farming; sheep and cattle moved out of the South Coast region (BOTT, 2009).

Hence, high commodity prices as underlying for this study are expected to further trigger these structural processes in regions favourable for crop production with a moderate farm growth and a shift to more land dedicated to crops. This is accompanied by a) rising land prices which terminate farm growth from a liquidity point of view and b) an increased exposition to production uncertainty due to the uniform specialisation on the cropping operation. The latter fact does also determine farm growths due to individual risk acceptance by the entrepreneurs.

A mixed farming system is analysed in the low rainfall region of the **Wheatbelt in Western Australia**. The production in this region is found to be significantly determined by soil salinity, herbicide resistant weeds and high production uncertainty. These factors induce a low input cropping strategy diversified on a greater range of crops and an integrated sheep enterprise.

Under high price conditions (S-0) the profitability of the typical farm increased fivefold leading to a sound remuneration of total production cost. Intensification of the cropping system is anticipated on the premise of average or good seasonal condition. If they occur, agronomical adjustments in scenario S-1 adumbrate an increasing share of canola in the crop portfolio to the detriment of legumes which are found supportive for the cropping regime (preceding crop effect) but not profitable grown on its own. Furthermore, the production of cereals would be guarded by higher fertiliser and plant protection rates.

Other than in the previous example, no economic benefit is estimated with the implementation of hybrid varieties in canola. However, these measures are leading to a further significant increase of profitability.

Substantial production output potential in wheat and canola is exclusively linked to average or good seasonal conditions. Canola production has the potential to increase by +21 % but is considered remaining at the current level for phytosanitary reasons in the long run. Wheat output benefits from yield advancements and has the potential to increase by +15 %.

As in the previously discussed example on the South Coast, changes to the farm setup are entirely focussed on efficiency which pays off in terms of profitability. The upgrade of the equipment to be able to handle liquid fertiliser does also involve the reduction of hired labour input and contractor cost to carry out the S-1 measures and is linked to a further yield increase. However, the panel does not anticipate immediate investments in new machinery to reduce vulnerability in case seasonal conditions fail.

During the investigation of the relationship between cropping and livestock several conditions were identified which decouple the decision to cease or keep the sheep from plain profit relations. Sheep are strongly linked to the personal preferences of the entrepreneur and his operational attitude towards resistance issues, the utilisation of salt-degraded land and permanent pasture or his attitude towards risk. Hence, sheep are kept on farm although cropping figures promise being the better alternative on the rotational pasture.

The reason for the general decline of Australian sheep numbers is according to local experts attributable to a) the uncomfortable working conditions aligned to run sheep whose technical improvements are entirely not comparable to the cropping industry and b) a shift in utilisation. Up until the early 1990's sheep breeds were dominated by Merinos farmed predominantly for wool. After the collapse of the Soviet Union the most important costumer for Australian wool broke away. In the following stocks were restructured and aligned to meat production. Today the West Australian sheep industry is mainly oriented on meat export, in particular live export to the Arabian world (YORK, 2010; HERBERT, 2010; MCNAMARA, 2010).

The prospect of an immediate response of the farm profitability is also a strong incentive to reassess and adjust the optimal specific intensity of the land use system on this typical farm. Although the average farm profitability increases tenfold with the full adaptation (S-2) to the price scenario total capital gains per farm are rather modest compared to the previously discussed case. However, land prices will react simultaneously though greater structural changes are not expected. A certain share of equity is used to build up liquidity to sustain potentially upcoming financial hardships.

A further scare factor to arable production in Western Australia is skilled labour. Forced by demand for similar qualifications from the mining industry a rising profitability of the cropping sector in remote areas will lead to increasing remunerations for hired labour.

The fourth typical farm in the comparison is located in the **Central West** region of **New South Wales**. This region in eastern Australia differs from the previously discussed locations in WA by natural conditions, mainly by the rainfall distribution and reliability. The typical farm is a mixed farming enterprise with sheep. The whole farm performance in particular the cereal dominated cash crop enterprise suffered from severe droughts during the investigation period leading to equity losses. This is reflected in the negative five year average farm profitability. The turn up of high commodity prices to the current situation would instantly minimise this net loss over total cost but can not entirely prevent the typical farm from forfeiting further equity.

When discussing adaptation strategies to cope with the pricing structure for inputs and outputs it became evident that the prevailing production uncertainty restricts any changes to the agronomy. Each further cash dollar spend in advance increases the vulnerability of the whole business which is already on the edge in terms of equity share. Thus, the current low cost structure of the cropping business is maintained under S-1 conditions and disposable income is used to fill gaps in the farm finance.

The prospect of reliable high price conditions and regained confidence about the productivity of the study region would, however, enforce a dynamic restructuring of the farm setup in scenario S-2. This includes the admission of canola in the crop portfolio to the detriment of pasture and livestock, a shift to 100 % No-Till sowing, an increased plant establishment effort and the consequent reduction of fixed assets including the cash out of key machinery such as the combine harvester. It is clearly intended to maintain a decent level of liquidity and to source out fieldwork operations to be carried out only on demand. High prices do thus clearly enforce the application of a broad range of risk management tools as suggested with the theoretical considerations at the beginning of this thesis.

On the premise of favourable seasonal conditions (mainly sufficient rainfall) the production output of wheat may potentially increase by +20 % and canola would potentially be produced on this typical farm.

The livestock enterprise on the typical farm in Central West is also subject to adjustment. The extreme yield failures in the past were contributed by a lack of moisture conservation farming practices which includes the optimal ratio between cropping and livestock. Since intensive grazing overburdens the capacity of soils which must afterwards be cultivated to allow cropping, the ratio of cropland vs. rotational pasture is reassessed in favour of arable utilisation and stock numbers are reduced. However, the sheep enterprise remains an important tactic in the frame of diversification and risk management.

Due to the tough economic situation found in the Central West region it can hardly be concluded how significant equity gains would affect further farm development. First priority is certainly granted to the consolidation of the business, compensation of financial deficiencies carried over from the resent years and remuneration of family labour. Further need is seen in the accumulation of capital to lift the equity share in the business according to the requirements of institutional creditors. Given this, major restructuring processes, farm growth or increasing payment reserves for other production factors are not expected.

Acknowledging these findings it can be concluded for the **low input farming systems** that high commodity prices 1) are an incentive for intensification of the production and changes of the farm configuration; 2) higher cost for direct inputs are targeted to be offset with increasing efficiency; 3) yield potentials which are not targeted under current conditions are intended to be exploited on the premise of good or average conditions under acceptance of higher production risk; 4) have a strong economic effect on profits in the short run which will, however, be used up to remunerate the land utilisation, labour configuration and capital deficiencies in the longer perspective.

5.1.3 Conclusions

The research conducted with the doctoral thesis in hand was focussed on farm level implications of high commodity prices, adaptation strategies and potentials in selected regions in Germany and Australia. In appreciation of the results presented for typical farms the following conclusions can be drawn with regard to the determinants identified in the regions:

– The group of farms selected for this comparison established diverse land use systems in their specific farming environment. They show characteristic features with regard to land utilisation, input intensity, yield level and production reliability. These features depict a general gradient from the highest level in the Magdeburger Börde region in Germany along the South Coast region and Wheatbelt of Western Australia to the lowest level in the Central West region of New South Wales in East Australia.
– A strong relation can be concluded between production reliability and the production factors configuration of land, labour and capital. High production uncertainty coincides with high shares of own land, family labour and equity while leased land, off-farm labour and higher debt rates prevail on farms in reliable conditions.
– All individual intensity levels discovered in the selected regions lead to more profit under the influence of higher prices caused by revenues increasing more strongly than the production cost even under particular consideration of rising energy prices. This leads farms to either generate substantial equity gains or at least reduce the experienced loss.

- A relation was identified between the intensity of production and the economic incentive to reassess the current agronomy and farm setup: The high intensive production system analysed in Germany shows the greatest response in profitability when high prices are adapted without any adjustments to the cropping regime. Further profit gains attributed to production adjustments are marginal. The Australian farms also show a strong response to high prices in the reference situation. However, the incentive to adjust production increases with a the declining gradient of intensity.
- The current crop yield and the estimated yield under scenario conditions differ. The delta between both figures increases with declining intensity and reliability of production. Production uncertainty constraints farming systems to exploit the full production potential under reference price conditions but if the value of the output increases a considerably higher risk is accepted.
- The coexistence of crop and livestock is a characteristic feature of the integrated farming systems analysed and confirmed although the profitability of the competing cropping enterprise increases in presence of the high price scenario. The sheep enterprise is kept to utilise the land not suitable for cropping and diversify the production portfolio. Livestock functions stabilising on the income situation since physical productivity is less strong related to environmental conditions compared to crops.
- All farm setup adjustments are carried out to increase efficiency. The monetary saving potential increases with higher input prices. The economic force of cost leadership remains untouched.

5.2 Application of focus groups to panel discussions with farmers

Underlying for the thesis in hand is a bottom-up approach which is aligned on typical farms. The typical farms are established by means of regional panels representing the expertise of local agricultural entrepreneurs. A major challenge for the success of the investigation was to unlock this potential.

Therefore a research design was defined which incorporates discussions with ‘focus groups’. Focus groups are a well established method in social empirical studies and were chosen since the concept involves per se a broad spectrum of tools which support this type of proactive research.

However, acknowledging the agricultural environment in which this investigation takes places the method was advanced to meet certain circumstances. These circumstances are named and considered in the following section.

5.2.1 Assessment of focus group methodology

The review of the relevant literature bears two authors who applied focus group discussions in research projects dealing with agriculture in the broadest sense:

– NESS (2007) investigated methods of negotiations in agriculture by conducting three focus groups of six to eight participants with agricultural background according to a standardised guideline. Two out of the three groups consisted exclusively of farmers owning or operating different kinds of agricultural enterprises. It is mentioned, that the farmers knew each other but weren't direct competitors.

  Further information about the limitations of the concept is not given. It can be assumed, that the topic did not relate to confidential information which farmers potentially did not want to share with each other.

– TESCH (2003) conducted an empirical study to investigate consumer's demand and source of information of agricultural products from vegetable origin. Therefore three focus group discussions were held in cooperation with a professional marketing institute. A professional moderator managed the sessions which addresses the possible subjective influence of the researcher (a member of the agricultural department at the University of Hohenheim, Germany) may have on the results.

Both sources do not outline the specific role of farmers as participants, discussing in focus groups conducted by agricultural scientists. Hence, further details with regard to this study can not be obtained.

However, to encounter this some general considerations about the sector and experiences from the investigation past may be more suitable to be expanded into the planning of further investigations with focus groups.

Consideration of the farm population

Especially in regions with larger farm sizes (i.e. Australia, Easter Europe etc.), the target group for participants is relatively small due to the low farm population. This has the following effects on the recruitment of focus groups:

(1) **Homogeneity** – The availability of farmers (or other selection criteria to be specified respectively) to organise standard focus groups is limited. Hence, the necessary number of individuals to run standard focus groups with the recommended recurrence might not be given. Under certain circumstances it can be necessary to deploy mini focus groups to get the discussion process started at least.

(2) **Anonymity** – Farmers are close neighbours or even know each other personally. This fact can be an advantage for the recruitment since one successfully approached farmer can recommend colleagues to recruit or even encourage them personally to participate in the meeting.

In this case the group is seen as a real group and the requirements on the personal reception and official opening are significantly lower.

(3) **Confidential data** – The possible disadvantage with the previously mentioned fact is that individual farmers may be reluctant to share sensible data (i.e. economic situation of the farm, received product prices, assessment of the local land market, business finance, etc.) since single farming businesses are direct competitors on local markets.

If the farm population is high in the selected region, the screening and recruiting process of random groups can be applied as already outlined. With critical acclaim of the fact that sensible data is discussed, the emphasis during the opening phase to generate a trustful and constructive atmosphere is of even higher relevance for the success of the meeting.

It can be concluded, that sensitive subjects are a challenge to be discussed with small basic totality or random groups. Since conditions are as diverse as the region in which the investigation takes place, changes in the selection and recruitment of the members are common and must be expected. A targeted investigation of this aspect might uncover the influence of the participant constellation on results.

Efficient and comprehensive approach

The methodology of focus groups offers the general possibility to integrate the discussion with a selected target group into a broad range of investigations since the procedure can be tailor made specifically on the answer of quite different questions. It has been shown in Section 2 which principles and approaches allow this.

Since the highly concentrated experience of agricultural entrepreneurs and their judgement regarding actual challenges is very rare and the most valuable output of this project, focus groups offer a relatively low input structure to access this particular knowledge.

The methodology also adumbrates the instruments to trace the data generating process to increase the degree of comprehensiveness. However, the transcription of the discussion outcome into analysable results is a time consuming process.

Validity and reproducibility of results

Focus groups improve the quality of results and increase the degree of validity and reproducibility. This is achieved with the sound execution of the focus group procedure containing instruments which can be fundamentally standardised and even centralised respectively (*). These instruments adumbrate:

- **planning and organisation** of the group session including group characteristics*, discussion guideline*, screening, recruiting and delivered material*
- **Stimulus*** to initiate the discussion
- External **information** input (computer models)*
- Chronological procedure and topics of the **discussion** according to guideline
- **Data gathering**
- **Evaluation processes***

With these instruments, the contribution of the introduced method to the required standard research design and the quality of results is significant.

The research conducted in this thesis also shows that the engineering expertise of the farmers expressed during the panel session corresponds remarkably well with findings from scientific literature. This suggests a high degree of reliability of the results and estimates gained from panels.

Furthermore, agricultural applied research is often settled in individual disciplines (e.g. plant nutrition, phytopathology, plant protection, agricultural engineering etc) and results do rarely cover the interrelations with an agricultural enterprise. In contrast to that, the panel merges expertise from various individual disciplines to the systematic framework of a typical farm. This can be assessed as fundamental advantage.

However, a remaining disadvantage of the concept is the limited representativeness of results. But as in the case of this investigation it is clearly not the objective of research involving groups to give an all-embracing report about agricultural production systems the investigation region.

Especially in the light of existing regional variability and entrepreneurial variety, further research might generate findings about the potential randomness of panel results in reference to the regional scale or how strong results differ between panels conducted in the same region.

Subjective influence of the researcher

Commonly one would anticipate that the researcher manages the group sessions and moderates the discussion process. For this case, the method identifies necessary soft skills. These skills are by far objectively investigated and can be approached by the conducting person e.g. by appropriate moderation seminars. These seminars are designed to inspire the moderating person to:

1. understand of the role of the moderator in the group session
2. become skilled in presentation and moderation techniques, group dynamics and solutions to overcome critical situations within the group
3. show empathy towards people and groups and a good feeling to address the respective situation.

Thus, the subjective influence of the researcher on the study can significantly be reduced with the application of focus group techniques. But it should be critically questioned if that is really a weakness of the research concept.

The experience gained in this investigation showed, however, that the self-correctional effect of the group discussion, generating a general consensus out of individual expressions, is obvious during the session. This happens naturally and must not be forced by the moderator. Controversial situations are rather to be finished without any constructive comment then somebody expressing an extreme point of view which may lead the discussion in an unwanted direction.

Furthermore, this investigation shows that excellent discussions outputs can be generated with farmers who already know the researcher personally and the topic. Pre-panel chats and short meetings prior to the meeting are very helpful to create this positive attitude.

Nevertheless, the personality and the behaviour of the moderator still have an influence on the outcome of the respective session. This should be shown exemplarily by focussing on the opening phase, which is undoubtedly seen critical for the success of the meeting: If the presenter behaves too formally or rigid in the first minutes, the desired discussion flow can be missing under certain circumstances. By contrast, too strong casualness or excessive humour can result in a lack of objectivity. Certainly, this concerns a very subjective feeling. Therefore, different reactions are to be expected between single groups.

The multilateral discussion process forces the moderator to fully concentrate on the conversation. It was experienced that the moderating person is not able to record findings in a written protocol. Thus, data quality is depending on the attendance of an assistant moderator. It is recommended by experience to conduct panel meetings as a team.

Consideration of consulting groups

The benefit of approaching real groups for the investigations is already outlined. In the agricultural community real groups are often given in farm consulting organisations. During the data collection phase of this study several consulting groups were approached for potential support and invited to participate in the panel. In principle, the attendance of a farm consultant does not have a significant influence on the group outcome. However, the course of discussion might be disturbed. The following critical situations were observed:

– Consultant sees panel farmers as clients and tries to “sell” strategies.
– Consultant starts advertising himself and his leading edge experience by pointing out “one of his best clients does…”.
– Consultant starts teaching the group and performs classroom situations. This embarrasses other participants to make further “underqualified” comments and takes a big effort from the moderator to bring the group back to a fruitful discussion.

Hence, the attendance of a consultant should critically be evaluated and is only recommended if the person is known personally and loyal to the researcher and the topic.

5.2.2 Conclusions for an application in a global network

The focus group methodology is an efficient and versatile data gathering tool which adumbrates elements which can easily be standardised or even organised centrally. This is a necessary precondition to transfer the concept to other locations or to extend the investigation geographically around a single topic. A wide area of application is thereby opened and the development of alternative research subjects is allowed. Hence, an application into the global *agri benchmark* network is recommended.

The improved standing of *agri benchmark* as a trustworthy and well-known research organisation can further enable an easier and sustainable approach of participants for farmer panel sessions than it is possible in the course of a doctoral research thesis.

On the other hand one has to consider, that the investigation „subjects” within *agri benchmark* in general and this study in particular are individual characters (agricultural entrepreneurs worldwide) with totally different backgrounds, experience levels and cultural imprints. For example, the planning and organisation of a session with farmers in Western Australia might generate valuable results, whereas the same setting would potentially fail in China, Russia or South America just because of cultural differences.

To encounter this, a good feeling for the local circumstances and careful interaction with people from other backgrounds is necessary and must be considered when planning focus group discussions internationally.

5.3 Application of the calculation tool TYPICROP

The infrastructure of the *agri benchmark* network in which this study is embedded, integrates a pool of experience in the field of production cost calculation and comparison farming systems worldwide.

Part of this doctoral research project was the development of the database program TYPICROP which is introduced in this thesis. Existing findings in databank design and experience gained with groups, other economic models and cost of production theory were incorporated during the development of TYPICROP. The following section discusses how the model TYPICROP complies with requirements of *agri benchmark* Cash Crop and supplements the technical consolidation.

Attractive model interface, short calculation times and explanatory power

The TYPICROP model developed in the course of this study contains completely new data input units termed Frontend. The Frontends are specifically designed to support the data collection process prior to a meeting and within the panel discussions. Major emphasis was placed on creating attractive interfaces, self explanatory structures to encourage user participation and quick feedback routines to validate inputs. Pre-tests showed significant improvements in response rates by first time users and user-acceptance. Furthermore, the data quality enhanced compared to the previously used tools. Thus, the applicability of TYPICROP Frontends for the purpose of comparable studies and *agri benchmark* Cash Crop is appropriate.

International application

The mandatory requirement of being able to calculate country specific formats (such as languages, currencies, dimensions and units) and regional production specifics (such as rotations, crops, various direct inputs and individual utilisation of production factors) has been taken into account. The TYPICROP input and calculation formats cover requirements regarding the locations used for this study but can potentially be applied to any production regions worldwide.

Focus on production systems and benchmarking indicators

With the development of TYPICROP the concept of maintaining a 'full liner' tool for all major farm enterprises is modified in order to analyse cash crop production systems in more detail. This conceptual modification is consistent with the requirements for this study as well as the development of the *agri benchmark* Cash Crop network.

The single fieldwork pass was defined as the cost object which allows the model to calculate physical and economic results specifically for the comparison of agronomical strategies in current situations and under prospective adaptations of typical cash crop farms. Furthermore, this approach allows a more sophisticated allocation of performance based costs such as labour, machinery, energy and a calculation of benchmarking indicators according to production economic standards.

In regards to the objectives of this study TYPICROP is a database with innovative multifunctional features. In this study it is applied to the data sourcing process, panel sessions to support data evaluation and strategy derivation and to generate aggregated results presented and discussed in this thesis.

TYPICROP can provide a significant advancement for the *agri benchmark's* technical infrastructure and a valuable update on the current stage of the methodological discussion within *agri benchmark* Cash Crop. However, the data base tool must be evaluated by means of its applicability and seen as a subject for constant improvement.

6 Summary

It is the objective of this thesis to examine in a bottom-up approach how arable farms might adapt to prospective high commodity prices and what growth in production output can potentially be discharged under varying agricultural framework conditions, land use strategies and intensity levels. To illustrate the influence of these determinants the analysis is focussed on four regions selected exemplarily in Germany and Australia.

The thesis is conducted within the global *agri benchmark* network. Within this scope the aim is pursued to develop a conceptual approach which can effectively be transferred to other locations. In this global context it is particularly aimed to draw first conclusions about differences between high-input and low-input production systems, the influence of the coexistence of arable and pastoral agriculture and which role production uncertainty takes up in regards to potential adaptation strategies.

At the beginning of the investigation the research concept is developed. This involves theoretical considerations about the influence of rising input and output prices on the production systems of crops and configuration of farms. It proves that price shifts have a substantial influence on the optimal production intensity and factor allocation to individual enterprises. Hypothesis derived from production theory suggest that adjustments in that regard are carried out on a disaggregated scale within the production system of individual crops under the detailed consideration of physical input and output measures. Subject to further theoretical discussion is the interpretation of uncertainty and risk which yields in the cognition that an explorative approach under due consideration of empirical values, alternative courses of action and the attitude of local entrepreneurs is the most promising for this study.

With regard to the expected complexity of farm level adjustments and linked entrepreneurial assessments of feasibility, the typical farm approach applied within *agri benchmark* Cash Crop is chosen to be reference for the data source. Typical farms minimise single farm influences on a higher aggregated level but are still detailed enough to analyse cause-effect relationships of single agronomical measures within the production system of single crops. Typical farms are established by means of producer panels in which the regional production-engineering expertise is accumulated. A critical review of the methodological setup of *agri benchmark* brought the conclusion, that the panel approach within *agri benchmark* incorporating hands-on experience and assessment capability from local farmers is in principle well suited for this study. However, a considerable lack of conceptual clarity about the organisation and the process of a discussion with the panel are identified.

Since the multilateral discussion process itself is found crucial to unlock the expertise and assessment potential from the local farmer panel and thus determining for the success of the investigation, a methodological concept is discovered in the next step of this thesis to improve the existing operating procedure: focus groups discussions. Focus group discussions are an established method in empirical social research containing characteristic elements which can be standardised and organised centrally. Milestones are the recruitment process in line with target group criteria, information brokerage to the participants, instructions to conduct the discussion, internal correction schemes, saturation indicators and evaluation standards. However, these elements are to be carefully adjusted to match the particularities of the regional environment for the research involving a small total farm population, neighbouring competition and data which is subjectively considered confidential. This is consequently carried out with the development of the research design.

In the planning of the investigation a further deficiency was identified with the existing technical appliances of *agri benchmark* Cash Crop to register, manage and analyse data of typical farms. In particular, the required level of detail to illustrate production systems and the intended immediate exploitation in the data sourcing process were the motivation to develop and utilise the data management tool TYPICROP. Given the outcome of this thesis, the experience made during the course of investigation and the positive feedback from participants it is summarised with regard to the conceptual objective that the focus group methodology and TYPICROP are innovative advancements of the *agri benchmark* Cash Crop methods which can support the prospective research conducted in the network.

Since adaptation strategies of arable farms to cope with high commodity prices are in the focus of this thesis, the conceptual design further implies the derivation of a consistent scenario for input and output prices at the farm gate. Assuming the conversion ability of agrarian commodities to biofuels which can substitute crude oil-based fuels, a minimum price can be derived from the price of oil for grain and oilseeds (so-called Bushel-Barrel-Correlation). Furthermore, the oil price determines directly the price of agricultural inputs rich in energy, most of all nitrogen fertiliser and fuel. The basic scaffolding of the price scenario is constructed by evaluation of time courses with the help of linear correlation and economic efficiency calculations of US-ethanol plants and is complemented with price assumptions for other major input goods. As a starting point for calculations serves the oil price forecast of the World Energy Outlook 2009 published by EIA (2009). On this basis it is discussed how typical farms will presumably react to the high price scenario under the assumptions that the temporal component not is considered (comparative-static). This approach is chosen to explore the whole production potential of the locations for the purposes of a potential estimation.

The presentation of results in this thesis proceeds in three parts: The first part implies a regional analysis of the economic and natural framework conditions for arable farming in the selected countries. Based on these findings, a containment of the investigation regions is carried out including an assessment of intensity and reliability of production. Thereby it is intended to identify potential determinants for the farm configuration, adaptation strategies and output potentials along a gradient of intensity. The second part presents results about the configuration of typical farms established in the selected regions as a comparison focussed on the utilisation of land, labour and capital. Reference for this is the five-year-average farm situation reflecting the period from 2005 to 2009. This provides the framework for the interpretation of the production systems of single crops, adjustment measures and estimated crop output potentials in the third part.

The broadacre arable farming sector and regional production structures of Germany and Australia are in the focus with the specification of the locations of typical farms. Both countries grow similar crops like cereals and oilseeds and are among the global top ten producers and exporters. However, due to a significant high share of exports in the total production output and the absence of any market measures the cropping sector of Australia is generally aligned to international competition. Producers in Australia are traditionally exposed to price fluctuations on global markets to a greater extend than German farmers where the domestic market dominates the sales channels and farm income is partly stabilised by policy interventions. With characteristic implications for the assessment of marketing uncertainty: While German panel farmers explicitly point out the intention to risk manage potential price fluctuation in the context of higher commodity prices, hedging measures are already widely applied to the farm level in Australia and no further reason for concern.

Beside this general endorsement, the selection of the countries and the selection of the regions within the countries discovered substantial differences in natural conditions relevant for crop production: seasonality, climate and soils. These characteristics lead to distinctive regional production structures and intensity of land use systems which are key for the establishment of the typical farms. Furthermore, with the analysis of the environmental conditions and selected empirical values the general production reliability of the regions can be assessed.

In Germany production of cash crops is relatively even distributed throughout the country with characteristic patterns of spatial concentration. One centre of crop production is the **Magdeburger Börde** in Saxony-Anhalt and indentified being relevant for this study. Natural conditions including rainfall (525 mm) are generally favourable for the production of winter crops especially quality wheat on a specialised cash crop farm with a high input level (190 kgN/ha) incorporating conservation tillage and high natural yields (8.2 t/ha). Other crops in the portfolio are winter rapeseed and sugarbeet accounting together for 30 % of the arable land. The uncertainty of production in the Magdeburger Börde is assessed *low*.

The production of cash crops in Australia is concentrated in the south-east and south-west of the continent due to the rather temperate climate and rainfall in these regions. Since Australia is located on the southern hemisphere, seasonality is shifted by six months. Crops are grown as summer crops, however, cultivated during the Australian winter from May to November. Western Australia and New South Wales are particularly suited for cash crop production. The selected states show substantial differences in yield evolution of major crops: Yield of cereals in Western Australia trend slightly positive and with fewer fluctuations compared to New South Wales. In the latter state yields trend negatively with substantial yield failures due to drought conditions in the last years. To depict a trend of production three locations are chosen in Australia.

The typical farm in the **South Coast** region in **Western Australia** was identified being a high performing specialised cash crop farm in the high rainfall zone characterised by climate conditions with two out of five years below average rainfall (516 mm). However, soil conditions are fragile with high acidity. This implies additional expenses in crop nutrition. Wheat production incorporates no-till seeding, fertiliser inputs of 60 kgN/ha and a yield level of 2.7 t/ha. The typical crop portfolio of the typical farm has a relatively fixed relation of 1/3 broadleaf crops (canola and lupins) versus 2/3 cereals (wheat and barley). Moderate yield fluctuations of these crops according to infrequent lack of rainfall cause a *moderate* production uncertainty.

A mixed farming system is analysed in the low rainfall region of the **Wheatbelt** in **Western Australia**. Climate conditions incorporate two out of five years below average rainfall (307 mm). Furthermore, the production in this region is found to be significantly determined by soil salinity and herbicide resistant weeds. Yield fluctuations are further caused by the risk of a major crop wipe-out by frost. These factors induce a low input cropping strategy (35 kgN/ha), one pass seeding system, diversification on a greater range of crops and an integrated sheep enterprise. Wheat yields of the typical farm level on state average at 1.9 t/ha. Thus production uncertainty is assessed *high*.

The **Central West** of **New South Wales** was severely hit by drought during the investigation period. The whole farm performance in particular the cereal dominated cash crop enterprise suffered during the investigation period leading to cash losses of equity. These dramatic conditions prevailed in four out of five years in which only half of the long term average rainfall of 445 mm was received. Accordingly the typical production system for wheat is incorporated in a mixed farming enterprise with sheep and operates on a very low intensity level (10 kgN/ha) and natural yield level (1.2 t/ha) with extreme fluctuations. The cropping program does not include any broadleaf crops. However, to maintain a reasonable alternation and phytosanitary status, a sequential cultivation pass is anticipated and cereals are typically ‘in rotation’ with three to seven consecutive years of pasture. Production uncertainty under these conditions is assessed *extreme*.

Utilisation and ownership structure of land of the typical farms correspond with indications regarding a grade of intensity: The German farm in this comparison has a high share of rented land (60 %) which leads to the conclusion that while the actual production risk is relatively low a considerable uncertainty exists of forfeiting land under tenancy. The Australian farms own a large part of their land. Hence, the conditions are the opposite: While farm land is widely secured by ownership, the environmental conditions elicit general production uncertainties in the investigation regions.

Different intensity levels also show remarkable characteristics regarding the source of labour. While the intense crop production in the Magdeburger Börde can only be carried out with a major share of hired labour in the total work force (0.45 labour units per 100 ha), the opposite situation is found in the rather extensive regions in Australia (0.06 labour units per 100 ha). Here farms are practically operated by family labour. This has an explicit effect on the cost structure and can be assessed as an adjustment to the prevailing production risk.

Capital structure shows major differences in depreciation strategies applied on the typical farms. Strong concentration on up-to-date equipment featuring technologies to increase efficiency in rather intensive production systems causes progressive machinery cost per hectare and a progressive share of long term fixed capital. By contrast, mechanisation of low-input production which is furthermore influenced by increased uncertainties shows the tendency of considerable low machinery cost per hectare and a greater share of cash cost incurring only on demand.

Analysis of the farm configuration shows that land use, labour organisation and strategies of deploying capital are economically rewarded. A strong relation is concluded between production reliability and the production factors configuration of land, labour and capital. High production uncertainty coincides with high shares of own land, family labour and equity while leased land, off-farm labour and higher debt rates prevail on farms in reliable environments.

Application of the high price scenario for agricultural commodities underlying for this thesis improves the profitability of the land use system of the examined typical farms. This is true even without any adaptation. However, the positive effect on the income of the typical farms is an incentive to further adjust production within a given course of action. In that regard substantial strategic differences are identified in the regions with regards to intensity level and production uncertainty.

For high-input farming system it is concluded that high commodity prices do not induce significant changes to the farm configuration. They will lead to slightly higher costs of production which are not immediately rewarded by increasing yields.

The typical farm in the Magdeburger Börde region in Germany shows the greatest response to the high price scenario without any adaptations. The profitability of the wheat dominated land use system incorporating high natural yields and relatively low production uncertainty almost doubles.

Potential adjustments adumbrate a slight increase of the production system intensity mainly with the intention to secure yield performance and sustainability of the land use system. However, the additional efforts can hardly be offset by increasing yields leading to consolidation of profitability. Investments carried out in a longer perspective focus on efficiency gains in fertiliser and chemical applications. Major changes in the cropping program such as tillage technology are not expected. Conversely, the anticipated adaptation strategies do not result in significant yield and production output potential increase. Estimated yields are already on a high level and will continue on the marginal positive long term trend identified in cultivated crops.

This effect encounters current considerations to expand the production portfolio towards alternative crops grown for energy production. Corn (for biogas) or sugarbeet (for ethanol) which have a land remuneration advantage in the reference situation become less attractive in a high price environment. It is furthermore a matter of how sugar will react in this production-price-structure of the typical farm. Given prices are tied with EU sugar regime at the current level in the long run, sugarbeet which is the most profitable crop in the reference scenario will lose on-farm competitive advantage in favour of winter wheat and winter rapeseed to a certain extend which are the general profiteers of the price scenario.

Since significant re-investments in operational farm assets are not anticipated, the panel is confident that under current low production conditions the additional profit is rather deployed to secure scare production factors in the current ownership structure of the typical farm. High prices have a strong economic effect on the farm profit in the short run which will, however, be used up to remunerate the land utilisation in a longer perspective.

High commodity prices are a strong economic incentive for intensification of the production of low input farming systems in Australia.

Ceteris paribus adaptation of the high price scenario brought a doubling of farm profits on the South Coast of Western Australia. However, further agronomical adjustments, most prominent the adjustment of the canola production and the increased nitrogen fertilisation brought a significant yield increase. This increased productivity generated a significant boost in profitability beyond the plain adaptation of higher prices. Costs of production are kept on almost the same level.

Under high price conditions the profitability of the typical farm in the Wheatbelt of Western Australia increased fivefold leading to a sound remuneration of total production cost. Intensification of the cropping system is anticipated on the premise of average or good season conditions. If they occur, agronomic adjustments adumbrate an increasing share of canola in the crop portfolio. Furthermore, the production of cereals would be guarded by higher fertiliser and plant protection rates.

On the typical farm in the Central West the emergence of high commodity prices to the current situation would instantly minimise the net loss over total cost but can not prevent the typical farm from forfeiting further equity. When discussing adaptation strategies to cope with the new pricing structure it became evident that the prevailing production risk restricts changes to the agronomy. Each further cash dollar spend in advance increases the vulnerability of the whole business which is already on the edge in terms of equity share. Thus, the current low cost structure of the cropping business is maintained and disposable income is used to fill gaps in the farm finance.

Higher costs for direct inputs are targeted to be offset with increasing efficiency in low input systems.

Further adjustments on the South Coast farm incorporate investments in key cost drivers. Important is the stimulus for acquisition of new seeding technology which is accompanied by a slight increase of the working depth and site specific direct crop input application. The increased efficiency of direct crop inputs reduces total cost of production whilst the increasing output has the potential to offset the reduction of canola to the initial acreage. High prices in the long run facilitate investments in farm assets and are thus a reasonable incentive to ‘Making every hectare a winning one’ considering the further increased average farm profitability.

Changes to the farm setup on the Wheatbelt farm are also entirely focussed on efficiency. The upgrade of the equipment enabling the handling of higher concentrated liquid nitrogen fertilisers not only involves the reduction of hired labour input and contractor cost but also a further yield increase. However, it is not immediately anticipated to invest in new machinery to reduce vulnerability in case season conditions fail.

The prospect of reliable high price conditions and potential regained confidence about the productivity in the Central West region hypothetically enforce a dynamic restructuring of the farm setup. This includes a shift to No-Till sowing practices, increased plant establishment effort and consequent reduction of fixed assets including cash out of key machinery. It is clearly intended to maintain a decent level of liquidity and to source out fieldwork operations which are then carried out only on demand. High prices thus accelerate the application of a broad range of risk management tools as suggested with the theoretical considerations at the beginning of this thesis.

Yield potentials which are not targeted under current conditions in low-input systems are intended to be exploited on the premise of good or average conditions under acceptance of higher production risk.

Greatest profiteer of crops grown on the typical farm in the South Coast region is canola. Sufficient output advancements are due to the admission of hybrid varieties and the increasing share in the cultivated land. The production output increases by +22 % to the detriment of lupins. Driven by concerns about the crop health status this will, however, diminish to +14 % in line with the adjustments of the farm setup in the long run. Canola is considered performing well due to the 'virginity' in the South Coast region and might react sensitive on prospective high shares in the cropping rotation. Furthermore, it is not predictable at this stage how resistances develop and might restrict the pattern of solely cash crop farming systems. If canola suffers from any of these challenges, the elaborated adaptation strategies are limited significantly. Wheat production output has the potential to increase by approximately +12 %.

In the Wheatbelt, substantial production output potential in wheat and canola is exclusively linked to average or good seasonal conditions. Canola production output has the potential to increase by +21 % but is considered remaining at the current level for phytosanitary reasons in the long run. Wheat output benefits from yield advancements and has the potential to increase by +15 %.

The estimation of production potential in the Central West region is rather vague. On the premise of favourable seasonal conditions, mainly sufficient rainfall, the production output of wheat may potentially increase by +20 % and canola would potentially be produced on this typical farm. This estimate is secured by historical yield figures from the beginning of the 2000's before weather conditions changed adversely.

It was exclusively elaborated in this investigation that the current crop yield and the estimated yield under scenario conditions differ. The delta between both figures increases with declining intensity and reliability of production. Production uncertainty obviously constraints farming systems to exploit the full production potential under reference price conditions but if the value of the output increases a considerably higher risk is taken.

High prices have a strong economic effect on profits in low-input systems in the short run which will, however, be used up to remunerate the land utilisation, labour configuration and capital deficiencies in the longer perspective.

When estimating the long term effects of high prices on the South Coast it must be kept in mind that the South Coast region started so shift from a solely livestock dominated region towards cropping only a few decades ago. Rising profitability of cash crop enterprises started a restructuring process during the last bull market for agricultural commodities. This lead specialised cash crop farms to grow to individual units of up to double the size of the typical farm. In various cases land was rededicated from extensive livestock production to crop farming; sheep and cattle moved out of the South Coast region to a great extend.

Hence, high commodity prices as underlying for this study are expected to further trigger these structural processes in regions favourable for crop production (moderate risk) with a moderate farm growth and a shift to more land dedicated to crops. This is accompanied by a) rising land prices which terminate farm growth from a liquidity point of view and b) an increased exposition to production uncertainty due to the uniform specialisation on the cropping operation. The latter fact also determines farm growths due to individual risk acceptance by the entrepreneurs.

The prospect of an immediate response of the farm profitability is also on the typical farm in the Wheatbelt a strong incentive to reassess and adjust the optimal specific intensity of the land use system. Although the average farm profitability tenfold with the full adaptation to the price scenario, total capital gains per farm are rather modest compared to the previously discussed case. However, land prices will react simultaneously though greater structural submissions are not expected. A certain share of equity is used to build up liquidity to sustain potentially upcoming financial hardships. A further scare factor to arable production in Western Australia is skilled labour. Forced by demand for similar qualifications from the mining industry a rising profitability of the cropping sector in remote areas will lead to increasing remuneration for hired labour.

Due to the tough economic situation found in the Central West region it can hardly be concluded how significant equity gains would affect further farm development. First priority is certainly granted to the consolidation of the business, compensation of financial deficiencies carried over from the recent years and remuneration of family labour. Further need is seen in the accumulation of capital to lift the equity share in the business according to the requirements of institutional creditors. Given this, major restructuring processes, farm growth or increasing payment reserves for other production factors are not expected.

Since the existing labour resources of the typical farms are fully deployed, intensification in terms of an increased hourly input to the production could only be realised by activating more hired labour which has two dimensions. Firstly, more hired labour yields in exclusively higher cash expenditures which need to be covered in the individual farming environment and production uncertainty. Secondly, farms will have to compete for additional skilled labour on local and international markets which especially in the case of Australia may result in higher wages to resist in the sector of primary industries. It must be expected that branches like mining are prospering again with a recovery of the world economy and rising commodity prices which is one of the basic assumptions of this thesis.

The coexistence of crop and livestock is a characteristic feature of integrated low-input farming systems and confirmed although the profitability of the competing cropping enterprise increases in presence of the high price scenario.

During the qualitative and quantitative investigation of the relationship between cropping and livestock enterprises in integrated mixed farming systems several conditions are identified which 'decouple' the decision whether to cease or keep the sheep from plain profit relations: Sheep farming in the Wheatbelt is strongly linked to the personal preferences of the entrepreneur and his operational attitude towards resistance issues, the utilisation of salt-degraded land and permanent pasture or his attitude towards risk. Livestock functions stabilising on the income situation since physical productivity is less strong related to environmental conditions compared to crops. Hence, sheep is kept on farm although cropping figures promise being the better alternative on the rotational pasture.

However, the livestock enterprise on the typical farm in Central West would however be subject to adjustment: The extreme yield failures in the past are contributed by a lack of moisture conservation farming practices which include the optimal ratio between cropping and livestock. Since intensive grazing overburdens the capacity of soils which must afterwards be cultivated to allow cropping, the ratio of cropland vs. rotational pasture would be reassessed in favour of arable utilisation and stock numbers were reduced on the premise of favourable season conditions. However, the sheep enterprise remains an important tactic in the frame of diversification and risk management.

Core part of the investigation was to examine how the typical farms in the selected regions might adapt to prospective high commodity prices and what growth in production output can potentially be discharged considering the agricultural framework conditions, land use strategies and intensity levels.

In consideration of the question, which factor constellation has potential of further growth in production output it can be concluded that high input systems contribute with marginal but reliable production output increase whilst low input systems show the greater potential yield dynamic which is, however, restricted to be exploited by the prevailing production uncertainty.

References

AMJAD M, CURTIS B (2006): Dual purpose winter wheats to improve productivity. In: Agribusiness Crop Updates 2006, Department of Agriculture and Food, Government of Western Australia, Perth WA, Australia. pp 9-12

ATTESLANDER P (1991): Methoden der empirischen Sozialforschung. 6.Auflage. Walter de Gruyter Berlin, New York, Germany

AUSPLOW (2011): Deep Blade System technical information. www.ausplow.com.au/deep-blade-system.htm, retrieved on 12/05/2011

AUSTRALIAN BUREAU OF AGRICULTURAL AND RESOURCE ECONOMICS AND SCIENCES ABARE (2011): Australian crop report No.157. Release date 15 February 2001. Canberra, ACT, Commonwealth of Australia

AUSTRALIAN BUREAU OF STATISTICS ABS (2009a): 4627.0 Land management and Farming in Australia, 2007-2008. Commonwealth of Australia

AUSTRALIAN BUREAU OF STATISTICS ABS (2009b): 7124.0 Historical Selected Agricultural Commodities, by State (1861 to Present). Commonwealth of Australia

AUSTRALIAN BUREAU OF STATISTICS ABS (2010a): 7106.0 Australian Farming in Brief 2010. Commonwealth of Australia

AUSTRALIAN BUREAU OF STATISTICS ABS (2010b): 3101.0 Australian Demographic Statistics 2010. Commonwealth of Australia

AUSTRALIAN BUREAU OF STATISTICS ABS (2010c): 7125.0 - Agricultural Commodities: Small Area Data, Australia (various years). Commonwealth of Australia

BANSE M, NOWICKI P, VAN MEIJL H (2008a): Why are current food prices so high? In: Sugarcane ethanol. Wageningen Academic Publishers, Netherlands: pp 227-247

BANSE M, VAN MEIJL H, TABEAU A, WOLTJER G (2008b): Will EU Biofuel Policies affect Global Agricultural Markets? European Review of Agricultural Economics 35(2): pp 117-141

BAXTER N (2011): Dry weather and input prices hikes emphasise VRT gains. In: Ground Cover Issue 91, March-April 2011, Grains Research and Development Corporation – GRDC, Canberra ACT, Commonwealth of Australia: p 16

BOM (2010): Bureau of Meteorology, Commonwealth of Australia

BOTT A (2009): Personal expert interview conducted on 16/12/2009 in Munglinup WA, Australia

BROWNE C (2011): Weeds take out more than water. In: Ground Cover Issue 91, March-April 2011, Grains Research and Development Corporation – GRDC, Canberra ACT, Commonwealth of Australia: p 13

BUNDESVERBAND BIOENERGIE E. V. BBE (2009): http://www.bioenergie.de/index.php?option=com_content&view=article&id=15&Itemid=22, retrieved pm 15/09/009

CARTER CA, GARDINER WH (1988): Elasticities. In: International Agricultural Trade. Westview Press Boulder & London

COOPERATE BULK HANDLING GROUP (CBH) (2009): Grain Pool harvest guide 2009-10 : A marketing guide for growers selling grain to Grain Pool this harvest. CBH Group, Perth WA, Australia

CSIRO (2004): Shaking Blackleg from Canola. CSIRO Plant Industry Communication Group, Clayton South VIC, Australia

D'EMDEN F (2010): Soil zones, moisture, NDVI and N rates : putting the pieces together. In: PAA Reminder September 2010, Precision Agronomics Australia Pty Ltd, Esperance WA, Australia: p 3

D'EMDEN FH, LLEWELLYN RS (2006): No-tillage adoption decisions in southern Australian cropping and the role of weed management. In: Australian journal of Experimental Agriculture, Issue 46, 2006. CSIRO publishing, Collingwood VIC, Australia

DABBERT S, BRAUN J (2006): Landwirtschaftliche Betriebslehre. Verlag Eugen Ulmer, Stuttgart, Germany

DAMMER I, SZYMOWIAK F (1998): Die Gruppendiskussion in der Marktforschung : Grundlagen – Moderation – Auswertung. Westdeutscher Verlag GmbH, Opladen/ Wiesbaden, Germany

DEBLITZ C (1993): Internationaler Vergleich von Systemen extensiver tiergebundener Grünlandnutzung : produktionstechnische und ökonomische Analyse, Wettbewerbsfähigkeit, internationale Übertragbarkeit. [Dissertation] Georg-August-Universität Göttingen, Germany

DEBLITZ C, HEMME T, ISERMEYER F, KNUTSON R, ANDERSON D, GOERTZ D, MOELLER C, RIEDEL J (1998): A framework for developing international representative farms: The case of dairy. AFPC working paper 98-8, Texas A&M University, USA

DEEKE U (2010): Pächter selber machen die Preise. In: LBB Rundschreiben 09/2010 : Informationen für landwirtschaftliche Unternehmen, die der Beratung durch die LBB und das BB Göttingen angeschlossen sind. BB Göttingen und LBB Göttingen (ed.), not published: pp 1-4

DEGGAU M (2006): Nutzung der Bodenfläche : Flächenerhebung 2004 nach Art der tatsächlichen Nutzung. In: Statistisches Bundesamt (eds.) Wirtschaft und Statistik 3/2006. Wiesbaden, Germany.

DENZIN NK, LINCOLN YS (1994): Handbook of qualitative research. Sage publications, London, UK

DESBIOLLES J (2008): No-Till Seeding Systems – Technologies & Performance Issues. Presentation at ACIAR - ICARDA Iraq project: planning meeting 7-11 Sept 2008. University of South Australia, Mawson Lakes Campus, South Australia, Australia

DIEPENBROCK W, FISCHBECK G, HEYLAND KU, KNAUER N (1999): Spezieller Pflanzenbau. 3., neu bearbeitete und ergänzte Auflage, UTB für Wissenschaft, Ulmer Verlag, Stuttgart, Germany

DÜRRENBERGER G, BEHRINGER J (1999): Die Fokusgruppe in Theorie und Anwendung. Akademie für Technikfolgenabschätzung in Baden-Württemberg, Stuttgart

DWD (2010): Deutscher Wetterdienst, Offenbach/Main, Germany

EBMEYER CD (2008): Crop portfolio composition under shifting output price relations - analyzed for selected locations in Canada and Germany. vTI, Landbauforschung Völkenrode SH 323, 303p [Dissertation]. Braunschweig, Germany

EDMUNDS H (2000): The focus groups research handbook. McGraw Hill, American Marketing Association, Chicago, Illinois, USA

EIDMAN V (1992): Theoretical and practical considerations in measuring cost and returns. In: AHEARN MC VASAVADA U (eds.) Cost and returns for agricultural commodities – Advances in concepts and measurement, Westview Press, Boulder, USA

ENERGY INFORMATION ADMINISTRATION (EIA) (2011): Petroleum & Other Liquids : Definitions, Sources and Explanatory Notes. EIA Website: http://tonto.eia.doe.gov/dnav/pet/TblDefs/pet_pri_spt_tbldef2.asp

ENERGY INFORMATION ADMINISTRATION EIA (2009a): International Energy Outlook 2009. Office of Integrated Analysis and Forecasting, U.S. Department of Energy, Washington DC, USA

ENERGY INFORMATION ADMINISTRATION EIA (2009b): EIA Website: http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm

EUROPEAN COMMISSION (2009a): Health Check of the CAP: current situation, commission proposal and council outcome. European Commission DG Agriculture and Rural Development, Brussels, Belgium

EUROPEAN COMMISSION (2009b): Report from the commission to the council and the European parliament on the coexistence of genetically modified crops with conventional and organic farming. European Commission DG Agriculture and Rural Development, Brussels, Belgium

FAO (2011): The State of Food and Agriculture 2010-2011. Food and Agriculture Organisation of the United Nations, Rome

FAOSTAT (2011): Statistical databases of the Food and Agriculture Organization (FAO) of the United Nations. Accessed in January 2011

FEIFFER A (2006): Sparpotential von mehr als 50 €/ha. In: LOP - Landwirtschaft ohne Pflug 07/2006, Gesellschaft für konservierende Bodenbearbeitung e. V., Verlag Emminger und Partner, Berlin, Germany: pp 28-31

FITZGERALD P (2010): GM canola in high demand in WA. In: Ground Cover Issue 88, September-October 2010, Grains Research and Development Corporation – GRDC, Canberra ACT, Commonwealth of Australia: p 38

FOOD AND AGRICULTURE POLICY RESEARCH INSTITUTE FAPRI (2009): Website: http://www.fapri.iastate.edu/outlook/2009

FREEBAIRN D (2010): Improving fallow efficiency – the key to higher yields in dry season. Grains Research and Development Corporation – GRDC, Research Updates, Canberra ACT, Commonwealth of Australia

GANDORFER M, MEYER-AURICH A, HEIßENHUBER A (2006): Die Bedeutung veränderter Preis-Kosten-Relationen für die Bemessung der Stickstoffdüngung. Schule und Beratung, Heft 7, Jahrgang 2006, Bayerischen Staatsministeriums für Ernährung, Landwirtschaft und Forsten, Landshut, Germany: pp III-7 – III-9

GIERSCH H (1961): Allgemeine Wirtschaftspolitik : Grundlagen. Betriebswirtschaftlicher Verlag Dr. Th. Gabler GmbH, Wiesbaden, Germany

GILL GS (1995): Development of herbicide resistance in annual ryegrass populations (Lolium rigidum Gaud.) in the cropping belt of Western Australia. Australian Journal of Experimental Agriculture 1995, Issue 35, CSIRO Publishing, Australia. pp 67–72

GLASER B, STRAUSS AL (1967): The Discovery of Grounded Theory. Strategies for Qualitative Research. Aldine, Chicago, USA

GOLDHOFER H (2006): Zur Wirtschaftlichkeit des Ethanolrüben-Anbaus in Bayern. Article found on http://www.lfl.bayern.de/ilb/pflanze/20292/linkurl_0_33.pdf

GOLDHOFER H, REISENWEBER J, ZICKGRAF W (2009): Berechnung des Deckungsbeitrages von Zuckerrüben. Article found on: http://www.lfl.bayern.de/ilb/db/14249/db_berechnung.php?was=zuckerrueben

GORDDARD RJ, PANNEL DJ, HERTZLER G (1995): An optimal control model for integrated weed management under herbicide resistance. Australian Journal of Agricultural Economics, Vol. 39, No. 1, Australia: pp 71-87

GRDC (2009): Managing the risk of frost. Fact Sheet March 2009, Grains Research and Development Corporation – GRDC, Canberra ACT, Commonwealth of Australia

GRDC (2011): Western Region : When to sow wheat to minimise risk. Fact Sheet March 2011, Grains Research and Development Corporation – GRDC, Canberra ACT, Commonwealth of Australia

HARWOOD J, HEIFNER R, COBLE K, PERRY J, SOMWARU A (1999): Managing Risk in Farming: Concepts Research and Analysis. Agricultural Economic report No. 774, Market and Trade Economics Division and Resources Economics Division, Economic Research Service, U.S. Department of Agriculture, Washington DC, USA: 125p

HEIMBACH U (2009): Zeitliches Auftreten der Rapsschädlinge (Abbildung). In: Ratgeber Pflanzenbau und Pflanzenschutz 2009. Landwirtschaftskammer Nordrhein-Westfalen, Pflanzenschutzdienst, Bonn, Germany

HEMME T (2000): Ein Konzept zur international vergleichenden Analyse von Politik- und Technikfolgen in der Landwirtschaft. FAL, Landbauforschung Völkenrode SH 215, 284 p [Dissertation]. Braunschweig, Germany

HEMME T, DEBLITZ C, ISERMEYER F, KNUTSON R, ANDERSON D (1999): Politik und Technikfolgenanalyse für typische Betriebe im Rahmen des „International Farm Comparison Network“ (IFCN). In: Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaus e. V., Vol. 35, Landwirtschaftsverlag Münster-Hiltrup, Germany

HEMME T, ISERMEYER F, DEBLITZ C (1997): TIPI-CAL, Version 1.0. Ein Modell zur Politik- und Technikfolgenabschätzung für typische Betriebe im internationalen Vergleich. FAL Braunschweig, Germany

HENRICHSMEYER W, WITZKE HP (1991): Agrarpolitik Band 1 : Agrarökonomische Grundlagen. UTB für Wissenschaft, Ulmer Verlag, Stuttgart, Germany

HERBERT A (2010): Economics of integrated crop & livestock farming in Australia. Presentation held at agri benchmark Cash Crop Conference 2010 in Perth WA, Australia. Date: 11/05/2011

HOFFMANN GM, SCHMUTTERER H (1999): Parasitäre Krankheiten und Schädlinge an landwirtschaftlichen Kulturpflanzen. 2. erweiterte und ergänzte Auflage. Ulmer Verlag, Stuttgart, Germany

HÜLSBERGEN KJ, LEITHOLD G, MICHEL D, SCHÖNMEIER H (1997): Humusbilanzierung – Methoden und Anwendung als Agrar-Umweltindikator. In: Umweltverträgliche Pflanzenproduktion : Indikatoren, Bilanzierungsansätze und ihre Einbindung in Ökobilanzen. Deutsche Bundesstiftung Umwelt (Hrsg.), Zeller Verlag, Osnabrück, Germany

HUMPISCH, G (1998): Getreide lagern, Belüften und Trocknen. Einführung in Grundlagen, Technik, Anwendung., Verlag Agrimedia Bergen/Dumme, Germany: 160p

IMKAMPE W (2007): Raps-Euphorie mit Auswüchsen. In: dlz agrarmagazin, Deutscher Landwirtschaftsverlag, München, Germany: pp 54-55

International Assessment of Agricultural Knowledge, Science and Technology for Development IAASTD (2008): Summary for Decision Makers of the Global Report. By Governments attending the IAASTD Intergovernmental Plenary in Johannesburg, South Africa (7-11 April 2008). Island Press, Washington DC, USA

Iowa State University ISU (2009): ISU Website: http://www.extension.iastate.edu/AgDM/energy/xls/d1-10ethanolprofitability.xls

Isermeyer F (1988): Produktionsstrukturen, Produktionskosten und Wettbewerbsstellung der Milcherzeugung in Nordamerika, Neuseeland und der EG. [Dissertation] Georg-August-Universität Göttingen. Wissenschaftsverlag Vauk, Kiel, Germany

Isermeyer F, Deblitz C (2005): How to measure the opportunity cost of land. Internes Papier des IFCN-Teams. FAL Braunschweig. Germany

Isermeyer H (1981): Überbetriebliche Maschinenverwendung und wo sie hinpasst. [Dissertation] Georg-August-Universität Göttingen. KTBL-Schrift 268, Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V., Darmstadt, Germany

Knowles P (2010): Personal expert interview conducted on 02/02/2010 in Wellington NSW, Australia

Krueger RA (1988): Focus groups : a practical guide for applied research. Sage publications, Newbury Park, USA

Krueger RA, Casey MA (2000): Focus groups : a practical guide for applied research 3rd edition. Sage publications, Thousand Oaks, California, USA

Künzel T (2010): Gutes Verhältnis pflegen. In: DLG-Mitteilungen 10/2010, Max-Eyth-Verlag, Frankfurt/Main, Germany: pp 18-19

Leible et al. (2003): Energie aus biogenen Rest- und Abfallstoffen. http://www.itas.fzk.de/deu/lit/2003/leua03a.pdf

Linker S (2004): N-Dünger: Preisknick am Harnstoff-Markt. http://www.agrarberatung-hessen.de/markt/aktuell/2004q4/01012004121301.html

Llewellyn R, Powles S (2000): Ryegrass resistance in Western Australia – where and how much?. Crop Updates, Department of Agriculture, Government of Western Australia, Perth WA, Australia

Loos P, Schäffer B (2001): Das Gruppendiskussionsverfahren. Theoretische Grundlagen und empirische Anwendung. Leske + Budrich, Opladen, Germany

Loss S, O'Dea T, Gathin P, Guthrie R, Leaver L (2001): A comparison of Flexi-N placements. Crop Updates, Department of Agriculture, Government of Western Australia, Perth WA, Australia

LOUGHMAN R, MACNISH G MCLEOD W (2000): Diseases. In: The Wheat Book : Principles and Practice. Anderson W K, Garlinge JR (Ed.), Department of Agriculture Western Australia, Perth WA, Australia

MALY M (2006): Errosionsschutz durch Strohmulch. In: LOP - Landwirtschaft ohne Pflug 04/2006, Gesellschaft für konservierende Bodenbearbeitung e. V., Verlag Emminger und Partner, Berlin, Germany: pp 24-27

MAURICE A (2010): Personal expert interview conducted on 01/02/2010 in Wellington NSW, Australia

MCCALLUM M (2007): Inter-row sowing using 2cm Auto-steer. Paper presented at GRDC Research Update for Advisors – Southern Region – Adelaide SA. GRDC, Kingston, Australian Capital Territory, Australia

MCNAMARA T (2010): Large scale farming in Western Australia. Presentation held at agri benchmark Cash Crop Conference 2010 in Perth WA, Australia. Date: 11/05/2010

MCNEE ME (2011): Cumulative effects on wheat crops of replacing summer fallow with grass or legume cover crops. [Doctoral Research Dissertation]. School of Agricultural and Wine Sciences, Charles Sturt University, Orange NSW, Australia

MEIER U (2001): Growth stages of mono-and dicotyledonous plants : BBCH Monograph. 2nd Edition. Federal Biological Research Centre for Agriculture and Forestry (BBA), Braunschweig, Germany

MINISTERSTYO SELSKOGO CHOSJAISTVA ROSSIISKAJA FEDERAZIJA (2008): Ministerstvo Selskogo Chosjaistva Rossiiskaja Federazija: Agropromischlennii Kompleks Rossii v 2007 godu. Moscow, Russian Federation

MONJARDINO M, PANNELL DJ, POWLES SB (2004): The economic value of pasture phases in the integrated management of annual ryegrass and wild radish in a Western Australian farming system. Australian Journal of Experimental Agriculture 2004, Issue 44, CSIRO Publishing, Australia: pp 265–271

NEBRASKA ENERGY OFFICE NEO (2009): NEO Website http://www.neo.ne.gov/statshtml/66.html

NEHRING K (2008): Wachstumspotenziale ausgewählter Ackerbau-Standorte : Flächenproduktivität im internationalen Vergleich. In: Agrar-Potenziale nutzen! : Herausforderung für Landwirte und Gesellschaft; DLG-Wintertagung 2008. DLG-Verlag Frankfurt a. M., Germany: pp 91-109

NEHRING K, MCNEE ME (2008): Australia: cropping systems under pressure. In: Zimmer Y et al. (2008) agri benchmark Cash Crop Report 2008. vTI-Braunschweig, Germany: pp 40-47

NEHRING K, ZIMMER Y, MÖLLMANN T (2010): Handbook Cash Crop Data Management. agri benchmark Cash Crop Network, Braunschweig, Germany

NEHRING P (2011): Ermittlung von Wirtschaftlichkeit, Substratzahlungsbereitschaft und Konkurrenzwirkungen von Biogasanlagen. Case study BGW Oschersleben, not published

NESS C (2007): Verhandlungsmethoden in der Landwirtschaft : Auswertung von Fokusgruppen. I&I Working paper, Institut für Agrarökonomie, Christian-Albrechts-Universität zu Kiel, Kiel, Germany

NORWOOD C (2011): Canola windrowing re-evaluated. In: Ground Cover Issue 91, March-April 2011, Grains Research and Development Corporation – GRDC, Canberra ACT, Commonwealth of Australia. pp 22-23

OBST A, GEHRING K (2002): Getreide : Krankheiten, Schädlinge, Unkräuter. Verlag Th. Mann, Gelsenkirchen-Buer, Germany

OECD-FAO (2009): Agricultural Outlook 2009-2018. Paris, France

OFFICE OF THE GENE TECHNOLOGY REGULATOR OGTR (2002): The biology and ecology of canola (Brassica napus). Canberra ACT, Commonwealth of Australia

PARKHOMENKO S (2004): International competitiveness of soybean, rapeseed and palm oil production in major producing regions. Landbauforschung Völkenrode : Sonderheft, 267p, Bundesforschungsanstalt für Landwirtschaft (FAL), Braunschweig, Germany

PATTON MQ (1990): Qualitative Evaluation and Research Methods. Sage publications, Thousand Oaks, USA

PAUL VH (2003): Raps : Krankheiten, Schädlinge, Schadpflanzen. Verlag Th. Mann, Gelsenkirchen-Buer, Germany

PENFOLD K (2011): Brome grass needs multi-pronged attack. In: Ground Cover Issue 91, March-April 2011, Grains Research and Development Corporation – GRDC, Canberra ACT, Commonwealth of Australia: p 37

PFEIFFER D (2010): Personal expert interview conducted on 27/04/2010 in Perth WA, Australia

REBBECK MA, KNELL GR (2007): Managing Frost Risk - a guide for southern Australian grains. South Australian Research and Development Institute (Ed.), Grains Research and Development Corporation – GRDC, Canberra ACT, Commonwealth of Australia

REICHMUTH C (1997): Vorratsschädlinge im Getreide. Aussehen – Biologie – Schadbild – Bekämpfung., Verlag Agrimedia Bergen/Dumme, Germany: 120p

REINHOLD J (2008): Bestimmung und Entwicklung des Wertes organischer Substanz in Kompost. http://www.kompost.de/uploads/media/6_Reinhold_01.pdf

RIEDEL J (1997): Projektion und Vergleich von Marktfruchtbetrieben mit Hilfe von Simulationsmodellen. [Diplomarbeit] Georg-August-Universität Göttingen, Germany

RIEDEL J, MÖLLER C (1999): Zur Behandlung der Abschreibung und den Kapitalkosten in Kostenanalysen des IFCN. Internes Papier des IFCN-Teams. FAL Braunschweig, Germany

RÜBENSAM E, RAUHE K (1964): Ackerbau. VEB Deutscher Landwirtschaftsverlag Berlin, Germany

SAAKE G, SATTLER KU, HEUER A (2008): Datenbanken : Konzepte und Sprachen. 3. aktualisierte und erw. Auflage, mitp, Heidelberg, Germany

SCHEFFER F (2002): Lehrbuch der Bodenkunde : Scheffer Schachtschabel. 15. neu bearbeitete und erweiterte Auflage. Spectrum Akademischer Verlag, Heidelberg, Germany

SCHILLING G (2000): Pflanzenernährung und Düngung. Ulmer Verlag, Stuttgart, Germany

SCHMIDHUBER J (2007): Impact of an Increased Biomass Use on Agricultural Markets, Prices and Food Security: A Longer-term Perspective

SCHNEIDER M (2009): Streifenbearbeitung zu Mais im Mitteldeutschen Trockengebiet – Vorteile auf erosionsgefährdeten Standorten. In: LOP - Landwirtschaft ohne Pflug 03/2009. Gesellschaft für konservierende Bodenbearbeitung e.V., Verlag Emminger und Partner, Berlin, Germany

SCHÖNBERGER H (2009): Welche Nährstoffversorgung braucht der Raps für Höchsterträge. Presentation held at Rapool-Ring meeting, 23.02.2009, Dr. H Schönberger, N.U. Agrar GmbH, Schackenthal, Germany

SCHONEY RA (1992): Alternatives for Estimating Cost and Theoretical Considerations: Discussion. In: Cost and returns for agricultural commodities: advances in concepts and measurement, AHEARN M C and VASAVA U (ed.), Westview Press, Boulder, Colorado, USA: pp 95-99

SCOTT F (2009): NSW Grains Report Summary 1993-2009, Industry and Investment NSW Government, Tamworth New South Wales, Australia

SEIS C, MAYNARD B, MAURICE A (2009): Pasture Cropping and No Kill Cropping: The Two Day Course in Profitable Regenerative Agriculture. The Advanced Pasture Cropping Company, Wellington NSW, Australia

STATISTISCHES BUNDESAMT (2009): Land- und Forstwirtschaft, Fischerei : Bodennutzung der Betriebe. Fachserie 3 Reihe 3.1.2. Wiesbaden, Germany

STEINHÄUSER H, LANGBEHN C, PETERS U (1992): Einführung in die landwirtschaftliche Betriebslehre, Allgemeiner Teil. 5. Auflage, Stuttgart, Germany

STEUBER T (2006): Microsoft Office Access 2003 für Windows : Grundlagen für Anwender. HERDT-Verlag für Bildungsmedien, Bodenheim, Germany

TESCH I (2003): Informationsbedarf und Informationsbeschaffung von Konsumenten bei Lebensmitteln pflanzlicher Herkunft : Eine empirische Untersuchung anhand von Fokus-Gruppen. Arbeitsbericht, Institut für Agrarpolitik und Landwirtschaftliche Marktlehre, Universität Hohenheim, Hohenheim, Germany

THOMAS G, JAYASENA K, BEARD C, PAYNTER B (2011): Management of barley powdery mildew in the face of fungicide resistance. Farmnote 466/2011, Department of Agriculture, Government of Western Australia, Perth WA, Australia

TYNER WE (2008): The US Ethanol and Biofuels Boom : Its Origins, Current Status and Future Prospects. In: Bioscience Vol. 58 No. 7, July/August 2008 University of California Press, Berkeley, California, USA: pp 646-653

U.S. DEPARTMENT OF AGRICULTURE, USDA (2008): Wheat Year in Review (Domestic): High U.S. Exports Drive Record Prices and Low 2007/08 Ending Stocks. Economic Research Service, USDA, Washington DC, USA

U.S. DEPARTMENT OF AGRICULTURE, USDA (2009): USDA Website: http://www.ers.usda.gov/Data/feedgrains/StandardReports/YBtable16.htm

VON BRAUN J (2007): The World Food Situation: New Driving Forces and Required Actions. International Food Policy Research Institute (IFPRI). Washington D.C., USA

WALTHER S, BAUER B, DE WITTE T, NEHRING K, ZIMMER Y (2009): Farm level implications of high energy prices on cash crop farms in the agri benchmark network. Unpublished working paper, agri benchmark Cash Crop Network, Braunschweig, Germany

WARD VM, BERTRAND JT, BROWN LF (1991): The comparability of focus group. In: Evaluation review : a review of applied social research, Sage publications, Beverly Hills, California, USA: pp 266-283

WHITE C (2000): Pulse and canola frost identification : the pocket guide. Bulletin 4401 April 2004, Department of Agriculture, Government of Western Australia, Perth WA, Australia

WINFIELD K, PAYNTER B, MALIK R (2007): Oat hay quality for export and domestic markets. Farmnote 209/2007, Department of Agriculture and Food, Government of Western Australia, Perth WA, Australia

WOLBER DM, BÜNTE R, ZANGE B (2008): Getreideherbizidstrategie Herbst 2008 : Oder wie bekommen wir das Kind wieder aus dem Brunnen?. In: Getreidemagazin 3/2008 Sonderdruck. Verlag Th. Mann, Gelsenkirchen-Buer, Germany: pp 2-10

YARA (2004): Bedienungshandbuch für den N-Sensor. YARA GmbH & Co. KG, Institut für Pflanzenernährung und Umweltforschung, Dülmen, Germany

YARA (2009): WEBSITE (http://www.yara.com/en/investor_relations/analyst_information/ fertilizer_prices/index.html)

YORK T (2010): Personal expert interview conducted on 31/03/2010 in Tammin WA, Australia

ZAICOU-KUNESCH C, SHACKLEY B, SHARMA D, AMJAD M, ANDERSON W (2005): Time of sowing, varieties and the flowering window. Farmnote 51/2005, Department of Agriculture, Government of Western Australia, Perth WA, Australia

ZEDDIES J, REISCH E (1992): Einführung in die landwirtschaftliche Betriebslehre: Spezieller Teil. 5. Auflage, Stuttgart, Germany

ZIMMER Y (2007): Cash Crop Report 2006 : benchmarking farming systems worldwide. FAL Braunschweig, Germany: 49 p

ZIMMER Y, ALBRECHT R (2011): Ertragsentwicklung in ausgewählten Regionen Deutschlands. Vortrag am 11.01.2011 im Rahmen der DLG-Wintertagung 2011 in München, Germany

ZIMMER Y, ALBRECHT R, KRUG J, MÖLLMANN T, NEHRING K, STROHM K, WALTHER S, VON DAVIER Z, DE WITTE T (2010): Cash Crop Report 2010 : benchmarking farming systems worldwide. vTI Braunschweig, Germany: 87p

ZIMMER Y, DEBLITZ C (2005): IFCN Cash Crops : A standard operating procedure to define typical farms. International Farm Comparison Network (IFCN), FAL, Braunschweig, Germany

ZIMMER Y, DEBLITZ C, ISERMEYER F (2006): A Look behind the Curtain: Total Production Cost and Production Systems as the driving Factors for Agricultural Competitiveness. International Farm Comparison Network (IFCN), FAL, Braunschweig, Germany

ZIMMER Y, DEBLITZ C, SEIFERT K (2009a): Die globale Landwirtschaft besser verstehen : Agrarökonomen betreiben internationales Netzwerk agri benchmark. Forschungsreport Ernährung, Landwirtschaft, Verbraucherschutz, Heft 2, Germany: pp 33–35

ZIMMER Y, EBMEYER C D, NEHRING K, MÖLLMANN T, DE WITTE THOMAS (2007): Cash Crop Report 2007 : benchmarking farming systems worldwide. FAL Braunschweig, Germany

ZIMMER Y, NEHRING K (2007): Strohpotentialstudie ausgewählter Ackerbauregionen. Unveröffentlichtes Arbeitspapier. FAL, Braunschweig, Germany

ZIMMER Y, NEHRING K (2008): Wirtschaftlichkeit der Bodenbearbeitung. In: Schonende Bodenbearbeitung : Systemlösungen für Profis. DLG-Verlag Frankfurt a. M., Germany: pp 93-110

ZIMMER Y, NEHRING K, MÖLLMANN T, DE WITTE T, WALTHER S (2009b): Cash Crop Report 2008 : benchmarking farming systems worldwide. vTI Braunschweig, Germany: 91p

ZIMMER Y, NEHRING K, MÖLLMANN T, DE WITTE T, WALTHER S (2009c): Cash Crop Report 2009 : benchmarking farming systems worldwide. vTI Braunschweig, Germany: 70p

ZMP (2008): Australien und Neuseeland. WeltAgrarMarkt-Sonderdruck MZM Band 83 August 2008. Zentrale Markt- und Preisberichtsstelle für Erzeugnisse der Land-, Forst- und Ernährungswirtschaft, Bonn, Germany

Appendix

Table A1: TYPICROP intellectual property, software requirements and version specifications

The conceptual design was conducted and hosted by: -		
Johann Heinrich von Thuenen-Institute **Institute of Farm Economics** **agri benchmark Cash Crop (associated workgroup)** **Bundesallee 50** **38116 Braunschweig** **Germany**		
For enquiries please contact		
contact:	**Dr. Yelto Zimmer**	**Klaus Nehring**
phone:	**+49 531 596 5155**	**+49 170 208 2935**
email:	**yelto.zimmer@vti.bund.de**	**klaus.nehring@t-online.de**
The technical programming was carried out by: -		
einsplus. EDV-Schulungen **Am Alten Bahnhof 6** **38122 Braunschweig** **Germany**		
contact:	**Michael Rommerskirch**	
phone:	**+49 531 349 9350**	
email:	**info@einsplus.net**	
All components of the TYPICROP quantification and data management tool were developed using the platform of the following standard software:		
System software PC:	**Microsoft Windows XP Professional**	
Application software:	**Microsoft Office Professional Edition 2003**	
Databank software:	**Microsoft Office Access 2003 (11.8166.8221) SP3**	
Programming language:	**Microsoft Visual Basic VBA 6.5.1024**	
Spreadsheet software:	**Microsoft Office Excel 2003 (11.8307.8221) SP3**	
For the calculations in line with this thesis the following versions of TYPICROP where used: -		
Frontend:	Version 4.27 -	
Admin:	Version 4.29 -	
Data storage file:	Version 1.1 -	

Figure A1: Profit and loss calculation of the cash crop enterprise -

Farm Name **AU4500SC-BS**
Year **2007**

agri benchmark

For a better understandig of farming systems worldwide

text	Unit	Total	canola	lupins	wheat	barley (malt)	barley
acreage	ha	4.200	1.000	400	1.400	700	700
yield	t/ha	---	1,80	1,58	2,66	3,00	3,00
market price	AUD/t	---	456	270	249	255	216
market revenue main product	AUD/ha	---	821	427	662	765	648
market revenue by-product	AUD/ha	---	0	0	0	0	0
other revenues	AUD/ha	---	0	0	0	0	0
gross revenue	**AUD/ha**	**2.907.816**	**821**	**427**	**662**	**765**	**648**
seed density	kg/ha	---	5,0	110,0	80,0	75,0	75,0
seed price	AUD/kg,U	---	0,6	0,3	0,3	0,2	0,2
seed total	**AUD/ha**	**69.530**	**3**	**31**	**22**	**17**	**17**
		AUD/kg					
N	kg/ha	1,20	72	6	60	60	60
P	kg/ha	2,18	20	10	15	15	15
K	kg/ha	0,00	0	0	0	0	0
fertilizer total	**AUD/ha**	**440.307**	**130**	**28**	**107**	**107**	**107**
herbizide	AUD/ha	---	39	49	44	44	44
fungizide	AUD/ha	---	10	0	15	20	20
insectizide	AUD/ha	---	14	11	0	0	0
other pesticide	AUD/ha	---	0	0	0	0	0
plant protection total	**AUD/ha**	**259.200**	**63**	**60**	**59**	**64**	**64**
contract work (crop related)	**AUD/ha**	**0**	**0**	**0**	**0**	**0**	**0**
crop insurance	**AUD/ha**	**21.200**	**6**	**3**	**5**	**6**	**4**
other direct costs (excl. drying)	**AUD/ha**	**67.200**	**16**	**16**	**16**	**16**	**16**
total direct cost	**AUD/ha**	**857.437**	**218**	**138**	**209**	**209**	**207**

text	Unit	Total	canola	lupins	wheat	barley (malt)	barley
diesel price	AUD/l	1,2					
diesel consumption field	l/ha	113.080	29,4	24,4	26,4	26,4	26,4
diesel cost field	AUD/ha	---	36	30	32	32	32
total diesel cost field	**AUD**	**139.088**					
diesel consumption overhead	l	16.920					
diesel cost overhead	**AUD**	**20.812**	--->	input overhead section 1)		AUD	20812
petrol cost overhead	AUD	8.040	--->	input overhead section 2)		AUD	8040
oil/lubricants	AUD	0					
fuel and supplies total	**AUD**	**167.940**					
repairs machinery	AUD	90.000					
repairs buildings	AUD	15.000					
repairs total	**AUD**	**105.000**					
dry energy total	**AUD**	**0**					
total number of workers	---	4	Including family labor				
work volume per year	h	5.200	Including family labor				
labor cost (hired)	AUD	80.000					
labor cost (family)	AUD	100.000					
labor total	**AUD**	**180.000**	Including family labor				
contract work (crop related)	AUD	0					
contract work (overhead)	**AUD**	**17.000**					
contract work total	AUD	17.000					
sub-total	**AUD**	**1.327.377**	Including total direct cost			check positions 1) and 2) for equal values	

Figure A1: Profit and loss calculation of the cash crop enterprise **(cont.)**

text	Unit	Total		
owned arable land	ha	3.150		
rented arable land	ha	1.050		
land cost arable land	**AUD**	**411.600**	Including opportunity cost for own land	
total other expenditures	**AUD**	**75.000**		
identification		number	purchase value	depreciation p.a.
tractors		2	550.000	76.000
towed machinery		3	380.000	58.100
selfpropelled machinery		7	1.740.000	186.160
buildings		6	409.000	22.700
annual depreciation	**AUD**	**342.960**		
total original cost	**AUD**	**3.079.000**		
share of debts in fixed assets	%	22		
interest rate	%	8,3		
interest cost on total orig. cost	**AUD**	**124.365**	Including opportunity cost for own capital	
share of debts in current assets	%	30		
interest rate	%	8,0		
inter. cost var. inputs (< 1 year)	**AUD**	**39.158**	Including opportunity cost for own capital	
total interest cost	**AUD**	**163.523**	Including opportunity cost for own capital	
total cost	**AUD**	**2.320.459**		
decoupled payment	AUD/ha	10		
total decoupled payment	**AUD**	**42.000**		
entrepreneur's profit	**AUD**	**629.357**		

Figure A2: TYPICROP finance cost calculation -

Finance cost debt current assets (cash cost)

field_inv_fin_ext_pha	=	tot_direct_cost_nofin_pha / 2 * (100 - equity_current_as[tbl_finance]) / 100 * inter_loan_short[tbl_finance] / 100

with

field_inv_fin_ext_pha	=	Finance cost debt current assets	[€]
tot_direct_cost_nofin_pha	=	Total direct cost excluding finance	[€]
equity_current_as	=	Equity share in current assets	[%]
inter_loan_short	=	Interest rate for short term operating loan (effective)	[%]

Finance cost equity current assets (opportunity cost)

field_inv_fin_own_pha	=	tot_direct_cost_nofin_pha / 2 * equity_current_as[tbl_finance] / 100 * inter_deposit_short[tbl_finance] / 100

with

field_inv_fin_own_pha	=	Finance cost equity current assets	[€]
tot_direct_cost_nofin_pha	=	Total direct cost excluding finance	[€]
equity_current_as	=	Equity share in current assets	[%]
inter_deposit_short	=	Interest rate for short term deposits (effective)	[%]

Average fixed capital (exemplarily for tractors, simultaneous calculation for other machines)

tractor_av_fixed_capital	=	((tractor_purchase_price - tractor_salvage_value) / 2) + tractor_salvage_value

with

tractor_av_fixed_capital	=	Average fixed capital (respective asset)	[€]
tractor_purchase_price	=	Historical purchase price	[€]
tractor_salvage_value	=	Salvage value of the current machine	[%]

Finance cost debt fixed assets (cash cost exemplarily for tractors, simultaneous calculation for other machines)

tractor_ext_finance_pa	=	tractor_av_fixed_capital * (100 - equity_fixed_as_sh[tbl_finance]) / 100 * inter_loan_fixed[tbl_finance] / 100

with

tractor_own_finance_pa	=	Finance cost equity fixed assets (respective asset)	[€/year]
tractor_av_fixed_capital	=	Average fixed capital (respective asset)	[€]
equity_fixed_as	=	Equity share in fixed assets	[%]
inter_loan_fixed	=	Interest rate for long term loan (effective)	[%]

Finance cost equity fixed assets (opportunity cost exemplarily for tractors, simultaneous calculation for other machines)

tractor_own_finance_pa	=	tractor_av_fixed_capital * equity_fixed_as_sh[tbl_finance] / 100 * inter_deposit_long[tbl_finance] / 100

with

tractor_own_finance_pa	=	Finance cost equity fixed assets (respective asset)	[€/year]
tractor_av_fixed_capital	=	Average fixed capital (respective asset)	[€]
equity_fixed_as	=	Equity share in fixed assets	[%]
inter_deposit_long	=	Interest rate for long term deposits (effective)	[%]

Figure A3: TYPICROP machinery depreciation cost calculation -

Machinery depreciation calculation - historical prices
(exemplarily for tractors, simultaneous calculation for other machines)

tractor_dep_pa = (tractor_purchase_price - tractor_salvage_value) / tractor_dep_dura

with

tractor_dep_pa	=	Annual depreciation cost (respective machine)	[€/a]
tractor_purchase_price	=	Historical purchase price	[€]
tractor_salvage_value	=	Salvage value of the current machine	[€]
tractor_dep_dura	=	Depreciation duration	[year(s)]

Machinery depreciation calculation - repurchase prices
(exemplarily for tractors, simultaneous calculation for other machines)

tractor_dep_pa = (tractor_repurch_price - tractor_salvage_value) / tractor_dep_dura

with

tractor_dep_pa	=	Annual depreciation cost (respective machine)	[€/a]
tractor_repurch_price	=	Current repurchase price	[€]
tractor_salvage_value	=	Salvage value of the current machine	[€]
tractor_dep_dura	=	Depreciation duration	[year(s)]

Figure A4: TYPICROP land cost calculation -

Average land rent (exemplarily for arable land, simultaneous calculation for grassland)

al_av_rent_pha = (1 / rent_dur_al * rent_new_al) + ((1 - 1 / rent_dur_al) * rent_old_al)

with

al_av_rent_pha	=	Average arable land rent	[€/ha]
rent_dur_al	=	Rent contract duration arable land	[year(s)]
rent_new_al	=	Arable land rent (new contracts)	[€/ha]
rent_old_al	=	Arable land rent (existing contracts)	[€/ha]

Average land opportunity cost (exemplarily for arable land, simultaneous calculation for grassland)

al_av_own_cost_pha = rent_new_al

with

al_av_own_cost_pha	=	Average arable land rent	[€/ha]
rent_new_al	=	Arable land rent (new contracts)	[€/ha]

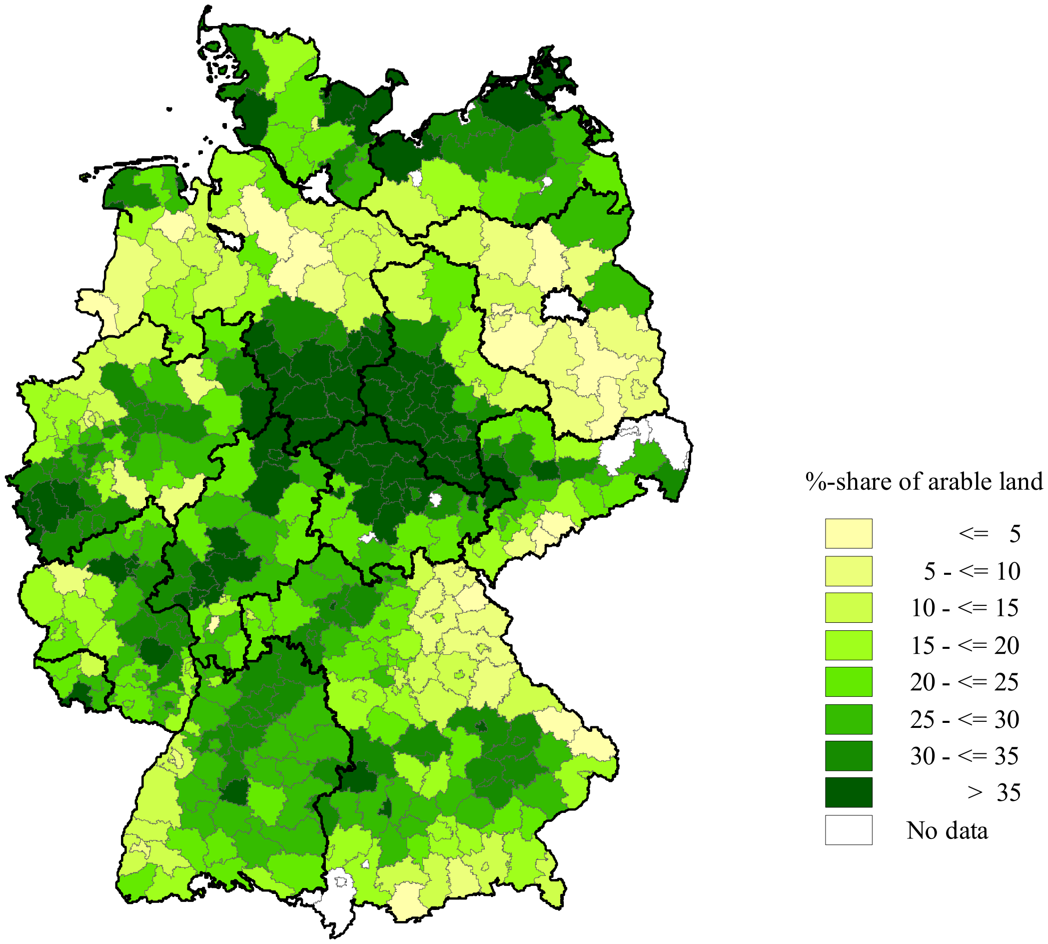
Average land use cost (exemplarily for arable land, simultaneous calculation for grassland)

al_av_cost_pha = (al_sh_rent * al_av_rent_pha) + (al_sh_own * al_av_own_cost_pha)

with

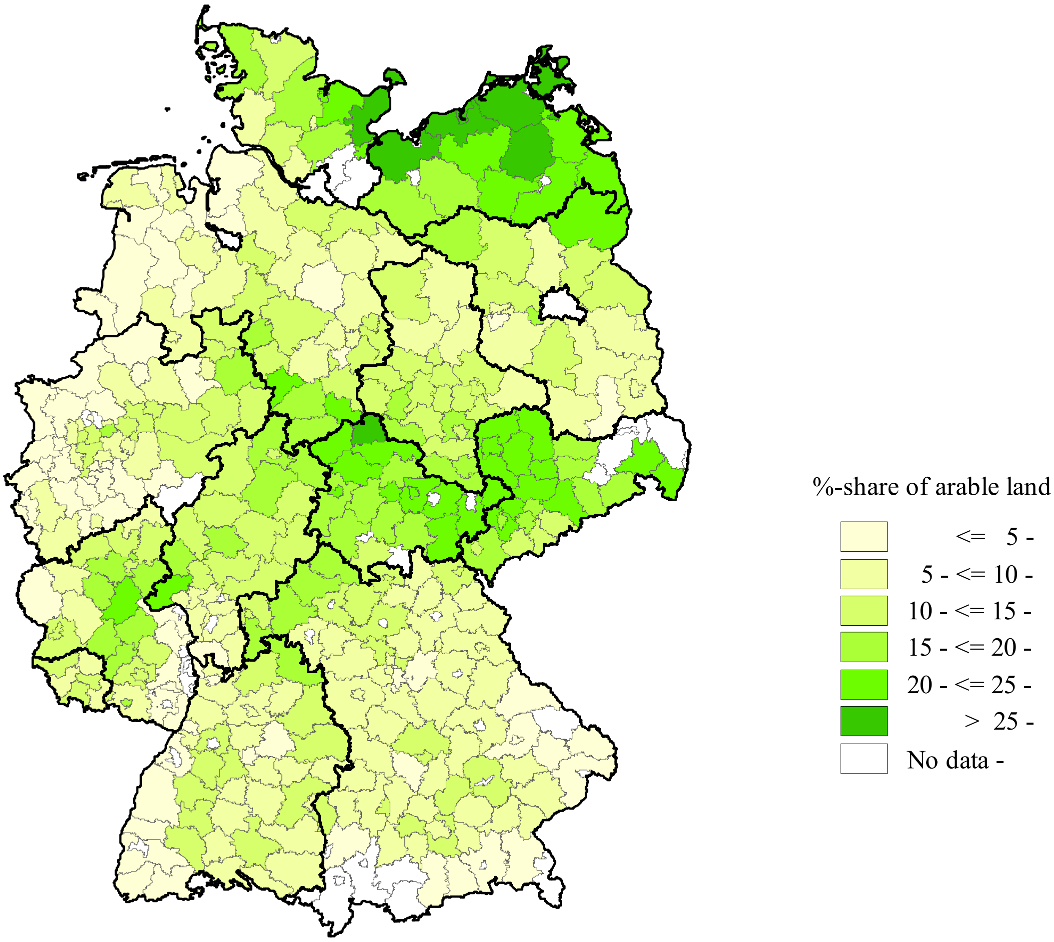
al_sh_rent	=	Share of own land in total arable land	[%]
al_av_rent_pha	=	Average arable land rent	[€/ha]
al_sh_own	=	Share of own land in total arable land	[%]
al_av_own_cost_pha	=	Average arable land rent	[€/ha]

Figure A5: Spatial distribution of wheat production in Germany (2007) -



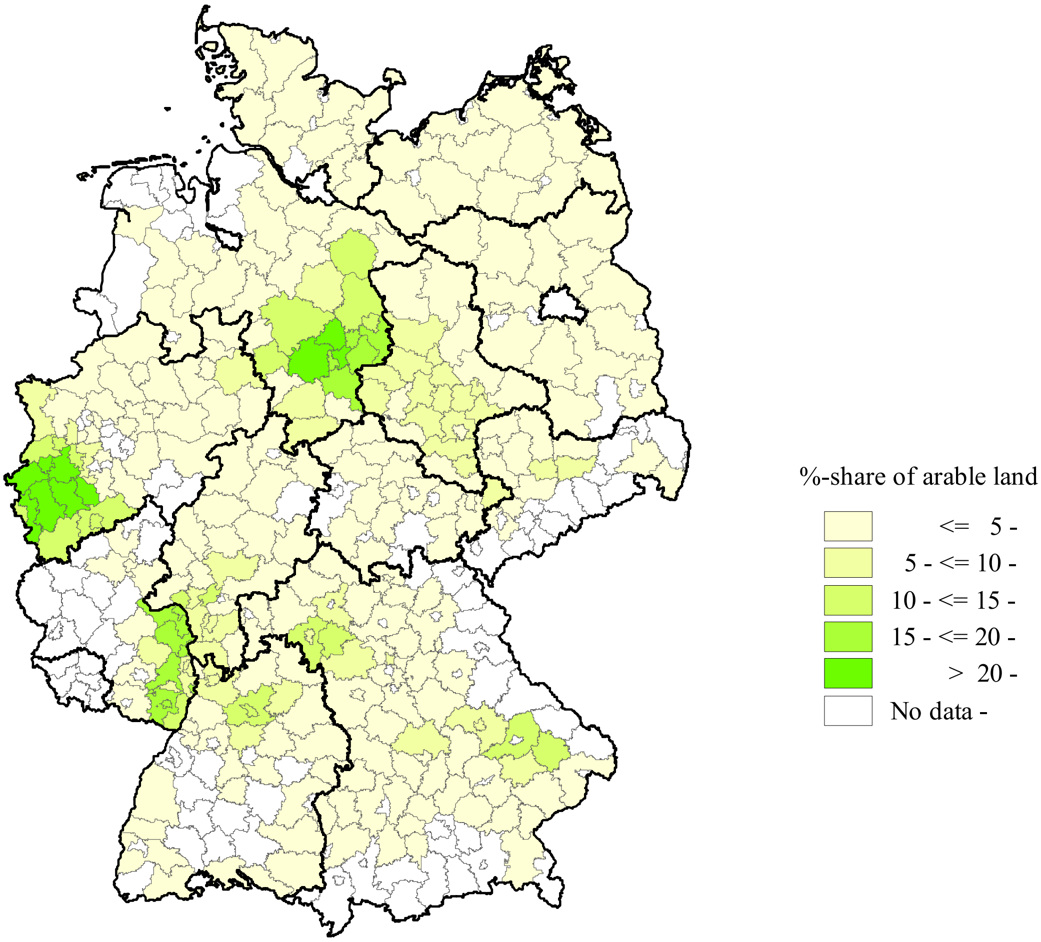
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3 (2007); own illustration.

Figure A6: Spatial distribution of rapeseed production in Germany (2007) -



Source: Statistisches Bundesamt, Fachserie 3, Reihe 3 (2007); own illustration.

Figure A7: Spatial distribution of sugarbeet production in Germany (2007)



Source: Statistisches Bundesamt, Fachserie 3, Reihe 3 (2007); own illustration.

Table A2: Machinery inventory DE 1300MB (Average 2005–2009)

Position	Number	hp/m	Utilisation	Price	Purchase year	Depreciation period	Salvage value	Repurchase price	Current value	Depreciation cost	Finance cost	Repair cost	Total annual cost
Tractors		hp	h/year	EUR		year(s)	EUR	EUR	EUR	EUR/a	EUR/a	EUR/a	EUR/a
Front-wheel-assist	1	360	700	117,000	2005	6	45,000	210,000	93,000	12,000	3,382	3,901	19,282
Front-wheel-assist	1	240	900	110,000	2003	12	33,000	190,000	84,333	6,417	2,985	4,915	14,316
Front-wheel-assist	1	185	950	80,000	2001	10	27,600	170,000	48,560	5,240	2,246	5,063	12,549
Towed machinery		m	ha/year										
Boomspray	1	30	7,650	80,000	2001	7	3,800	110,000	14,686	10,886	1,749	4,746	17,381
Seeding combination	1	6	1,150	53,100	2001	7	15,800	80,000	21,129	5,329	1,438	7,867	14,634
Field cultivator	1	6	950	39,000	2005	7	4,500	49,000	29,143	4,929	908	5,182	1,526
Trailer comb. (16 t)	2	1	1,300	24,700	1994	30	5,500	31,300	16,380	640	630	220	1,490
Disc harrow	1	8	1,240	26,700	2000	15	6,500	30,700	17,273	1,347	693	2,279	4,319
Trailer comb. (18 t)	2	1	1,300	26,200	2000	30	6,600	29,500	21,627	653	685	188	1,526
Land roller	1	12	325	16,600	1996	99	2,800	20,200	15,067	139	405	113	657
Sugarbeet seeder	1	6	100	13,900	1997	15	600	16,600	5,033	887	303	474	1,663
Fert. spreader + N-Sensor	1	30	4,950	9,500	2005	25	3,500	15,000	9,020	240	271	1,504	2,015
Canola front for header	1	9	325	7,400	2001	7	2,000	8,200	2,771	771	196	239	1,206
Mover	1	4	1,300	6,900	1998	99	1,000	8,100	6,364	60	165	804	1,029
Sidemover	1	2	1,300	6,100	1999	99	1,000	7,000	5,688	52	148	803	1,003
Auger	1	1	1,300	3,600	1998	99	1	4,200	3,273	36	75	203	314
Watertrailer	1	1	1,300	2,800	1998	99	1	3,300	2,546	28	58	102	189
Molluscicide spreader	1	15	1,300	1,069	2001	15	200	1,200	128,545	11,018	6,439	8,574	26,031
Plough	1	3	1,300	37,974	1998	99	1	--	34,522	384	793	129	1,305
Self-propelled machinery		PS	ha/year										
Combine (hybrid)	1	550	850	258,621	2005	9	58,000	280,000	214,039	22,291	6,609	4,873	33,773
Telehandler	1	120	1,300	43,000	1999	20	13,800	55,000	31,320	1,460	1,186	998	3,643
Ute 4x4	1	90	1,300	20,000	2001	10	2,500	30,000	9,500	1,750	470	1,088	3,307

Source: Own calculation.

Table A3: Machinery inventory AU 4500SC (Average 2005–2009)

Position	Number	hp/m	Utilisation	Price	Purchase year	Depreciation period	Salvage value	Repurchase price	Current value	Depreciation cost	Finance cost	Repair cost	Total annual cost
Tractors		hp	h/year	EUR		year(s)	EUR	EUR	EUR	EUR/a	EUR/a	EUR/a	EUR/a
Four-wheel-drive/tracks	1	330	550	202,000	2006	5	77,127	214,242	177,025	24,974	8,520	2,141	35,636
Front-wheel-assist	1	220	370	134,666	2006	5	26,933	146,909	113,120	21,547	4,933	1,847	28,326
Towed machinery		m	ha/year										
Airseeder incl. seedcart	1	12	4,200	177,515	2005	5	33,054	214,242	119,731	28,892	6,428	8,092	43,412
Chaser bin	1	1	4,200	27,545	2005	10	4,897	30,606	23,016	2,265	990	634	3,889
Spreader	1	20	3,334	27,545	2004	5	5,509	28,158	14,324	4,407	1,009	1,852	7,268
Self-propelled machinery		PS	ha/year										
Combine (hybrid)	2	400	2,100	318,302	2005	5	189,757	428,484	266,884	25,709	15,509	7,201	48,418
Boomspray	1	180	22,000	214,242	2005	5	42,848	214,242	145,685	34,279	7,848	9,601	51,727
Truck+Tipper	1	500	4,200	91,818	2000	10	24,485	97,939	44,685	6,733	3,550	6,600	16,884
Swather	1	150	1,000	73,454	2005	5	14,691	76,515	49,949	11,753	2,691	3,292	17,735
Ute 4x4	2	100	4,500	24,485	2004	5	61	27,545	9,831	4,885	749	2,052	7,686

Source: Own calculation.

Table A4: Machinery inventory AU 4000WB (Average 2005–2009)

Position	Number	hp/m	Utilisation	Price	Purchase year	Depreciation period	Salvage value	Repurchase price	Current value	Depreciation cost	Finance cost	Repair cost	Total annual cost
Tractors		hp	h/year	EUR		year(s)	EUR	EUR	EUR	EUR/a	EUR/a	EUR/a	EUR/a
Four-wheel-drive	1	400	300	214,242	2001	10	37,951	244,848	108,468	17,629	8,039	10,077	35,745
Front-wheel-assist	1	200	960	122,424	2001	10	13,467	134,666	57,050	10,896	4,332	6,228	21,455
Towed machinery		m	ha/year										
Chaser bin 20 t	1	1	3,200	36,727	2000	12	12,242	36,727	22,444	2,040	1,561	2,223	5,824
Boomspray 7000 l	1	30	13,000	73,454	2003	8	6,121	73,454	39,788	8,417	2,536	5,240	16,193
Airseeder + Cart	1	14	3,700	183,636	2002	15	18,364	214,242	128,545	11,018	6,439	8,574	26,031
Self-propelled machinery		PS	ha/year										
Combine (single rotor)	1	300	3,200	214,242	2003	8	134,666	379,514	174,454	9,947	11,121	6,193	27,261
Truck	1	350	3,200	73,454	2005	10	30,606	73,454	64,885	4,285	3,317	1,334	8,936
Loader	1	120	4,000	19,588	1995	20	12,242	24,485	15,181	367	1,015	686	2,068
Ute	1	80	4,000	18,364	2003	10	1	18,364	11,018	1,836	585	1,143	3,565

Source: Own calculation.

Table A5: Machinery inventory AU 2800CW (Average 2005–2009)

Position	Number	hp/m	Utilisation	Price	Purchase year	Depreciation period	Salvage value	Repurchase price	Current value	Depreciation cost	Finance cost	Repair cost	Total annual cost
Tractors		hp	h/year	EUR		year(s)	EUR	EUR	EUR	EUR/a	EUR/a	EUR/a	EUR/a
Four-wheel-drive	1	350	200	171,394	1997	15	12,242	214,242	65,293	10,610	5,651	3,099	19,361
Front-wheel-assist + loader	1	120	300	85,697	1998	15	6,121	91,818	37,951	5,305	2,826	1,395	9,525
Towed machinery		m	ha/year										
Airseeder incl. Seedcart	1	12	900	122,424	2000	15	12,242	171,394	71,006	7,345	4,144	2,454	13,943
Boomspray towed	1	20	4,200	48,970	1998	12	4,285	52,030	15,456	3,724	1,639	1,599	6,962
Cultivator	1	6	600	30,606	1995	15	4,591	--	9,794	1,734	1,083	993	3,811
Self-propelled machinery		PS	ha/year										
Combine (single rotor)	1	240	900	153,030	2000	15	26,933	220,363	94,185	8,406	5,538	2,808	16,753
Utes	2	60	3,000	12,242	1995	20	1	18,364	4,897	612	377	350	1,339
Truck	1	200	3,000	36,727	1995	30	3,673	--	23,505	1,102	1,243	631	2,976

Source: Own calculation.

Table A6: Building inventory DE 1300MB (Average 2005–2009)

Building	Construction year	Construction cost	Depreciation period	Reconstruction cost	Current value	Depreciation cost	Finance cost	Repair cost	Total annual cost
		EUR	year(s)	EUR	EUR	EUR/a	EUR/a	EUR/a	EUR/a
Grain storage 6000 t	1996	422,900	30	600,000	267,800	14,097	8,828	7,157	30,082
Machinery shed	1998	87,200	30	93,000	61,000	2,907	1,820	1,207	5,934
Liquid fertiliser storage	2001	30,400	20	32,000	21,300	1,520	635	421	2,576
Farmyard flooring	1998	29,000	30	31,000	20,300	967	605	402	1,974
Service point	2001	25,300	20	30,000	17,700	1,265	528	350	2,143
Weighbridge	2001	25,300	30	30,000	20,200	843	528	234	1,605
Fuel station 30 000 l	2001	12,700	20	14,000	8,900	635	265	176	1,076
Social facilities	1988	9,700	30	10,300	3,600	323	203	284	809
Aeration fan 15 kw (2x)	1996	4,900	20	6,200	2,200	245	102	124	472
Aeration fan 15 kw (1x)	2000	2,800	20	3,100	1,800	140	58	45	244

Source: Own calculation.

Table A7: Building inventory AU 4500SC (Average 2005–2009)

Building	Construction year	Construction cost	Depreciation period	Reconstruction cost	Current value	Depreciation cost	Finance cost	Repair cost	Total annual cost
		EUR	year(s)	EUR	EUR	EUR/a	EUR/a	EUR/a	EUR/a
Machinery shed	2005	42,848	30	45,909	40,000	1,428	1,308	356	3,093
Augers (2x)	2000	22,036	10	23,261	6,600	2,204	673	1,924	4,801
Field bins 40 t (12x)	2000	61,212	20	67,333	39,800	3,061	1,869	2,673	7,602
Silos for seed 70 t (4x)	1995	29,382	30	30,606	17,600	979	897	1,466	3,342
Fertilizer shed 200 t	2000	42,848	30	45,909	32,900	1,428	1,308	1,247	3,984
Workshop	2000	52,030	30	55,091	39,900	1,734	1,588	1,515	4,837

Source: Own calculation.

Table A8: Building inventory AU 4000WB (Average 2005–2009)

Building	Construction year	Construction cost	Depreciation period	Reconstruction cost	Current value	Depreciation cost	Finance cost	Repair cost	Total annual cost
		EUR	year(s)	EUR	EUR	EUR/a	EUR/a	EUR/a	EUR/a
Field bins 30 t (6x)	1995	48970	20	55,091	19,600	2,448	1,561	431	4,440
Workshop	1980	30606	30	30,606	3,100	1,020	976	404	2,399
Silos for seed 40 t (8x)	1980	39176	30	61,212	3,900	1,306	1,249	517	3,071
Auger	2000	12242	12	12,242	5,100	1,020	390	105	1,515
Fertilizer shed 350 t	1995	61212	30	183,636	36,700	2,040	1,951	359	4,350
Machinery shed	2003	30606	30	30,606	26,500	1,020	976	60	2,056
Shearing shed	1975	91818	75	202,000	52,600	1,224	2,927	574	4,725

Source: Own calculation.

Table A9: Building inventory AU 2800CW (Average 2005–2009)

Building	Construction year	Construction cost	Depreciation period	Reconstruction cost	Current value	Depreciation cost	Finance cost	Repair cost	Total annual cost
		EUR	year(s)	EUR	EUR	EUR/a	EUR/a	EUR/a	EUR/a
Shearing shed	1980	183,636	75	226,484	117,500	2,448	5,651	3,171	11,271
Machinery sheds	1980	110,182	75	140,788	70,500	1,469	3,391	1,902	6,762
Silos for seed 30 t (6x)	1990	36,727	20	45,909	5,500	1,836	1,130	1,497	4,464
Field bins 30 t (4x)	1995	14,691	20	14,691	5,900	735	452	423	1,609
Augers (3x)	1995	12,242	20	36,727	4,900	612	377	352	1,341

Source: Own calculation.

Figure A8: Road train as typically used for grain transport in Australia -

Source: Own picture. -

Table A10: Nutritive needs (kg) of major crops per unit of crop output (t) -

Crop		N	P	K	Mg	CaO	S
Wheat	kg/t	20.00	3.51	4.96	1.18	0.85	1.25
Rapeseed	kg/t	50.00	8.72	5.60	3.17	6.25	13.00
Barley	kg/t	20.00	3.51	4.96	1.18	0.85	1.25
Sugarbeet	kg/t	1.80	0.37	1.99	0.40	0.80	0.15
Straw	kg/t	5.00	1.31	11.62	--	--	--
Oaten hay	kg/t	25.00	4.82	16.58	1.18	0.85	1.25

Source: Diepenbrock et al. (1999); Schilling (2000); own illustration.

Table A11: Average yields (2005–2009) of major crops (t/ha) and macro nutrient target fertilisation (kg/ha) of typical farms

Crop	Yield (t/ha)	Factor*	Macro nutrient target fertilisation (kg nutrient/ha)					
			N	P	K	Mg	CaO	S
DE 1300MB								
Wheat	8.2	1.0	163.4	28.7	40.5	9.6	6.9	10.2
Rapeseed	4.0	1.0	200.9	35.0	22.5	12.7	25.1	52.2
Sugarbeet	58.6	1.0	105.5	21.7	116.7	23.3	46.9	8.8
AU 4500SC								
Wheat	2.7	1.5	79.7	14.0	19.8	4.7	3.4	5.0
Canola	1.8	1.0	90.1	15.7	10.1	5.7	11.3	23.4
Barley	3.0	1.0	60.1	10.5	14.9	3.5	2.6	3.8
AU 4000WB								
Wheat	1.9	1.0	37.9	6.7	9.4	2.2	1.6	2.4
Canola	1.0	1.0	47.5	8.3	5.3	3.0	5.9	12.4
Barley	2.1	1.0	42.1	7.4	10.4	2.5	1.8	2.6
Oaten hay	3.8	1.0	95.6	18.4	63.4	4.5	3.3	4.8
AU 2800CW								
Wheat	1.3	0.8	20.1	3.5	5.0	1.2	0.9	1.3
Barley	1.4	0.8	22.4	3.9	5.5	1.3	1.0	1.4

* The factor describes the releation between nutrient uptake of crops and supply by fertilisation. The balance is buffered by the nutrient content of the soil.
Source: Own calculation.

Figure A9: Production system of winter wheat (following sugarbeet) on DE 1300MB and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	end 09	Spreading	Dry chicken manure (organic) N20 P11 K14 CaO43 Mg4 S2	19	5
2	end 09	Spreading	Chloride of Potash (mineral) K26 Mg3 S3	15	4
			+ Triple-superphosphate (mineral) P10	17	
3	beg 10	Stubble tillage	Field cultivator, working depth 15 cm		38
4	beg 10	Seeding	Seeding combination, seed fungicide treated	56	29
5	mid 10	Spraying	Selective herbicide	13	6
6	end 10	Spraying	Selective herbicide	29	6
7	beg 03	Fertiliser	Sulphate of ammonia (mineral) N22 S24	17	3
8	mid 03	Fertiliser	Urea (mineral) N28	17	3
9	beg 04	Plant protection	Growth regulator	2	6
10	mid 04	Fertiliser	Urea (mineral) N74	45	3
11	beg 05	Plant protection	Selective herbicide, growth regulator	11	6
12	mid 05	Plant protection	Selective herbicide, fungicide, leaf dressing Mg1 S1	30	6
13	beg 06	Fertiliser	Urea (mineral) N42	25	3
14	beg 06	Plant protection	Fungicide, insecticide, leaf dressing Mg1 S1	27	6
15	mid 08	Harvest	Combine harvest		63
16	mid 08	Transport	On farm from field to storage		11
17	mid 08	Other	On farm handling at storage facility		9
			Total	324	207

Summary				
Crop		Winter wheat (following sugarbeet)		
Tillage		Conservation tillage with mulch-seed		
Seed	kg/ha	180	56	EUR/ha
Fertilisation	Nutrient kg/ha	N185 P21 K41 CaO43 Mg8 S31	159	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (2), insecticide (1), other (2)	108	EUR/ha
Yield	t/ha	7.8		

Source: Own calculation.

Figure A10: Production system of winter wheat (following winter rapeseed) on DE 1300MB and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	end 08	Stubble tillage	Disc harrow, working depth 5cm		15
2	beg 09	Spreading	Dry chicken manure (organic) N30 P17 K22 CaO65Mg5 S2	29	8
3	mid 09	Spreading	Chloride of Potash (mineral) K17 Mg2 S2	9	3
			+ Triple-superphosphate (mineral) P10	17	
4	end 09	Spraying	Total herbicide	9	6
5	beg 10	Seeding	Seeding combination, seed fungicide treated	47	28
6	beg 10	Other	Molluscicide	7	3
7	mid 10	Plant protection	Selective herbicide	25	6
8	beg 03	Fertiliser	Sulphate of ammonia (mineral) N22 S24	17	3
9	mid 03	Fertiliser	Urea (mineral) N28	17	3
10	beg 04	Plant protection	Growth regulator	2	6
11	mid 04	Fertiliser	Urea (mineral) N70	42	6
12	beg 05	Plant protection	Selective herbicide, growth regulator	11	6
13	end 05	Plant protection	Selective herbicide, fungicide, leaf dressing Mg1 S1	30	6
14	beg 06	Fertiliser	Urea (mineral) N37	22	3
15	mid 06	Plant protection	Fungicide, insecticide, leaf dressing Mg1 S1	27	6
16	beg 08	Harvest	Combine harvest		100
17	beg 08	Transport	On farm from field to storage		11
18	beg 08	Other	On farm handling at storage facility		9
			Total	311	226

Summary				
Crop		Winter wheat (following winter rapeseed)		
Tillage		Conservation tillage with mulch-seed		
Seed	kg/ha	150	47	EUR/ha
Fertilisation	Nutrient kg/ha	N185 P27 K39 CaO65 Mg9 S30	157	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (2), insecticide (1), other (3)	107	EUR/ha
Yield	t/ha	8.6		

Source: Own calculation.

Figure A11: Production system of sugarbeet (following winter wheat) on DE 1300MB and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	end 08	Stubble tillage	Disc harrow, working depth 5cm		17
2	end 09	Spreading	Dry chicken manure (organic) N40 P22 K30 CaO86 Mg7 S2	39	10
3	end 09	Stubble tillage	Field cultivator, working depth 15cm		38
4	beg 03	Fertiliser	Chloride of Potash (mineral) K82 Mg9 S10	46	3
5	mid 03	Spraying	Total herbicide	11	6
6	end 03	Fertiliser	Urea (mineral) N81		
7	beg 04	Seedbed preparation	Disc harrow, working depth 6cm		23
8	beg 04	Seeding	Sugarbeet seeder	235	29
9	beg 05	Plant protection	Selective herbicide	40	6
10	mid 05	Plant protection	Selective herbicide	40	6
11	end 05	Plant protection	Selective herbicide, spray agent	45	6
12	beg 07	Other	Manual labour: strip of bolters -		34
13	beg 08	Plant protection	Fungicide, leaf dressing B1	38	6
14	end 10	Harvest	Sugarbeet harvester (Contractor) -		220
			Total -	494	403

Summary				
Crop		Sugarbeet (following winter wheat)		
Tillage		Conservation tillage with mulch-seed		
Seed	units/ha	1.1	235	EUR/ha
Fertilisation	Nutrient kg/ha	N121 P22 K112 CaO86 Mg16 S12	139	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (1), insecticide (0), other (1)	169	EUR/ha
Yield	t/ha	58,6 @ 18% average sugar content		

Source: Own calculation.

Table A12: Profitability of single crops and farm average DE 1300MB (2005) -

Crop		Sugar beet (quota)	Winter wheat	Winter wheat	Winter wheat	Winter rapeseed	Set aside	Farm average
Previous Crop		WW	WRa	WW	SB	WW		
Acreage	ha	81	325	425	81	325	13	1,250
Crop yield	t/ha	57	8.2	7.7	7.5	4.3		
Output price	EUR/t	46	100	100	100	214		
Market revenue	**EUR/ha**	**2,609**	**824**	**767**	**748**	**924**	**0**	**933**
Seed	EUR/ha	235	47	48	56	44		59
Nitrogen (N)	EUR/ha	60	93	95	92	122		98
Phosphorus (P)	EUR/ha	16	22	16	18	28		20
Potassium (K)	EUR/ha	32	6	6	10	0		7
Other	EUR/ha	5	5	3	5	19		8
Fertilizer (total)	EUR/ha	113	126	120	126	169		133
Herbicides	EUR/ha	132	49	57	57	91		68
Fungicides	EUR/ha	33	43	62	43	77		57
Insecticides	EUR/ha	0	6	6	6	24		10
Other	EUR/ha	4	10	9	3	1		6
Pesticides (total)	EUR/ha	169	107	135	108	192		141
Crop establishment cost	**EUR/ha**	**518**	**280**	**303**	**290**	**405**	**0**	**333**
Dry energy cost	EUR/ha	0	5	5	5	1		4
Crop insurance (hail)	EUR/ha	14	9	12	7	8		10
Other	EUR/ha	0	0	0	0	0		0
Finance field inventory	EUR/ha	8	4	5	5	6		5
Total direct cost	**EUR/ha**	**540**	**298**	**324**	**306**	**420**	**0**	**352**
Gross margin[1)]	**EUR/ha**	**2,069**	**526**	**443**	**442**	**504**	**0**	**581**
Labour	EUR/ha	275	132	183	162	151	19	164
Contractor	EUR/ha	230	108	10	5	18		51
Machinery	EUR/ha	110	76	144	132	137	7	120
Diesel	EUR/ha	44	35	65	53	61	9	53
Other	EUR/ha	17	6	5	5	6		6
Total operating cost	**EUR/ha**	**677**	**357**	**407**	**356**	**372**	**35**	**395**
Operating profit[2)]	**EUR/ha**	**1,392**	**169**	**36**	**86**	**132**	**-35**	**186**
Building cost	EUR/ha	103	32	30	29	36		37
Total land cost	EUR/ha	348	346	346	346	346	345	346
Decoupled payments	EUR/ha	327	327	327	327	327	327	327
Net land cost[3)]	EUR/ha	21	19	19	19	19	18	19
Miscellaneous cost	EUR/ha	263	83	77	75	93		94
Total cost	**EUR/ha**	**1,604**	**790**	**857**	**786**	**941**	**53**	**897**
Profit[4)]	**EUR/ha**	**1,005**	**34**	**-90**	**-38**	**-17**	**-53**	**36**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A13: Profitability of single crops and farm average DE 1300MB (2006) -

Crop		Sugar beet (quota)	Winter wheat	Winter wheat	Winter wheat	Winter rapeseed	Set aside	Farm average
Previous Crop		WW	WRa	WW	SB	WW		
Acreage	ha	81	325	425	81	325	13	1,250
Crop yield	t/ha	51	7.9	7.4	7.2	3.7		
Output price	EUR/t	37	144	144	144	232		
Market revenue	**EUR/ha**	**1,874**	**1,143**	**1,063**	**1,037**	**856**	**0**	**1,070**
Seed	EUR/ha	235	47	48	56	44		59
Nitrogen (N)	EUR/ha	61	95	97	94	126		100
Phosphorus (P)	EUR/ha	16	21	16	17	27		20
Potassium (K)	EUR/ha	34	7	7	11	0		7
Other	EUR/ha	5	5	3	5	19		8
Fertilizer (total)	EUR/ha	116	127	122	127	172		135
Herbicides	EUR/ha	132	49	57	57	91		68
Fungicides	EUR/ha	33	43	62	43	77		57
Insecticides	EUR/ha	0	6	6	6	24		10
Other	EUR/ha	4	10	9	3	1		6
Pesticides (total)	EUR/ha	169	107	135	108	192		141
Crop establishment cost	**EUR/ha**	**520**	**281**	**304**	**292**	**407**	**0**	**335**
Dry energy cost	EUR/ha	0	6	5	5	1		4
Crop insurance (hail)	EUR/ha	14	9	12	7	8		10
Other	EUR/ha	0	0	0	0	0		0
Finance field inventory	EUR/ha	8	4	5	5	6		5
Total direct cost	**EUR/ha**	**542**	**300**	**327**	**308**	**423**	**0**	**354**
Gross margin[1)]	**EUR/ha**	**1,332**	**843**	**736**	**728**	**433**	**0**	**716**
Labour	EUR/ha	275	132	183	162	151	19	164
Contractor	EUR/ha	230	108	10	5	18		51
Machinery	EUR/ha	110	76	144	132	137	7	120
Diesel	EUR/ha	42	34	62	50	58	9	51
Other	EUR/ha	11	7	6	6	5		6
Total operating cost	**EUR/ha**	**668**	**356**	**405**	**355**	**368**	**34**	**393**
Operating profit[2)]	**EUR/ha**	**664**	**487**	**331**	**374**	**65**	**-34**	**323**
Building cost	EUR/ha	64	39	36	36	29		37
Total land cost	EUR/ha	347	346	346	346	346	345	346
Decoupled payments	EUR/ha	327	327	327	327	327	327	327
Net land cost[3)]	EUR/ha	20	19	19	19	19	18	19
Miscellaneous cost	EUR/ha	165	101	94	91	75		94
Total cost	**EUR/ha**	**1,460**	**815**	**881**	**809**	**915**	**52**	**897**
Profit[4)]	**EUR/ha**	**414**	**328**	**182**	**228**	**-59**	**-52**	**173**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A14: Profitability of single crops and farm average DE 1300MB (2007) -

Crop		Sugar beet (quota)	Sugar beet (ethanol)	Winter wheat	Winter wheat	Winter wheat	Winter rapeseed	Set aside	Farm average
Previous Crop		WW	WW	WRa	WW	SB	WW		
Acreage	ha	81	19	325	387	100	325	13	1,250
Crop yield	t/ha	67	67	7.4	6.8	6.7	3.5		
Output price	EUR/t	37	25	219	219	219	257		
Market revenue	**EUR/ha**	**2,501**	**1,678**	**1,612**	**1,498**	**1,461**	**887**	**0**	**1,418**
Seed	EUR/ha	235	235	47	48	56	44		62
Nitrogen (N)	EUR/ha	57	57	87	89	87	116		92
Phosphorus (P)	EUR/ha	15	15	20	15	17	26		19
Potassium (K)	EUR/ha	32	32	6	6	10	0		7
Other	EUR/ha	5	5	7	4	7	24		10
Fertilizer (total)	EUR/ha	109	109	121	115	120	167		129
Herbicides	EUR/ha	132	132	49	57	57	91		69
Fungicides	EUR/ha	33	33	43	62	43	77		56
Insecticides	EUR/ha	0	0	6	6	6	24		10
Other	EUR/ha	4	4	10	9	3	1		6
Pesticides (total)	EUR/ha	169	169	107	135	108	192		142
Crop establishment cost	**EUR/ha**	**513**	**513**	**275**	**297**	**285**	**402**	**0**	**332**
Dry energy cost	EUR/ha	0	0	6	5	5	1		4
Crop insurance (hail)	EUR/ha	14	11	9	12	7	8		10
Other	EUR/ha	0	0	0	0	0	0		0
Finance field inventory	EUR/ha	8	8	4	5	4	6		5
Total direct cost	**EUR/ha**	**535**	**532**	**294**	**319**	**302**	**418**	**0**	**351**
Gross margin[1)]	**EUR/ha**	**1,966**	**1,145**	**1,318**	**1,179**	**1,159**	**469**	**0**	**1,067**
Labour	EUR/ha	274	274	131	182	160	150	19	164
Contractor	EUR/ha	230	230	108	10	5	18		55
Machinery	EUR/ha	111	111	76	145	133	137	7	120
Diesel	EUR/ha	40	40	32	59	47	55	8	48
Other	EUR/ha	11	7	7	7	6	4		6
Total operating cost	**EUR/ha**	**666**	**662**	**354**	**402**	**352**	**364**	**34**	**393**
Operating profit[2)]	**EUR/ha**	**1,300**	**483**	**964**	**777**	**807**	**105**	**-34**	**674**
Building cost	EUR/ha	65	43	42	39	38	23		37
Total land cost	EUR/ha	347	346	346	346	346	346	345	346
Decoupled payments	EUR/ha	337	337	337	337	337	337	337	337
Net land cost[3)]	EUR/ha	10	9	9	9	9	9	8	9
Miscellaneous cost	EUR/ha	167	112	108	100	97	59		95
Total cost	**EUR/ha**	**1,443**	**1,359**	**806**	**869**	**798**	**872**	**42**	**884**
Profit[4)]	**EUR/ha**	**1,059**	**319**	**806**	**629**	**662**	**14**	**-42**	**534**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A15: Profitability of single crops and farm average DE 1300MB (2008) -

Crop		Sugar beet (quota)	Sugar beet (ethanol)	Winter wheat	Winter wheat	Winter wheat	Winter rapeseed	Set aside	Farm average
Previous Crop		WW	WW	WRa	WW	SB	WW		
Acreage	ha	81	19	325	387	100	325	13	1,250
Crop yield	t/ha	58	58	10.3	9.6	9.4	4.4		
Output price	EUR/t	38	27	152	152	152	404		
Market revenue	**EUR/ha**	**2,198**	**1,567**	**1,570**	**1,461**	**1,424**	**1,790**	**0**	**1,606**
Seed	EUR/ha	235	235	47	48	56	44		62
Nitrogen (N)	EUR/ha	76	76	117	120	116	155		123
Phosphorus (P)	EUR/ha	15	15	29	15	25	26		22
Potassium (K)	EUR/ha	37	37	7	7	12	0		8
Other	EUR/ha	5	5	6	3	6	20		8
Fertilizer (total)	EUR/ha	133	133	158	145	159	200		161
Herbicides	EUR/ha	132	132	49	57	57	91		69
Fungicides	EUR/ha	33	33	43	62	43	77		56
Insecticides	EUR/ha	0	0	6	6	6	24		10
Other	EUR/ha	4	4	10	9	3	1		6
Pesticides (total)	EUR/ha	169	169	107	135	108	192		142
Crop establishment cost	**EUR/ha**	**537**	**537**	**312**	**327**	**323**	**436**	**0**	**365**
Dry energy cost	EUR/ha	0	0	7	7	7	2		5
Crop insurance (hail)	EUR/ha	14	11	9	12	7	8		10
Other	EUR/ha	0	0	0	0	0	0		0
Finance field inventory	EUR/ha	8	8	5	5	5	7		6
Total direct cost	**EUR/ha**	**560**	**557**	**334**	**352**	**342**	**452**	**0**	**385**
Gross margin[1)]	**EUR/ha**	**1,638**	**1,010**	**1,236**	**1,109**	**1,082**	**1,338**	**0**	**1,221**
Labour	EUR/ha	274	274	131	182	160	150	19	164
Contractor	EUR/ha	230	230	108	10	5	18		55
Machinery	EUR/ha	111	111	76	145	133	137	7	120
Diesel	EUR/ha	49	49	39	72	58	67	10	59
Other	EUR/ha	9	6	6	6	6	7		6
Total operating cost	**EUR/ha**	**672**	**670**	**360**	**414**	**362**	**379**	**36**	**404**
Operating profit[2)]	**EUR/ha**	**966**	**340**	**876**	**695**	**720**	**958**	**-36**	**817**
Building cost	EUR/ha	50	36	36	33	33	41		37
Total land cost	EUR/ha	346	346	346	346	346	346	345	346
Decoupled payments	EUR/ha	337	337	337	337	337	337	337	337
Net land cost[3)]	EUR/ha	9	9	9	9	9	9	8	9
Miscellaneous cost	EUR/ha	129	92	92	86	84	105		95
Total cost	**EUR/ha**	**1,421**	**1,364**	**831**	**894**	**830**	**987**	**44**	**929**
Profit[4)]	**EUR/ha**	**777**	**203**	**739**	**566**	**595**	**803**	**-44**	**677**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A16: Profitability of single crops and farm average DE 1300MB (2009) -

Crop		Sugar beet (quota)	Sugar beet (ethanol)	Winter wheat	Winter wheat	Winter wheat	Winter rapeseed	Set aside	Farm average
Previous Crop		WW	WW	WRa	WW	SB	WW		
Acreage	ha	81	19	325	387	100	325	13	1,250
Crop yield	t/ha	60	60	9.1	8.5	8.3	4.2		
Output price	EUR/t	36	25	120	120	120	283		
Market revenue	**EUR/ha**	**2,151**	**1,509**	**1,097**	**1,020**	**995**	**1,189**	**0**	**1,152**
Seed	EUR/ha	235	235	47	48	56	44		62
Nitrogen (N)	EUR/ha	112	112	172	177	172	230		182
Phosphorus (P)	EUR/ha	11	11	45	11	43	19		24
Potassium (K)	EUR/ha	95	95	19	19	30	0		21
Other	EUR/ha	5	5	15	10	15	39		19
Fertilizer (total)	EUR/ha	222	222	252	217	260	287		246
Herbicides	EUR/ha	132	132	49	57	57	91		69
Fungicides	EUR/ha	33	33	43	62	43	77		56
Insecticides	EUR/ha	0	0	6	6	6	24		10
Other	EUR/ha	4	4	10	9	3	1		6
Pesticides (total)	EUR/ha	169	169	107	135	108	192		142
Crop establishment cost	**EUR/ha**	**627**	**627**	**406**	**399**	**424**	**523**	**0**	**449**
Dry energy cost	EUR/ha	0	0	5	5	5	1		3
Crop insurance (hail)	EUR/ha	14	11	9	12	7	8		10
Other	EUR/ha	0	0	0	0	0	0		0
Finance field inventory	EUR/ha	10	10	6	6	7	8		7
Total direct cost	**EUR/ha**	**651**	**648**	**426**	**422**	**443**	**540**	**0**	**469**
Gross margin[1)]	**EUR/ha**	**1,500**	**861**	**671**	**598**	**552**	**649**	**0**	**683**
Labour	EUR/ha	274	274	131	182	160	150	19	164
Contractor	EUR/ha	230	230	108	10	5	18		55
Machinery	EUR/ha	111	111	76	145	133	138	7	120
Diesel	EUR/ha	49	49	38	70	57	65	10	57
Other	EUR/ha	12	8	6	6	5	6		6
Total operating cost	**EUR/ha**	**675**	**671**	**359**	**412**	**360**	**377**	**35**	**402**
Operating profit[2)]	**EUR/ha**	**826**	**190**	**312**	**186**	**192**	**272**	**-35**	**281**
Building cost	EUR/ha	69	48	35	33	32	38		37
Total land cost	EUR/ha	347	346	346	346	346	346	345	346
Decoupled payments	EUR/ha	337	337	337	337	337	337	337	337
Net land cost[3)]	EUR/ha	10	9	9	9	9	9	8	9
Miscellaneous cost	EUR/ha	177	124	90	84	82	98		95
Total cost	**EUR/ha**	**1,580**	**1,500**	**919**	**959**	**925**	**1,061**	**43**	**1,011**
Profit[4)]	**EUR/ha**	**571**	**9**	**178**	**61**	**70**	**128**	**-43**	**141**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A17: Profitability of single crops and farm average DE 1300MB (Scenario S-0) -

Crop		Sugar beet (quota)	Sugar beet (ethanol)	Winter wheat	Winter wheat	Winter wheat	Winter rapeseed	Set aside	Farm average
Previous Crop		WW	WW	WRa	WW	SB	WW		
Acreage	ha	81	19	325	387	100	325	13	1,250
Crop yield	t/ha	59	59	8.6	8.0	7.8	4.0		
Output price	EUR/t	39	31	215	215	215	433		
Market revenue	**EUR/ha**	**2,285**	**1,817**	**1,849**	**1,720**	**1,677**	**1,741**	**0**	**1,776**
Seed	EUR/ha	283	283	67	69	81	61		84
Nitrogen (N)	EUR/ha	133	133	206	211	205	276		218
Phosphorus (P)	EUR/ha	26	26	48	26	42	46		38
Potassium (K)	EUR/ha	79	79	16	16	25	0		17
Other	EUR/ha	8	8	13	10	13	55		22
Fertilizer (total)	EUR/ha	246	246	283	262	286	377		295
Herbicides	EUR/ha	159	159	58	69	68	109		83
Fungicides	EUR/ha	40	40	51	75	51	92		68
Insecticides	EUR/ha	0	0	7	7	7	28		12
Other	EUR/ha	5	5	12	11	3	1		7
Pesticides (total)	EUR/ha	203	203	128	162	130	230		170
Crop establishment cost	**EUR/ha**	**732**	**732**	**479**	**492**	**496**	**668**	**0**	**549**
Dry energy cost	EUR/ha	0	0	14	13	12	3		9
Crop insurance (hail)	EUR/ha	14	11	9	12	7	8		10
Other	EUR/ha	0	0	0	0	0	0		0
Finance field inventory	EUR/ha	11	11	8	8	8	10		9
Total direct cost	**EUR/ha**	**757**	**754**	**509**	**525**	**523**	**689**	**0**	**577**
Gross margin[1)]	**EUR/ha**	**1,528**	**1,063**	**1,340**	**1,195**	**1,154**	**1,051**	**0**	**1,199**
Labour	EUR/ha	272	272	130	184	160	149	18	164
Contractor	EUR/ha	230	230	108	10	5	18		55
Machinery	EUR/ha	110	110	76	146	132	137	7	120
Diesel	EUR/ha	75	75	63	123	95	111	17	97
Other	EUR/ha	8	6	6	6	6	6		6
Total operating cost	**EUR/ha**	**696**	**694**	**383**	**469**	**398**	**421**	**42**	**442**
Operating profit[2)]	**EUR/ha**	**833**	**369**	**956**	**726**	**756**	**631**	**-42**	**757**
Building cost	EUR/ha	48	38	39	36	35	37		38
Total land cost	EUR/ha	346	346	346	346	346	346	345	346
Decoupled payments	EUR/ha	331	331	331	331	331	331	331	331
Net land cost[3)]	EUR/ha	15	15	15	15	15	15	14	15
Miscellaneous cost	EUR/ha	122	97	98	92	89	93		95
Total cost	**EUR/ha**	**1,638**	**1,598**	**1,045**	**1,137**	**1,061**	**1,255**	**56**	**1,166**
Profit[4)]	**EUR/ha**	**647**	**218**	**804**	**583**	**616**	**486**	**-56**	**610**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A18: Profitability of single crops and farm average DE 1300MB (Scenario S-1) -

Crop		Sugar beet (quota)	Sugar beet (ethanol)	Winter wheat	Winter wheat	Winter wheat	Winter rapeseed	Set aside	Farm average
Previous Crop		WW	WW	WRa	WW	SB	WW		
Acreage	ha	81	19	325	387	100	325	13	1,250
Crop yield	t/ha	59	59	8.7	8.1	7.9	4.1		
Output price	EUR/t	39	31	215	215	215	433		
Market revenue	**EUR/ha**	**2,309**	**1,835**	**1,871**	**1,742**	**1,699**	**1,775**	**0**	**1,800**
Seed	EUR/ha	283	283	67	69	81	61		84
Nitrogen (N)	EUR/ha	133	133	223	227	226	296		234
Phosphorus (P)	EUR/ha	26	26	51	26	46	46		39
Potassium (K)	EUR/ha	79	79	16	16	25	0		17
Other	EUR/ha	8	8	15	11	15	57		24
Fertilizer (total)	EUR/ha	246	246	305	280	312	399		314
Herbicides	EUR/ha	190	190	70	83	82	129		99
Fungicides	EUR/ha	47	47	62	90	62	110		81
Insecticides	EUR/ha	0	0	8	8	8	34		14
Other	EUR/ha	6	6	14	14	4	1		9
Pesticides (total)	EUR/ha	244	244	154	194	156	274		203
Crop establishment cost	**EUR/ha**	**773**	**773**	**526**	**542**	**548**	**735**	**0**	**601**
Dry energy cost	EUR/ha	0	0	14	13	12	3		9
Crop insurance (hail)	EUR/ha	14	11	9	8	7	12		10
Other	EUR/ha	0	0	0	0	0	0		0
Finance field inventory	EUR/ha	12	12	8	8	9	11		9
Total direct cost	**EUR/ha**	**798**	**795**	**557**	**571**	**576**	**761**	**0**	**630**
Gross margin[1)]	**EUR/ha**	**1,510**	**1,040**	**1,313**	**1,170**	**1,122**	**1,014**	**0**	**1,171**
Labour	EUR/ha	244	244	150	191	143	133	17	164
Contractor	EUR/ha	230	230	108	10	5	18		55
Machinery	EUR/ha	91	91	92	151	119	124	6	120
Diesel	EUR/ha	74	74	88	147	102	110	17	111
Other	EUR/ha	8	6	6	6	6	6		6
Total operating cost	**EUR/ha**	**648**	**646**	**444**	**506**	**375**	**392**	**39**	**456**
Operating profit[2)]	**EUR/ha**	**863**	**394**	**869**	**664**	**747**	**622**	**-39**	**715**
Building cost	EUR/ha	48	38	39	36	35	37		38
Total land cost	EUR/ha	346	346	346	346	346	346	345	346
Decoupled payments	EUR/ha	331	331	331	331	331	331	331	331
Net land cost[3)]	EUR/ha	15	15	15	15	15	15	14	15
Miscellaneous cost	EUR/ha	126	100	102	95	93	97		99
Total cost	**EUR/ha**	**1,636**	**1,595**	**1,158**	**1,224**	**1,095**	**1,303**	**53**	**1,237**
Profit[4)]	**EUR/ha**	**673**	**240**	**712**	**518**	**604**	**473**	**-53**	**563**

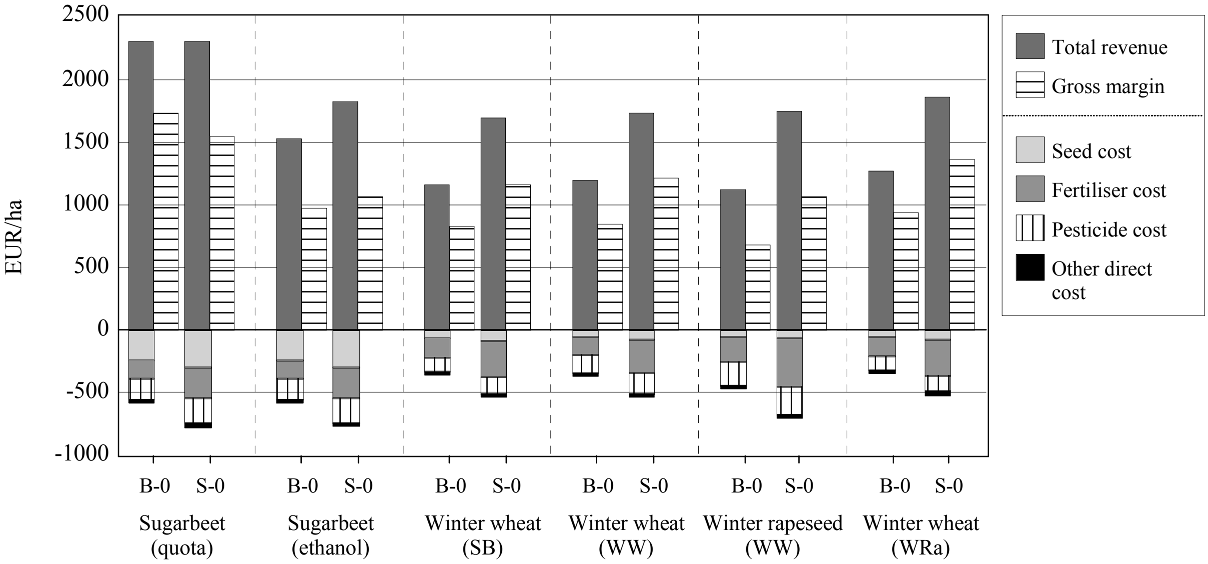
1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A19: Profitability of single crops and farm average DE 1300MB (Scenario S-2) -

Crop		Sugar beet (quota)	Sugar beet (ethanol)	Winter wheat	Winter wheat	Winter wheat	Winter rapeseed	Set aside	Farm average
Previous Crop		WW	WW	WRa	WW	SB	WW		
Acreage	ha	81	19	325	387	100	325	13	1,250
Crop yield	t/ha	62	62	9.0	8.4	8.2	4.2		
Output price	EUR/t	39	31	215	215	215	433		
Market revenue	**EUR/ha**	**2,399**	**1,907**	**1,935**	**1,806**	**1,763**	**1,819**	**0**	**1,861**
Seed	EUR/ha	283	283	67	69	81	61		84
Nitrogen (N)	EUR/ha	133	133	223	227	226	296		234
Phosphorus (P)	EUR/ha	26	26	51	26	46	46		39
Potassium (K)	EUR/ha	79	79	16	16	25	0		17
Other	EUR/ha	8	8	15	11	15	57		24
Fertilizer (total)	EUR/ha	246	246	305	280	312	399		314
Herbicides	EUR/ha	190	190	70	83	82	129		99
Fungicides	EUR/ha	47	47	62	90	62	110		81
Insecticides	EUR/ha	0	0	8	8	8	34		14
Other	EUR/ha	6	6	14	14	4	1		9
Pesticides (total)	EUR/ha	244	244	154	194	156	274		203
Crop establishment cost	**EUR/ha**	**773**	**773**	**526**	**542**	**548**	**735**	**0**	**601**
Dry energy cost	EUR/ha	0	0	14	13	12	3		9
Crop insurance (hail)	EUR/ha	14	11	9	8	7	12		10
Other	EUR/ha	0	0	0	0	0	0		0
Finance field inventory	EUR/ha	12	12	8	8	9	11		9
Total direct cost	**EUR/ha**	**798**	**795**	**557**	**571**	**576**	**761**	**0**	**630**
Gross margin[1)]	**EUR/ha**	**1,600**	**1,111**	**1,378**	**1,235**	**1,187**	**1,057**	**0**	**1,231**
Labour	EUR/ha	244	244	150	191	143	133	17	164
Contractor	EUR/ha	230	230	108	10	5	18		55
Machinery	EUR/ha	101	101	106	167	135	136	6	134
Diesel	EUR/ha	74	74	88	147	102	110	17	111
Other	EUR/ha	8	6	6	6	6	6		6
Total operating cost	**EUR/ha**	**658**	**656**	**459**	**522**	**391**	**403**	**40**	**470**
Operating profit[2)]	**EUR/ha**	**943**	**455**	**919**	**712**	**796**	**654**	**-40**	**761**
Building cost	EUR/ha	48	38	39	36	36	37		38
Total land cost	EUR/ha	346	346	346	346	346	346	345	346
Decoupled payments	EUR/ha	331	331	331	331	331	331	331	331
Net land cost[3)]	EUR/ha	15	15	15	15	15	15	14	15
Miscellaneous cost	EUR/ha	127	101	103	96	93	96		99
Total cost	**EUR/ha**	**1,647**	**1,606**	**1,173**	**1,241**	**1,111**	**1,313**	**54**	**1,251**
Profit[4)]	**EUR/ha**	**752**	**301**	**762**	**565**	**652**	**506**	**-54**	**610**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Figure A12: Comparison of total revenue, direct cost structure and gross margin (€/ha) of major crops on DE 1300MB, reference scenario (B-0) vs. high price scenario



Gross margin response	-11 %	+11 %	+43 %	+45 %	+58 %	+44 %

Source: Own calculation.

Table A20: Gross margin calculation of straw sales DE 1300MB under high price conditions

Assumptions:	Straw yield:	**4.9**	**t/ha**	60 % of Winter wheat yield (8,2 t/ha)
	Acreage:	**250**	**ha/a**	30 % of Winter wheat acreage (840 ha)

Nutrient		N	P	K	Mg	Total
Content	kg/dt fm[1)]	0.50	0.13	1.17	0.12	
Value (free root)	EUR/kg	1.35	3.00	1.10	2.09	
Removal	kg/t	5.00	1.31	11.70	1.21	
per t straw	EUR/t	6.75	3.93	12.87	2.53	26
Removal	kg/ha	24.50	6.42	57.33	5.93	
per ha	EUR/ha	33.08	19.26	63.06	12.39	128

2. Gross margin calculation

	Per tonne (straw) EUR/t	Per hectare (harvested) EUR/ha	Per hectare (average) EUR/ha
Return	60	294	64
Direct cost			
Nutrient value	26	128	28
Lost benefit[2)]	10	49	11
Cost saving harvest	-4	-20	-4
Cost saving tillage	-2	-10	-2
Management and insurance	3	15	3
Total direct cost	33	162	35
Gross margin	27	132	29

Notes: 1) Fresh mass.
2) Improvement of soil structure, avoidance of additional on field operations and soil compaction, evaporation protection.

Source: Feiffer (2006); Hülsbergen et al. (1997); Schilling (2000); Zimmer & Nehring (2007); own calculation.

Figure A13: Production system of barley on AU 4500SC and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	mid 01	Spraying	Total herbicide	6	4
2	mid 04	Spraying	Total herbicide	3	4
3	end 04	Spraying	Total herbicide	9	4
4	beg 05	Seeding NO-TILL	Airseeder (discs) + FlexiN (mineral) N22 + fungicide	35	26
		Fertilizer	+ DAP (mineral) N10 P15	27	
5	end 05	Plant protection	Selective herbicide	9	4
6	end 08	Fertilizer	Urea (mineral) N28	19	8
7	mid 09	Plant protection	Fungicide	6	4
8	mid 11	Harvest	Combine harvest		29
9	mid 11	Transport	On field transport (chaser bin)		8
10	mid 11	Transport	On road transport (truck)		8
			Total -	115	82

Summary				
Crop		Barley (following wheat)		
Tillage		No-Till seeding		
Seed	kg/ha	75	10	EUR/ha
Fertilisation	Nutrient kg/ha	N60 P15 K0 CaO0 Mg0 S0	65	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (2), insecticide (0), other (0)	39	EUR/ha
Yield	t/ha	3.0		

Source: Own calculation.

Figure A14: Production system of lupins on AU 4500SC and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	mid 01	Spraying	Total herbicide	6	4
2	mid 04	Spraying	Total herbicide	6	4
3	end 04	Spraying	Total herbicide	9	4
4	beg 05	Seeding NO-TILL	Airseeder (discs) + DAP (mineral) N6 P10	36	26
5	end 05	Plant protection	Selective herbicide	9	4
6	mid 09	Plant protection	Insecticide	7	4
7	mid 11	Harvest	Combine harvest		29
8	mid 11	Transport	On field transport (chaser bin)		8
9	mid 11	Transport	On road transport (truck)		8
			Total	73	89

Summary				
Crop		Lupins (following barley)		
Tillage		No-Till seeding		
Seed	kg/ha	110	19	EUR/ha
Fertilisation	Nutrient kg/ha	N6 P10 K0 CaO0 Mg0 S0	17	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (0), insecticide (1), other (0)	37	EUR/ha
Yield	t/ha	1.6		

Source: Own calculation.

Table A21: Profitability of single crops and farm average AU 4500SC (2005) -

Crop		Canola	Wheat	Barley (malt)	Barley (feed)	Lupins	Farm average
Previous Crop		Barley	Ca/Lu	Wheat	Wheat	Barley	
Acreage	ha	1,000	1400	700	700	400	
Crop yield	t/ha	2.1	3.3	3.0	3.0	1.8	
Output price	EUR/t	193	110	110	98	134	
Market revenue	**EUR/ha**	**396**	**364**	**333**	**296**	**242**	**344**
Seed	EUR/ha	2	14	10	10	19	10
Nitrogen (N)	EUR/ha	40	33	33	33	3	32
Phosphorus (P)	EUR/ha	21	17	17	17	11	17
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	1	0	0	0	0	0
Fertilizer (total)	EUR/ha	62	50	50	50	14	49
Herbicides	EUR/ha	24	27	27	27	30	27
Fungicides	EUR/ha	6	9	12	12	0	9
Insecticides	EUR/ha	9	0	0	0	7	3
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	39	36	39	39	37	38
Crop establishment cost	**EUR/ha**	**102**	**99**	**99**	**99**	**70**	**97**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	4	3	4	2	2	3
Other	EUR/ha	10	10	10	10	10	10
Finance field inventory	EUR/ha	3	3	3	3	2	3
Total direct cost	**EUR/ha**	**119**	**116**	**116**	**114**	**84**	**113**
Gross margin[1)]	**EUR/ha**	**277**	**249**	**218**	**182**	**158**	**231**
Labour	EUR/ha	28	26	26	26	24	26
Contractor	EUR/ha	3	2	2	2	2	2
Machinery	EUR/ha	93	79	79	79	73	82
Diesel	EUR/ha	15	13	13	13	12	14
Other	EUR/ha	3	2	2	2	2	2
Total operating cost	**EUR/ha**	**141**	**123**	**123**	**123**	**113**	**126**
Operating profit[2)]	**EUR/ha**	**136**	**125**	**95**	**59**	**45**	**104**
Building cost	EUR/ha	8	8	7	6	5	7
Total land cost	EUR/ha	60	60	60	60	60	60
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	60	60	60	60	60	60
Miscellaneous cost	EUR/ha	11	11	10	9	7	10
Total cost	**EUR/ha**	**340**	**317**	**316**	**312**	**269**	**317**
Profit[4)]	**EUR/ha**	**56**	**47**	**18**	**-16**	**-27**	**27**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A22: Profitability of single crops and farm average AU 4500SC (2006) -

Crop		Canola	Wheat	Barley (malt)	Barley (feed)	Lupins	Farm average
Previous Crop		Barley	Ca/Lu	Wheat	Wheat	Barley	
Acreage	ha	1,000	1,400	700	700	400	4,200
Crop yield	t/ha	1.7	2.3	2.4	2.4	1.4	
Output price	EUR/t	266	125	150	132	179	
Market revenue	**EUR/ha**	**441**	**281**	**360**	**317**	**251**	**336**
Seed	EUR/ha	2	13	10	10	18	10
Nitrogen (N)	EUR/ha	42	35	35	35	4	34
Phosphorus (P)	EUR/ha	22	17	17	17	11	17
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	1	0	0	0	0	0
Fertilizer (total)	EUR/ha	64	52	52	52	14	51
Herbicides	EUR/ha	23	26	26	26	29	26
Fungicides	EUR/ha	6	9	12	12	0	8
Insecticides	EUR/ha	8	0	0	0	7	3
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	38	35	38	38	36	37
Crop establishment cost	**EUR/ha**	**104**	**101**	**100**	**100**	**69**	**98**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	4	3	4	2	2	3
Other	EUR/ha	10	10	10	10	10	10
Finance field inventory	EUR/ha	3	3	3	3	2	3
Total direct cost	**EUR/ha**	**121**	**117**	**117**	**115**	**83**	**114**
Gross margin[1)]	**EUR/ha**	**321**	**164**	**244**	**202**	**169**	**221**
Labour	EUR/ha	27	26	26	26	23	26
Contractor	EUR/ha	3	2	2	2	2	2
Machinery	EUR/ha	92	77	77	77	71	80
Diesel	EUR/ha	15	14	14	14	13	14
Other	EUR/ha	3	2	2	2	2	2
Total operating cost	**EUR/ha**	**139**	**121**	**121**	**121**	**111**	**124**
Operating profit[2)]	**EUR/ha**	**182**	**44**	**122**	**81**	**58**	**97**
Building cost	EUR/ha	9	6	8	7	5	7
Total land cost	EUR/ha	59	59	59	59	59	59
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	59	59	59	59	59	59
Miscellaneous cost	EUR/ha	13	8	10	9	7	10
Total cost	**EUR/ha**	**341**	**310**	**315**	**311**	**265**	**314**
Profit[4)]	**EUR/ha**	**101**	**-29**	**45**	**6**	**-14**	**21**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A23: Profitability of single crops and farm average AU 4500SC (2007) -

Crop		Canola	Wheat	Barley (malt)	Barley (feed)	Lupins	Farm average
Previous Crop		Barley	Ca/Lu	Wheat	Wheat	Barley	
Acreage	ha	1,000	1,400	700	700	400	4,200
Crop yield	t/ha	1.9	2.9	3.5	3.5	1.9	
Output price	EUR/t	332	236	238	207	180	
Market revenue	**EUR/ha**	**640**	**693**	**831**	**724**	**342**	**675**
Seed	EUR/ha	2	14	10	10	19	10
Nitrogen (N)	EUR/ha	44	37	37	37	4	35
Phosphorus (P)	EUR/ha	22	17	17	17	11	18
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	1	0	0	0	0	0
Fertilizer (total)	EUR/ha	67	54	54	54	15	53
Herbicides	EUR/ha	24	27	27	27	30	26
Fungicides	EUR/ha	6	9	12	12	0	9
Insecticides	EUR/ha	9	0	0	0	7	3
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	39	36	39	39	37	38
Crop establishment cost	**EUR/ha**	**107**	**104**	**103**	**103**	**70**	**101**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	4	3	4	2	2	3
Other	EUR/ha	10	10	10	10	10	10
Finance field inventory	EUR/ha	4	3	3	3	2	3
Total direct cost	**EUR/ha**	**124**	**120**	**120**	**119**	**84**	**117**
Gross margin[1)]	**EUR/ha**	**516**	**573**	**711**	**605**	**258**	**558**
Labour	EUR/ha	28	26	26	26	24	26
Contractor	EUR/ha	3	2	2	2	2	2
Machinery	EUR/ha	95	80	80	80	74	83
Diesel	EUR/ha	19	17	17	17	16	17
Other	EUR/ha	2	2	3	2	1	2
Total operating cost	**EUR/ha**	**146**	**128**	**128**	**128**	**117**	**131**
Operating profit[2)]	**EUR/ha**	**371**	**445**	**583**	**477**	**141**	**427**
Building cost	EUR/ha	7	8	9	8	4	7
Total land cost	EUR/ha	60	60	60	60	60	60
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	60	60	60	60	60	60
Miscellaneous cost	EUR/ha	9	10	12	11	5	10
Total cost	**EUR/ha**	**346**	**326**	**330**	**325**	**270**	**326**
Profit[4)]	**EUR/ha**	**294**	**367**	**502**	**399**	**72**	**349**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A24: Profitability of single crops and farm average AU 4500SC (2008) -

Crop		Canola	Wheat	Barley (malt)	Barley (feed)	Lupins	Farm average
Previous Crop		Barley	Ca/Lu	Wheat	Wheat	Barley	
Acreage	ha	1,000	1,400	700	700	400	4,200
Crop yield	t/ha	1.7	2.7	2.9	2.9	1.1	
Output price	EUR/t	326	152	146	129	166	
Market revenue	**EUR/ha**	**561**	**410**	**424**	**373**	**188**	**421**
Seed	EUR/ha	2	13	10	10	18	10
Nitrogen (N)	EUR/ha	53	44	44	44	4	42
Phosphorus (P)	EUR/ha	20	15	15	15	10	16
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	1	0	0	0	0	0
Fertilizer (total)	EUR/ha	73	59	59	59	14	58
Herbicides	EUR/ha	23	25	25	25	28	25
Fungicides	EUR/ha	6	9	12	12	0	8
Insecticides	EUR/ha	8	0	0	0	6	3
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	36	34	37	37	35	36
Crop establishment cost	**EUR/ha**	**111**	**106**	**106**	**106**	**67**	**104**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	3	3	3	2	2	3
Other	EUR/ha	9	9	9	9	9	9
Finance field inventory	EUR/ha	4	3	3	3	2	3
Total direct cost	**EUR/ha**	**127**	**122**	**122**	**121**	**80**	**119**
Gross margin 1)	**EUR/ha**	**434**	**288**	**302**	**253**	**108**	**302**
Labour	EUR/ha	26	25	25	25	23	25
Contractor	EUR/ha	2	2	2	2	2	2
Machinery	EUR/ha	92	75	75	75	69	78
Diesel	EUR/ha	24	21	21	21	20	22
Other	EUR/ha	3	2	2	2	1	2
Total operating cost	**EUR/ha**	**147**	**125**	**125**	**125**	**114**	**129**
Operating profit 2)	**EUR/ha**	**287**	**163**	**176**	**128**	**-6**	**173**
Building cost	EUR/ha	9	7	7	6	3	7
Total land cost	EUR/ha	57	57	57	57	57	57
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost 3)	EUR/ha	57	57	57	57	57	57
Miscellaneous cost	EUR/ha	12	9	9	8	4	9
Total cost	**EUR/ha**	**352**	**320**	**320**	**317**	**258**	**321**
Profit 4)	**EUR/ha**	**209**	**90**	**103**	**57**	**-70**	**100**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A25: Profitability of single crops and farm average AU 4500SC (2009) -

Crop		Canola	Wheat	Barley (malt)	Barley (feed)	Lupins	Farm average
Previous Crop		Barley	Ca/Lu	Wheat	Wheat	Barley	
Acreage	ha	1,000	1,400	700	700	400	4,200
Crop yield	t/ha	1.7	2.1	3.2	3.2	1.7	
Output price	EUR/t	235	119	116	79	142	
Market revenue	**EUR/ha**	**388**	**250**	**370**	**254**	**234**	**302**
Seed	EUR/ha	2	13	9	9	17	9
Nitrogen (N)	EUR/ha	67	56	56	56	6	53
Phosphorus (P)	EUR/ha	42	33	33	33	21	34
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	1	0	0	0	0	0
Fertilizer (total)	EUR/ha	110	89	89	89	27	88
Herbicides	EUR/ha	22	25	25	25	28	25
Fungicides	EUR/ha	6	8	11	11	0	8
Insecticides	EUR/ha	8	0	0	0	6	2
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	36	33	36	36	34	35
Crop establishment cost	**EUR/ha**	**147**	**135**	**134**	**134**	**78**	**132**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	3	3	3	2	2	3
Other	EUR/ha	9	9	9	9	9	9
Finance field inventory	EUR/ha	5	4	4	4	3	4
Total direct cost	**EUR/ha**	**164**	**151**	**151**	**150**	**91**	**148**
Gross margin[1)]	**EUR/ha**	**224**	**99**	**219**	**104**	**142**	**154**
Labour	EUR/ha	26	24	24	24	22	24
Contractor	EUR/ha	2	2	2	2	2	2
Machinery	EUR/ha	91	78	78	78	71	80
Diesel	EUR/ha	17	15	15	15	14	15
Other	EUR/ha	3	2	2	2	2	2
Total operating cost	**EUR/ha**	**138**	**121**	**121**	**121**	**111**	**124**
Operating profit[2)]	**EUR/ha**	**86**	**-22**	**97**	**-17**	**32**	**30**
Building cost	EUR/ha	9	6	8	6	5	7
Total land cost	EUR/ha	56	56	56	56	56	56
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	56	56	56	56	56	56
Miscellaneous cost	EUR/ha	12	8	11	8	7	9
Total cost	**EUR/ha**	**378**	**340**	**347**	**339**	**270**	**344**
Profit[4)]	**EUR/ha**	**10**	**-90**	**22**	**-86**	**-36**	**-42**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A26: Profitability of single crops and farm average AU 4500SC (Scenario S-0) -

Crop		Canola	Wheat	Barley (malt)	Barley (feed)	Lupins	Farm average
Previous Crop		Barley	Canola	Wheat	Wheat	Barley	
Acreage	ha	1,000	1,400	700	700	400	4,200
Crop yield	t/ha	1.8	2.7	3.0	3.0	1.6	
Output price	EUR/t	419	202	206	178	194	
Market revenue	**EUR/ha**	**755**	**537**	**619**	**534**	**307**	**580**
Seed	EUR/ha	2	20	18	18	24	15
Nitrogen (N)	EUR/ha	81	69	69	69	7	66
Phosphorus (P)	EUR/ha	49	38	38	38	24	39
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	1	0	0	0	0	0
Fertilizer (total)	EUR/ha	130	107	107	107	31	105
Herbicides	EUR/ha	29	32	32	32	36	32
Fungicides	EUR/ha	7	11	15	15	0	10
Insecticides	EUR/ha	10	0	0	0	8	3
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	46	43	47	47	44	45
Crop establishment cost	**EUR/ha**	**179**	**170**	**172**	**172**	**98**	**166**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	4	3	4	2	2	3
Other	EUR/ha	10	10	10	10	10	10
Finance field inventory	EUR/ha	6	5	5	5	3	5
Total direct cost	**EUR/ha**	**198**	**188**	**191**	**190**	**113**	**184**
Gross margin[1)]	**EUR/ha**	**557**	**349**	**427**	**344**	**193**	**396**
Labour	EUR/ha	28	26	26	26	24	26
Contractor	EUR/ha	3	2	2	2	2	2
Machinery	EUR/ha	88	72	72	72	66	75
Diesel	EUR/ha	29	26	26	26	24	27
Other	EUR/ha	3	2	2	2	1	2
Total operating cost	**EUR/ha**	**150**	**129**	**130**	**129**	**118**	**133**
Operating profit[2)]	**EUR/ha**	**406**	**220**	**298**	**215**	**75**	**263**
Building cost	EUR/ha	9	6	7	6	3	7
Total land cost	EUR/ha	60	60	60	60	60	60
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	60	60	60	60	60	60
Miscellaneous cost	EUR/ha	13	9	11	9	5	10
Total cost	**EUR/ha**	**430**	**393**	**399**	**395**	**300**	**394**
Profit[4)]	**EUR/ha**	**325**	**144**	**220**	**140**	**7**	**186**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A27: Profitability of single crops and farm average AU 4500SC (Scenario S-1) -

Crop		Canola (hybrid)	Canola (GM)	Canola	Barley (malt)	Wheat	Barley (feed)	Lupins	Farm average
Previous Crop		Barley	Barley	Barley	Wheat	Ca/Lu	Wheat	Barley	
Acreage	ha	400	100	600	700	1,400	700	300	4,200
Crop yield	t/ha	2.1	2.1	1.9	3.3	3.0	3.3	1.6	
Output price	EUR/t	419	404	419	206	202	178	194	
Market revenue	**EUR/ha**	**881**	**848**	**797**	**670**	**596**	**579**	**310**	**647**
Seed	EUR/ha	51	59	2	18	20	18	24	21
Nitrogen (N)	EUR/ha	81	81	81	76	76	76	7	73
Phosphorus (P)	EUR/ha	49	49	49	38	38	38	24	40
Potassium (K)	EUR/ha	0	0	0	0	0	0	0	0
Other	EUR/ha	1	1	1	0	0	0	0	0
Fertilizer (total)	EUR/ha	130	130	130	115	115	115	31	113
Herbicides	EUR/ha	45	26	45	35	35	35	39	37
Fungicides	EUR/ha	7	7	7	17	13	17	0	12
Insecticides	EUR/ha	10	10	10	0	0	0	8	3
Other	EUR/ha	0	0	0	0	0	0	0	0
Pesticides (total)	EUR/ha	63	43	63	52	48	52	47	53
Crop establishment cost	**EUR/ha**	**245**	**232**	**196**	**185**	**183**	**185**	**101**	**187**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	5	5	4	4	3	2	2	3
Other	EUR/ha	0	0	0	0	0	0	0	0
Finance field inventory	EUR/ha	7	7	6	6	5	6	3	6
Total direct cost	**EUR/ha**	**257**	**244**	**205**	**194**	**191**	**193**	**106**	**195**
Gross margin[1)]	**EUR/ha**	**624**	**604**	**592**	**476**	**405**	**386**	**205**	**452**
Labour	EUR/ha	29	28	29	25	25	25	24	26
Contractor	EUR/ha	5	5	5	5	5	5	0	5
Machinery	EUR/ha	92	90	92	66	66	66	66	73
Diesel	EUR/ha	25	24	25	21	21	21	20	22
Other	EUR/ha	3	3	3	2	2	2	1	2
Total operating cost	**EUR/ha**	**154**	**150**	**154**	**119**	**119**	**119**	**111**	**127**
Operating profit[2)]	**EUR/ha**	**469**	**454**	**438**	**357**	**286**	**267**	**93**	**324**
Building cost	EUR/ha	10	10	9	8	7	7	4	7
Total land cost	EUR/ha	63	63	63	63	62	62	61	63
Decoupled payments	EUR/ha	0	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	63	63	63	63	62	62	61	63
Miscellaneous cost	EUR/ha	14	13	13	11	9	9	5	10
Total cost	**EUR/ha**	**499**	**480**	**444**	**394**	**388**	**389**	**287**	**403**
Profit[4)]	**EUR/ha**	**382**	**368**	**353**	**277**	**208**	**189**	**24**	**244**

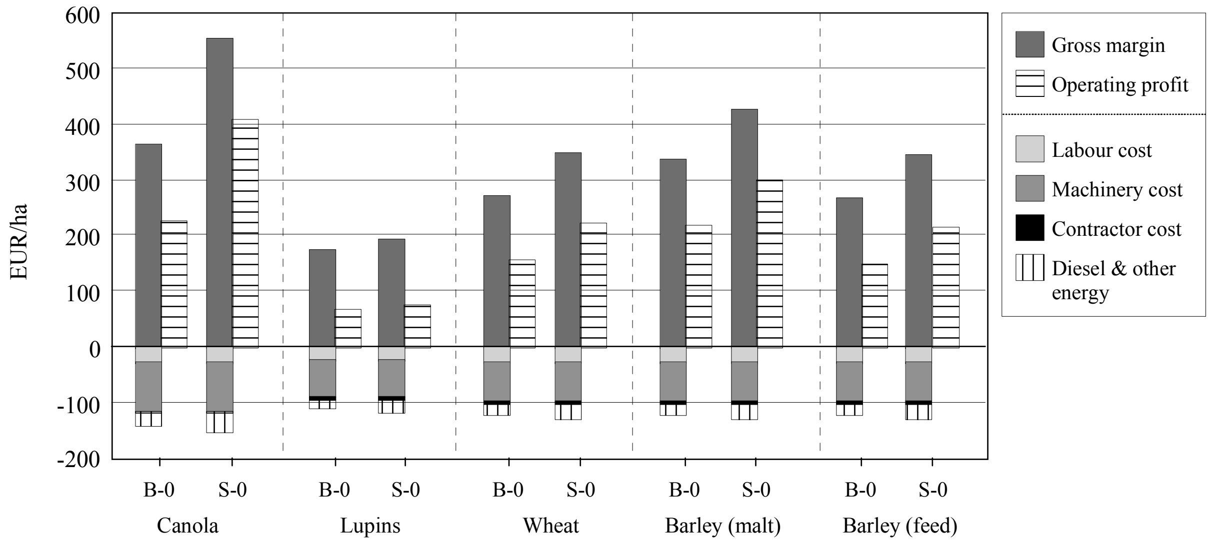
1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A28: Profitability of single crops and farm average AU 4500SC (Scenario S-2) -

Crop		Canola (hybrid)	Canola (GM)	Canola	Barley (malt)	Wheat	Barley (feed)	Lupins	Farm average
Previous Crop		Barley (feed)	Barley (feed)	Barley	Wheat	Canola/ Lupins	Wheat	Barley	
Acreage	ha	400	100	500	700	1,400	700	400	4,200
Crop yield	t/ha	2.2	2.2	2.0	3.3	3.0	3.3	1.6	
Output price	EUR/t	419	404	419	206	202	178	194	
Market revenue	**EUR/ha**	**901**	**869**	**818**	**681**	**606**	**588**	**310**	**647**
Seed	EUR/ha	51	59	2	18	20	18	24	21
Nitrogen (N)	EUR/ha	76	76	76	72	72	72	5	66
Phosphorus (P)	EUR/ha	31	31	31	21	21	21	17	23
Potassium (K)	EUR/ha	0	0	0	0	0	0	0	0
Other	EUR/ha	1	1	1	0	0	0	0	0
Fertilizer (total)	EUR/ha	108	108	108	93	93	93	22	90
Herbicides	EUR/ha	45	26	45	35	35	35	39	37
Fungicides	EUR/ha	7	7	7	17	13	17	0	12
Insecticides	EUR/ha	10	10	10	0	0	0	8	3
Other	EUR/ha	0	0	0	0	0	0	0	0
Pesticides (total)	EUR/ha	63	43	63	52	48	52	47	52
Crop establishment cost	**EUR/ha**	**223**	**210**	**174**	**163**	**161**	**163**	**92**	**163**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	5	5	4	4	3	2	2	3
Other	EUR/ha	0	0	0	0	0	0	0	0
Finance field inventory	EUR/ha	7	6	5	5	5	5	3	5
Total direct cost	**EUR/ha**	**234**	**222**	**182**	**172**	**168**	**170**	**97**	**172**
Gross margin[1)]	**EUR/ha**	**667**	**647**	**635**	**509**	**438**	**418**	**214**	**475**
Labour	EUR/ha	31	29	31	26	26	26	25	27
Contractor	EUR/ha	5	5	5	5	5	5	0	4
Machinery	EUR/ha	101	99	101	73	73	73	72	79
Diesel	EUR/ha	27	26	27	22	22	22	22	23
Other	EUR/ha	3	3	3	2	2	2	1	2
Total operating cost	**EUR/ha**	**166**	**161**	**166**	**128**	**128**	**128**	**120**	**136**
Operating profit[2)]	**EUR/ha**	**501**	**486**	**469**	**381**	**310**	**290**	**93**	**339**
Building cost	EUR/ha	11	11	10	9	8	7	4	8
Total land cost	EUR/ha	68	67	67	66	65	65	63	66
Decoupled payments	EUR/ha	0	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	68	67	67	66	65	65	63	66
Miscellaneous cost	EUR/ha	16	16	15	12	11	11	6	12
Total cost	**EUR/ha**	**496**	**477**	**440**	**387**	**380**	**381**	**289**	**393**
Profit[4)]	**EUR/ha**	**406**	**392**	**377**	**294**	**226**	**206**	**21**	**254**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Figure A15: Comparison of gross margin, operating cost structure and operating profit (€/ha) of major crops on AU 4500SC, reference scenario (B-0) vs. high price scenario (S-0)



Operating profit response	+80 %	+16 %	+43 %	+38 %	+47 %

Source: Own calculation.

Figure A16: Production system of lupins on AU 4000WB and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	beg 04	Spraying	Total herbicide	5	4
2	mid 04	Spraying	Total herbicide	9	4
3	mid 04	Seeding NO-TILL	Airseeder (tines) + TSP (mineral) P8	28	21
4	end 04	Spraying	Selective herbicide	7	4
5	mid 07	Spraying	Selective herbicide + insecticide	8	4
6	beg 11	Harvest	Combine harvest		13
7	beg 11	Transport	On field transport (chaser bin)		7
8	beg 11	Transport	On road transport (truck)		7
			Total	57	64

Summary				
Crop		Lupins (following wheat/barley/oaten hay)		
Tillage		No-Till seeding		
Seed	kg/ha	90	13	EUR/ha
Fertilisation	Nutrient kg/ha	N0 P8 K0 CaO0 Mg0 S0	15	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (0), insecticide (1), other (0)	29	EUR/ha
Yield	t/ha	1.04		

Source: Own calculation.

Figure A17: Production system of peas on AU 4000WB and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	beg 06	Spraying	Total herbicide	9	4
2	beg 06	Seeding NO-TILL	Airseeder (tines) + TSP (mineral) P8	30	21
3	mid 06	Spraying	Selective herbicide	6	4
4	mid 07	Spraying	Selective herbicide	9	4
5	mid 09	Spraying	Insecticide	6	4
6	end 10	Spraying	Optional herbicide	4	4
7	mid 11	Harvest	On field transport (chaser bin)		13
8	mid 11	Transport	On road transport (truck)		7
			Total	64	61

Summary				
Crop		Peas (following wheat/barley/oaten hay)		
Tillage		No-Till seeding		
Seed	kg/ha	100	15	EUR/ha
Fertilisation	Nutrient kg/ha	N0 P8 K0 CaO0 Mg0 S0	15	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (0), insecticide (1), other (0)	34	EUR/ha
Yield	t/ha	0.76		

Source: Own calculation.

Figure A18: Production system of barley on AU 4000WB and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	beg 04	Spraying	Total herbicide	6	5
2	mid 05	Spraying	Total herbicide	9	4
3	mid 05	Seeding NO-TILL	Airseeder (tines) + DAP (mineral) N8 P13	28	21
4	mid 05	Spraying	Selective herbicide	6	4
5	mid 07	Fertilizer	Urea (mineral) N19	14	4
6	end 07	Spraying	Selective herbicide + fungicide	12	4
7	mid 11	Harvest	Combine harvest		13
8	mid 11	Transport	On field transport (chaser bin)		7
9	mid 11	Transport	On road transport (truck)		7
			Total	75	69

Summary				
Crop		Barley (following wheat)		
Tillage		No-Till seeding		
Seed	kg/ha	55	9	EUR/ha
Fertilisation	Nutrient kg/ha	N27 P9 K0 CaO0 Mg0 S0	32	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (1), insecticide (0), other (0)	34	EUR/ha
Yield	t/ha	2.11		

Source: Own calculation.

Figure A19: Production system of oaten hay on AU 4000WB and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	end 02	Spreading	Lime on light land CaO1		7
2	beg 04	Spraying	Total herbicide	6	4
3	mid 05	Spraying	Total herbicide	21	4
4	mid 05	Seeding NO-TILL	Airseeder (tines) + DAP (mineral) N8 P13	37	21
		Fertilizer	+ Urea (mineral) N14	10	
5	mid 07	Fertilizer	Urea (mineral) N14	20	
		Fertilizer	+ MoP (mineral) K20	10	4
6	end 07	Spraying	Selective herbicide	9	4
7	end 10	Harvest	Cutting, baling and stapling (contractor)		86
8	end 10	Transport	Loading and on-road transport (contractor)		55
			Total	114	185

Summary				
Crop		Oaten hay (following wheat)		
Tillage		No-Till seeding		
Seed	kg/ha	120	18	EUR/ha
Fertilisation	Nutrient kg/ha	N36 P9 K20 CaO1 Mg0 S0	60	EUR/ha
Chemicals	Applications	Herbicide (3), fungicide (0), insecticide (0), other (0)	37	EUR/ha
Yield	t/ha	3.82		

Source: Own calculation.

Figure A20: Performance, pricing and market revenues of Merino x Dorper first cross lamb operation (Average 2005–2009)

Management	6	weeks lambing period from May to June		
	6	months grazing period until 18-20 kg typical carcase weight		
	100	% clearance of lamb mob		
Weight gain	4.5	kg birth weight		
	0.25	kg live weight gain per day		
	140	days average age		
	39.5	kg live weight at end of grazing period		
Marketing of first cross lambs	49	% dressing percentage	2.42	€/kg carcase weight
	19.36	kg dressing weight	3.06	€/skin
		Market revenue:	**49.90**	**€/lamb**
	Quality		Shearing in Jan/Feb	
Wool production of Merinos	21	Micron	6.2	kg greasy fleece weight
	5.07	€/kg	68	% yield (clean wool)
	88	% Clip basis		
	5.76	€/kg clean wool fleece	4.22	kg clean fleece per head
		Market revenue:	**24.29**	**€/head**

Source: NSW National livestock reporting service data.

Table A29: Profitability of single crops and farm average AU 4000WB (2005) -

Crop		Barley (malt)	Oaten hay	Pasture	Wheat	Wheat	Barley (feed)	Canola	Lupins	Peas	Farm average
Previous Crop		Wheat	Wheat	Sheep	Pa	Pe/Lu/Ca	Wheat	Barley	Barley	Barley	
Acreage	ha	330	100	300	100	1,500	530	330	260	150	3,600
Crop yield	t/ha	2.4	4.1		1.5	1.5	2.4	0.8	0.1	0.1	
Output price	EUR/t	110	101		156	110	92	196	123	135	
Market revenue	**EUR/ha**	**259**	**412**	**169**	**234**	**166**	**216**	**157**	**12**	**13**	**172**
Seed	EUR/ha	9	18	0	9	9	9	1	13	15	9
Nitrogen (N)	EUR/ha	15	21	2	21	21	15	24	0	0	16
Phosphorus (P)	EUR/ha	10	10	3	10	10	10	11	12	12	10
Potassium (K)	EUR/ha	0	17	0	17	17	0	0	0	0	8
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	26	49	5	49	49	26	35	12	12	34
Herbicides	EUR/ha	28	37	6	37	37	28	37	28	28	31
Fungicides	EUR/ha	6	0	0	0	0	6	0	0	0	1
Insecticides	EUR/ha	0	0	0	0	0	0	3	1	6	1
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Pesticides (total)	EUR/ha	34	37	6	37	37	34	41	29	34	33
Crop establishment cost	**EUR/ha**	**69**	**104**	**11**	**95**	**95**	**69**	**77**	**54**	**61**	**76**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	2	1	0	2	2	2	2	1	1	2
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Finance field inventory	EUR/ha	2	4	0	3	3	2	3	2	2	3
Total direct cost	**EUR/ha**	**74**	**109**	**11**	**101**	**101**	**74**	**82**	**57**	**64**	**81**
Gross margin[1)]	**EUR/ha**	**186**	**303**	**157**	**133**	**65**	**143**	**75**	**-45**	**-51**	**92**
Labour	EUR/ha	29	11	48	26	26	29	31	28	31	29
Contractor	EUR/ha	4	152	9	11	11	4	4	0	0	11
Machinery	EUR/ha	44	25	18	42	42	44	47	44	47	41
Diesel	EUR/ha	9	4	3	9	9	9	10	9	10	9
Other	EUR/ha	2	4	1	2	1	2	1	0	0	2
Total operating cost	**EUR/ha**	**89**	**196**	**79**	**90**	**89**	**89**	**93**	**82**	**88**	**91**
Operating profit[2)]	**EUR/ha**	**97**	**107**	**78**	**43**	**-24**	**54**	**-18**	**-127**	**-138**	**1**
Building cost	EUR/ha	9	15	6	9	6	8	6	0	0	6
Total land cost	EUR/ha	61	62	61	61	61	61	60	60	60	61
Decoupled payments	EUR/ha	0	0	0	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	61	62	61	61	61	61	60	60	60	61
Miscellaneous cost	EUR/ha	21	33	13	18	13	17	12	1	1	14
Total cost	**EUR/ha**	**254**	**414**	**171**	**278**	**269**	**248**	**254**	**200**	**213**	**252**
Profit[4)]	**EUR/ha**	**6**	**-2**	**-2**	**-44**	**-104**	**-32**	**-97**	**-188**	**-200**	**-80**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A30: Profitability of single crops and farm average AU 4000WB (2006) -

Crop		Oaten hay	Pasture	Wheat	Wheat	Barley (feed)	Canola	Lupins	Peas	Farm average
Previous Crop		Wheat	Sheep	Pa	Pe/Lu/Ca	Wheat	Barley	Barley	Barley	
Acreage	ha	100	300	100	1,500	860	330	260	150	3,600
Crop yield	t/ha	3.2		1.5	1.5	1.3	0.6	1.1	0.6	
Output price	EUR/t	107		127	127	132	288	165	147	
Market revenue	**EUR/ha**	**347**	**165**	**191**	**191**	**165**	**173**	**182**	**88**	**180**
Seed	EUR/ha	18	0	9	9	9	1	13	15	8
Nitrogen (N)	EUR/ha	22	2	22	22	16	25	0	0	17
Phosphorus (P)	EUR/ha	10	3	10	10	10	12	12	12	10
Potassium (K)	EUR/ha	18	0	18	18	0	0	0	0	9
Other	EUR/ha	0	0	0	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	51	5	51	51	27	37	12	12	36
Herbicides	EUR/ha	36	6	36	36	27	37	27	27	30
Fungicides	EUR/ha	0	0	0	0	6	0	0	0	1
Insecticides	EUR/ha	0	0	0	0	0	3	1	6	1
Other	EUR/ha	0	0	0	0	0	0	0	0	0
Pesticides (total)	EUR/ha	36	6	36	36	33	40	28	33	32
Crop establishment cost	**EUR/ha**	**105**	**11**	**96**	**96**	**69**	**78**	**54**	**60**	**77**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	1	0	2	2	2	2	1	1	2
Other	EUR/ha	0	0	0	0	0	0	0	0	0
Finance field inventory	EUR/ha	4	0	3	3	2	3	2	2	3
Total direct cost	**EUR/ha**	**110**	**12**	**102**	**102**	**74**	**83**	**56**	**63**	**81**
Gross margin[1)]	**EUR/ha**	**237**	**154**	**89**	**89**	**91**	**90**	**125**	**25**	**99**
Labour	EUR/ha	11	47	26	26	28	30	28	30	28
Contractor	EUR/ha	149	9	11	11	4	4	0	0	11
Machinery	EUR/ha	24	17	41	41	43	46	43	46	40
Diesel	EUR/ha	4	3	9	9	10	10	10	10	9
Other	EUR/ha	3	1	2	2	1	1	2	1	2
Total operating cost	**EUR/ha**	**192**	**78**	**88**	**88**	**87**	**92**	**82**	**87**	**90**
Operating profit[2)]	**EUR/ha**	**46**	**76**	**1**	**1**	**4**	**-2**	**43**	**-62**	**10**
Building cost	EUR/ha	12	6	7	7	6	6	6	3	6
Total land cost	EUR/ha	60	59	59	59	59	59	59	59	59
Decoupled payments	EUR/ha	0	0	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	60	59	59	59	59	59	59	59	59
Miscellaneous cost	EUR/ha	26	12	14	14	12	13	13	7	13
Total cost	**EUR/ha**	**399**	**166**	**269**	**269**	**238**	**252**	**218**	**219**	**249**
Profit[4)]	**EUR/ha**	**-52**	**-1**	**-79**	**-79**	**-73**	**-79**	**-36**	**-131**	**-69**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A31: Profitability of single crops and farm average AU 4000WB (2007) -

Crop		Oaten hay	Pasture	Wheat	Barley (malt)	Barley (feed)	Wheat	Lupins	Peas	Farm average
Previous Crop		Wheat	Sheep	Pa	Wheat	Wheat	Pe/Lu/Ca	Barley	Barley	
Acreage	ha	100	300	100	735	455	1,500	260	150	3,600
Crop yield	t/ha	4.2		2.1	2.5	2.5	2.1	1.1	1.0	
Output price	EUR/t	105		230	180	211	230	186	196	
Market revenue	**EUR/ha**	**442**	**168**	**471**	**448**	**524**	**471**	**205**	**196**	**416**
Seed	EUR/ha	18	0	9	9	9	9	13	15	9
Nitrogen (N)	EUR/ha	22	2	22	17	17	22	0	0	16
Phosphorus (P)	EUR/ha	11	4	11	11	11	11	13	13	10
Potassium (K)	EUR/ha	18	0	18	0	0	18	0	0	9
Other	EUR/ha	0	0	0	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	51	5	51	27	27	51	13	13	35
Herbicides	EUR/ha	37	6	37	28	28	37	28	28	30
Fungicides	EUR/ha	0	0	0	6	6	0	0	0	2
Insecticides	EUR/ha	0	0	0	0	0	0	1	6	0
Other	EUR/ha	0	0	0	0	0	0	0	0	0
Pesticides (total)	EUR/ha	37	6	37	34	34	37	29	34	32
Crop establishment cost	**EUR/ha**	**106**	**11**	**98**	**70**	**70**	**98**	**55**	**62**	**77**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	1	0	2	2	2	2	1	1	2
Other	EUR/ha	0	0	0	0	0	0	0	0	0
Finance field inventory	EUR/ha	4	0	3	3	3	3	2	2	3
Total direct cost	**EUR/ha**	**111**	**12**	**103**	**75**	**75**	**103**	**58**	**65**	**82**
Gross margin[1)]	**EUR/ha**	**330**	**157**	**367**	**373**	**449**	**367**	**147**	**131**	**334**
Labour	EUR/ha	11	48	26	29	29	26	28	31	29
Contractor	EUR/ha	152	9	11	4	4	11	0	0	11
Machinery	EUR/ha	25	18	42	45	45	42	45	47	41
Diesel	EUR/ha	5	3	11	11	11	11	11	12	10
Other	EUR/ha	2	1	2	2	2	2	1	1	2
Total operating cost	**EUR/ha**	**195**	**79**	**92**	**91**	**91**	**92**	**85**	**91**	**93**
Operating profit[2)]	**EUR/ha**	**135**	**78**	**276**	**282**	**358**	**276**	**62**	**40**	**242**
Building cost	EUR/ha	7	3	7	7	8	7	3	3	6
Total land cost	EUR/ha	60	60	61	60	61	61	60	60	60
Decoupled payments	EUR/ha	0	0	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	60	60	61	60	61	61	60	60	60
Miscellaneous cost	EUR/ha	14	6	15	15	17	15	7	6	14
Total cost	**EUR/ha**	**388**	**159**	**278**	**248**	**252**	**278**	**213**	**225**	**255**
Profit[4)]	**EUR/ha**	**54**	**10**	**193**	**200**	**272**	**193**	**-8**	**-29**	**161**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A32: Profitability of single crops and farm average AU 4000WB (2008) -

Crop		Oaten hay	Pasture	Wheat	Wheat	Barley (feed)	Canola	Lupins	Peas	Farm average
Previous Crop		Wheat	Sheep	Pa	Pe/Lu/Ca	Wheat	Barley	Barley	Barley	
Acreage	ha	100	300	100	1,500	860	330	260	150	3,600
Crop yield	t/ha	3.5		2.3	2.3	2.3	1.2	1.7	1.1	
Output price	EUR/t	118		188	188	115	329	159	202	
Market revenue	**EUR/ha**	**414**	**159**	**424**	**424**	**259**	**395**	**270**	**222**	**340**
Seed	EUR/ha	17	0	9	9	9	1	12	14	8
Nitrogen (N)	EUR/ha	27	2	27	27	20	31	0	0	20
Phosphorus (P)	EUR/ha	10	3	10	10	10	11	11	11	9
Potassium (K)	EUR/ha	20	0	20	20	0	0	0	0	9
Other	EUR/ha	0	0	0	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	56	5	56	56	29	41	11	11	39
Herbicides	EUR/ha	35	6	35	35	26	35	26	26	29
Fungicides	EUR/ha	0	0	0	0	6	0	0	0	1
Insecticides	EUR/ha	0	0	0	0	0	3	1	6	1
Other	EUR/ha	0	0	0	0	0	0	0	0	0
Pesticides (total)	EUR/ha	35	6	35	35	32	38	27	32	31
Crop establishment cost	**EUR/ha**	**108**	**11**	**100**	**100**	**70**	**81**	**51**	**57**	**79**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	1	0	2	2	2	2	1	1	2
Other	EUR/ha	0	0	0	0	0	0	0	0	0
Finance field inventory	EUR/ha	4	0	4	4	3	3	2	2	3
Total direct cost	**EUR/ha**	**113**	**11**	**106**	**106**	**75**	**86**	**54**	**60**	**83**
Gross margin[1)]	**EUR/ha**	**301**	**147**	**318**	**318**	**184**	**309**	**216**	**162**	**257**
Labour	EUR/ha	11	45	25	25	27	29	27	29	27
Contractor	EUR/ha	143	9	10	10	4	4	0	0	11
Machinery	EUR/ha	23	17	39	39	42	44	42	44	38
Diesel	EUR/ha	6	4	13	13	14	15	14	15	13
Other	EUR/ha	2	1	2	2	1	2	1	1	1
Total operating cost	**EUR/ha**	**185**	**75**	**89**	**89**	**88**	**94**	**84**	**89**	**90**
Operating profit[2)]	**EUR/ha**	**116**	**73**	**229**	**229**	**96**	**215**	**133**	**73**	**166**
Building cost	EUR/ha	7	3	7	7	4	7	5	4	6
Total land cost	EUR/ha	57	57	57	57	57	57	57	57	57
Decoupled payments	EUR/ha	0	0	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	57	57	57	57	57	57	57	57	57
Miscellaneous cost	EUR/ha	16	6	16	16	10	15	10	8	13
Total cost	**EUR/ha**	**379**	**151**	**275**	**275**	**234**	**258**	**209**	**218**	**249**
Profit[4)]	**EUR/ha**	**36**	**7**	**149**	**149**	**24**	**137**	**61**	**4**	**91**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A33: Profitability of single crops and farm average AU 4000WB (2009) -

Crop		Barley (malt)	Oaten hay	Pasture	Wheat	Wheat	Barley (feed)	Canola	Lupins	Peas	Farm average
Previous Crop		Wheat	Wheat	Sheep	Pa	Pe/Lu/Ca	Wheat	Barley	Barley	Barley	
Acreage	ha	330	100	300	100	1,500	530	330	260	150	3,600
Crop yield	t/ha	2.2	4.1		2.2	2.2	2.2	1.2	1.2	1.0	
Output price	EUR/t	110	95		101	101	77	244	113	130	
Market revenue	**EUR/ha**	**242**	**390**	**156**	**219**	**219**	**169**	**292**	**136**	**130**	**210**
Seed	EUR/ha	9	17	0	9	9	9	1	12	14	8
Nitrogen (N)	EUR/ha	26	34	3	34	34	26	40	0	0	26
Phosphorus (P)	EUR/ha	20	20	7	20	20	20	22	24	24	20
Potassium (K)	EUR/ha	0	21	0	21	21	0	0	0	0	10
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	46	76	9	76	76	46	62	24	24	56
Herbicides	EUR/ha	25	34	6	34	34	25	35	25	25	29
Fungicides	EUR/ha	6	0	0	0	0	6	0	0	0	1
Insecticides	EUR/ha	0	0	0	0	0	0	3	1	6	1
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Pesticides (total)	EUR/ha	31	34	6	34	34	31	38	27	31	31
Crop establishment cost	**EUR/ha**	**86**	**127**	**15**	**119**	**119**	**86**	**101**	**63**	**69**	**95**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	2	1	0	2	2	2	2	1	1	2
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Finance field inventory	EUR/ha	3	4	1	4	4	3	4	2	2	3
Total direct cost	**EUR/ha**	**91**	**132**	**16**	**125**	**125**	**91**	**106**	**66**	**73**	**100**
Gross margin[1)]	**EUR/ha**	**151**	**258**	**140**	**94**	**94**	**78**	**186**	**70**	**58**	**110**
Labour	EUR/ha	27	10	44	24	24	27	28	26	28	27
Contractor	EUR/ha	4	140	8	10	10	4	4	0	0	10
Machinery	EUR/ha	41	23	16	39	39	41	43	41	43	38
Diesel	EUR/ha	10	4	3	9	9	10	11	10	11	9
Other	EUR/ha	2	3	1	1	1	1	2	1	1	1
Total operating cost	**EUR/ha**	**83**	**181**	**73**	**84**	**84**	**83**	**88**	**78**	**83**	**85**
Operating profit[2)]	**EUR/ha**	**68**	**77**	**67**	**10**	**10**	**-5**	**98**	**-8**	**-26**	**25**
Building cost	EUR/ha	7	11	4	6	6	5	8	4	4	6
Total land cost	EUR/ha	56	56	56	56	56	56	56	56	56	56
Decoupled payments	EUR/ha	0	0	0	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	56	56	56	56	56	56	56	56	56	56
Miscellaneous cost	EUR/ha	14	23	9	13	13	10	18	8	8	13
Total cost	**EUR/ha**	**251**	**404**	**158**	**284**	**284**	**244**	**276**	**212**	**223**	**259**
Profit[4)]	**EUR/ha**	**-10**	**-14**	**-2**	**-65**	**-65**	**-76**	**16**	**-76**	**-93**	**-49**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A34: Profitability of single crops and farm average AU 4000WB (Scenario S-0) -

Crop		Barley (malt)	Oaten hay	Pasture	Wheat	Wheat	Barley (feed)	Canola	Lupins	Peas	Farm average
Previous Crop		Wheat	Wheat	Sheep	Pa	Pe/Lu/Ca	Wheat	Barley	Barley	Barley	
Acreage	ha	330	100	300	100	1,500	530	330	260	150	3,600
Crop yield	t/ha	2.1	3.8		1.9	1.9	2.1	1.0	1.0	0.8	
Output price	EUR/t	181	143		195	195	143	413	187	211	
Market revenue	**EUR/ha**	**381**	**545**	**186**	**371**	**371**	**302**	**392**	**195**	**160**	**332**
Seed	EUR/ha	13	29	0	13	13	13	2	16	18	12
Nitrogen (N)	EUR/ha	28	37	3	37	37	28	43	0	0	28
Phosphorus (P)	EUR/ha	23	23	8	23	23	23	26	27	27	22
Potassium (K)	EUR/ha	0	30	0	30	30	0	0	0	0	14
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	51	91	10	91	91	51	69	27	27	65
Herbicides	EUR/ha	33	44	7	44	44	33	45	33	34	37
Fungicides	EUR/ha	7	0	0	0	0	7	0	0	0	2
Insecticides	EUR/ha	0	0	0	0	0	0	5	2	7	1
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Pesticides (total)	EUR/ha	40	44	7	44	44	40	50	35	42	40
Crop establishment cost	**EUR/ha**	**105**	**164**	**18**	**148**	**148**	**105**	**120**	**78**	**87**	**117**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	2	1	0	2	2	2	2	1	1	2
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Finance field inventory	EUR/ha	4	6	1	5	5	4	4	3	3	4
Total direct cost	**EUR/ha**	**111**	**171**	**18**	**156**	**156**	**111**	**126**	**82**	**91**	**123**
Gross margin[1)]	**EUR/ha**	**270**	**374**	**168**	**215**	**215**	**192**	**266**	**113**	**69**	**208**
Labour	EUR/ha	29	11	47	26	26	29	31	28	31	29
Contractor	EUR/ha	4	152	9	11	11	4	4	0	0	11
Machinery	EUR/ha	44	25	18	42	42	44	47	44	47	41
Diesel	EUR/ha	18	8	5	16	16	18	19	18	19	16
Other	EUR/ha	2	3	1	2	2	1	2	1	1	2
Total operating cost	**EUR/ha**	**97**	**198**	**80**	**97**	**97**	**97**	**102**	**91**	**97**	**98**
Operating profit[2)]	**EUR/ha**	**173**	**175**	**88**	**118**	**118**	**95**	**163**	**22**	**-28**	**110**
Building cost	EUR/ha	7	10	4	7	7	6	7	4	3	6
Total land cost	EUR/ha	61	61	60	61	61	60	61	60	60	60
Decoupled payments	EUR/ha	0	0	0	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	61	61	60	61	61	60	61	60	60	60
Miscellaneous cost	EUR/ha	16	22	8	15	15	12	16	8	7	14
Total cost	**EUR/ha**	**291**	**463**	**170**	**335**	**335**	**286**	**313**	**245**	**258**	**302**
Profit[4)]	**EUR/ha**	**90**	**82**	**16**	**36**	**36**	**16**	**79**	**-50**	**-97**	**30**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A35: Profitability of single crops and farm average AU 4000WB (Scenario S-1) -

Crop		Barley (malt)	Oaten hay	Pasture	Wheat	Wheat	Barley (feed)	Canola	Lupins	Peas	Farm average
Previous Crop		Wheat	Wheat	Sheep	Pa	Pe/Lu/Ca	Wheat	Barley	Barley	Barley	
Acreage	ha	330	100	300	100	1,500	530	400	260	80	3,600
Crop yield	t/ha	2.3	3.8		2.1	2.1	2.3	1.0	1.0	0.8	
Output price	EUR/t	181	143		195	195	143	413	187	211	
Market revenue	**EUR/ha**	**417**	**545**	**186**	**410**	**410**	**331**	**392**	**195**	**160**	**361**
Seed	EUR/ha	13	29	0	13	13	13	2	16	18	12
Nitrogen (N)	EUR/ha	47	37	3	45	59	47	43	0	0	43
Phosphorus (P)	EUR/ha	23	23	8	23	23	23	26	27	27	22
Potassium (K)	EUR/ha	0	30	0	30	30	0	0	0	0	14
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	70	91	10	98	112	70	69	27	27	80
Herbicides	EUR/ha	33	44	7	44	44	33	45	33	34	37
Fungicides	EUR/ha	7	0	0	6	6	7	0	0	0	4
Insecticides	EUR/ha	0	0	0	0	0	0	5	2	7	1
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Pesticides (total)	EUR/ha	40	44	7	50	50	40	50	35	42	43
Crop establishment cost	**EUR/ha**	**124**	**164**	**18**	**162**	**176**	**124**	**120**	**78**	**87**	**134**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	2	1	0	2	2	2	2	1	1	2
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Finance field inventory	EUR/ha	4	6	1	6	6	4	4	3	3	5
Total direct cost	**EUR/ha**	**131**	**171**	**18**	**170**	**185**	**131**	**126**	**82**	**91**	**141**
Gross margin[1)]	**EUR/ha**	**287**	**374**	**168**	**240**	**225**	**200**	**266**	**113**	**69**	**220**
Labour	EUR/ha	29	11	47	26	26	29	31	28	31	29
Contractor	EUR/ha	4	152	9	14	14	4	4	0	0	13
Machinery	EUR/ha	44	25	18	42	42	44	47	44	47	41
Diesel	EUR/ha	18	8	5	16	16	18	19	18	19	16
Other	EUR/ha	2	2	1	2	2	1	2	1	1	2
Total operating cost	**EUR/ha**	**97**	**198**	**80**	**100**	**100**	**97**	**102**	**91**	**97**	**100**
Operating profit[2)]	**EUR/ha**	**190**	**175**	**88**	**141**	**125**	**104**	**163**	**22**	**-28**	**120**
Building cost	EUR/ha	7	9	3	7	7	6	7	3	3	6
Total land cost	EUR/ha	61	61	60	61	61	60	61	60	60	60
Decoupled payments	EUR/ha	0	0	0	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	61	61	60	61	61	60	61	60	60	60
Miscellaneous cost	EUR/ha	16	21	7	15	15	12	15	7	6	14
Total cost	**EUR/ha**	**311**	**460**	**169**	**353**	**368**	**306**	**311**	**244**	**257**	**321**
Profit[4)]	**EUR/ha**	**106**	**85**	**17**	**57**	**42**	**25**	**81**	**-49**	**-97**	**40**

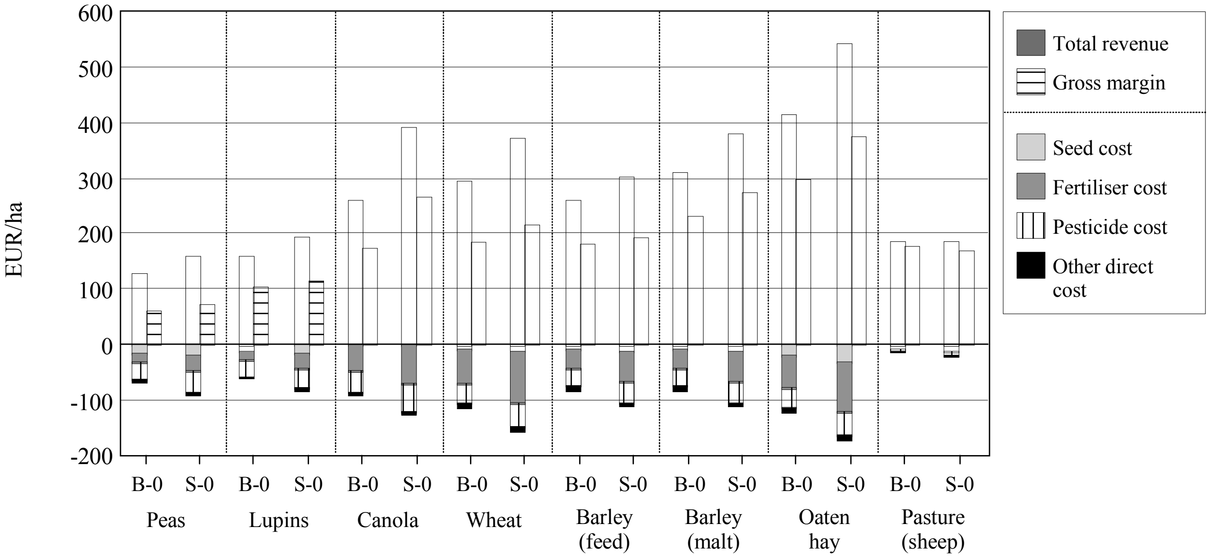
1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A36: Profitability of single crops and farm average AU 4000WB (Scenario S-2) -

Crop		Barley (malt)	Oaten hay	Pasture	Wheat	Wheat	Barley (feed)	Canola	Lupins	Peas	Farm average
Previous Crop		Wheat	Wheat	Sheep	Pa	Pe/Lu/Ca	Wheat	Barley	Barley	Barley	
Acreage	ha	330	100	300	100	1,500	530	330	260	150	3,600
Crop yield	t/ha	2.4	3.8		2.2	2.2	2.4	1.0	1.0	0.8	
Output price	EUR/t	181	143		195	195	143	413	187	211	
Market revenue	**EUR/ha**	**435**	**545**	**186**	**430**	**430**	**345**	**392**	**195**	**160**	**369**
Seed	EUR/ha	13	29	0	13	13	13	2	16	18	12
Nitrogen (N)	EUR/ha	65	44	3	55	55	65	51	0	0	46
Phosphorus (P)	EUR/ha	23	23	8	23	23	23	26	27	27	22
Potassium (K)	EUR/ha	0	30	0	30	30	0	0	0	0	14
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	88	97	10	108	108	88	77	27	27	83
Herbicides	EUR/ha	33	44	7	44	44	33	45	33	34	37
Fungicides	EUR/ha	7	0	0	6	6	7	0	0	0	4
Insecticides	EUR/ha	0	0	0	0	0	0	5	2	7	1
Other	EUR/ha	2	0	0	2	2	2	0	0	0	1
Pesticides (total)	EUR/ha	42	44	7	52	52	42	50	35	42	44
Crop establishment cost	**EUR/ha**	**144**	**171**	**18**	**174**	**174**	**144**	**128**	**78**	**87**	**139**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	2	1	0	2	2	2	2	1	1	2
Other	EUR/ha	0	0	0	0	0	0	0	0	0	0
Finance field inventory	EUR/ha	5	6	1	6	6	5	5	3	3	5
Total direct cost	**EUR/ha**	**151**	**178**	**18**	**182**	**182**	**151**	**135**	**82**	**91**	**146**
Gross margin[1)]	**EUR/ha**	**284**	**367**	**168**	**247**	**247**	**194**	**257**	**113**	**69**	**223**
Labour	EUR/ha	28	11	46	25	25	28	29	27	29	28
Contractor	EUR/ha	0	148	9	10	10	0	0	0	0	9
Machinery	EUR/ha	46	26	19	43	43	46	48	46	48	42
Diesel	EUR/ha	18	8	5	16	16	18	19	18	19	16
Other	EUR/ha	2	2	1	2	2	1	2	1	1	2
Total operating cost	**EUR/ha**	**93**	**195**	**79**	**96**	**96**	**92**	**98**	**91**	**97**	**96**
Operating profit[2)]	**EUR/ha**	**191**	**172**	**88**	**152**	**152**	**102**	**160**	**22**	**-27**	**127**
Building cost	EUR/ha	8	10	3	8	8	6	7	3	3	6
Total land cost	EUR/ha	61	61	60	61	61	60	60	60	60	60
Decoupled payments	EUR/ha	0	0	0	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	61	61	60	61	61	60	60	60	60	60
Miscellaneous cost	EUR/ha	16	21	7	16	16	13	15	7	6	14
Total cost	**EUR/ha**	**328**	**464**	**168**	**362**	**362**	**323**	**314**	**244**	**257**	**323**
Profit[4)]	**EUR/ha**	**107**	**81**	**18**	**68**	**67**	**22**	**78**	**-49**	**-96**	**46**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Figure A21: Comparison of revenue, direct cost structure and gross margin (€/ha) of major crops on AU 4000WB, reference scenario (B-0) vs. high price scenario (S-0) -



	Peas	Lupins	Canola	Wheat	Barley (feed)	Barley (malt)	Oaten hay	Pasture (sheep)
Gross margin response	+16%	+13%	+56%	+17%	+8%	+18%	+26%	-3%

Source: Own calculation.

Figure A22: Production system of barley on AU 2800CW and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	mid 12	Spraying	Total herbicide	7	5
2	end 02	Spraying	Total herbicide	7	5
3	beg 05	Seeding NO-TILL	Airseeder (tines) + MAP (mineral) N10 P21	52	26
4	mid 07	Spraying	Selective herbicide	18	5
5	mid 08	Spraying	Selective herbicide	12	5
6	beg 12	Harvest	Combine harvest		22
7	beg 12	Transport	On road transport (truck)		4
			Total	98	72

Summary				
Crop		Barley (following wheat)		
Tillage		No-Till seeding		
Seed	kg/ha	38	12	EUR/ha
Fertilisation	Nutrient kg/ha	N10 P21 K0 CaO0 Mg0 S0	41	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (0), insecticide (0), other (0)	45	EUR/ha
Yield	t/ha	1.80		

Source: Own calculation.

Figure A23: Production system of wheat on AU 2800CW and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	mid 12	Spraying	Total herbicide	7	5
2	end 02	Spraying	Total herbicide	7	4
3	beg 05	Seeding NO-TILL	Airseeder (tines) + MAP (mineral) N10 P21	52	26
4	mid 07	Spraying	Selective herbicide	18	5
5	mid 08	Spraying	Selective herbicide	12	5
6	mid 12	Harvest	Combine harvest		22
7	mid 12	Transport	On road transport (truck)		3
			Total	98	70

Summary				
Crop		Wheat (following barley)		
Tillage		No-Till seeding		
Seed	kg/ha	38	12	EUR/ha
Fertilisation	Nutrient kg/ha	N10 P21 K0 CaO0 Mg0 S0	41	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (0), insecticide (0), other (0)	45	EUR/ha
Yield	t/ha	1.66		

Source: Own calculation.

Figure A24: Production system of dual purpose wheat on AU 2800CW and physical direct inputs differentiated by month and type of operation (Average 2005–2009)

No.	Time in month	Type of operation	Description, nutrient origin and input [kg/ha] where applicable	Direct cost EUR/ha	Operating cost EUR/ha
1	mid 12	Spraying	Total herbicide	7	5
2	end 02	Spraying	Total herbicide	7	5
3	beg 03	Seeding NO-TILL	Airseeder (tines) + MAP (mineral) N12 P25	61	26
4	mid 07	Spraying	Selective herbicide	18	5
5	mid 08	Spraying	Selective herbicide	12	5
6	mid 12	Harvest	Combine harvest		22
7	mid 12	Transport	On road transport (truck)		3
			Total	107	71

Summary				
Crop		Wheat (dual purpose following barley)		
Tillage		No-Till seeding		
Seed	kg/ha	38	12	EUR/ha
Fertilisation	Nutrient kg/ha	N12 P25 K0 CaO0 Mg0 S0	50	EUR/ha
Chemicals	Applications	Herbicide (4), fungicide (0), insecticide (0), other (0)	45	EUR/ha
Yield	t/ha	1.66		
Grazing	sheep/ha	6-7 (alternating paddocks, max 10 weeks, stock off in August)		

Source: Own calculation.

Table A37: Profitability of single crops and farm average AU 2800CW (2005) -

Crop		Wheat dual	Pasture	Wheat	Barley (feed)	Wheat	Farm average
Previous Crop		Barley	Sheep	Barley	Wheat	Pasture	
Acreage	ha	290	1200	10	300	300	2,100
Crop yield	t/ha	2.8		2.8	3.1	2.8	
Output price	EUR/t	86		86	71	86	
Market revenue	**EUR/ha**	**260**	**117**	**239**	**217**	**239**	**169**
Seed	EUR/ha	7	0	7	7	7	3
Nitrogen (N)	EUR/ha	7	0	6	6	6	3
Phosphorus (P)	EUR/ha	32	1	26	26	26	13
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	40	1	32	32	32	16
Herbicides	EUR/ha	45	0	45	29	21	14
Fungicides	EUR/ha	0	0	0	0	0	0
Insecticides	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	45	0	45	29	21	14
Crop establishment cost	**EUR/ha**	**92**	**1**	**85**	**68**	**61**	**32**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	37	0	0	0	21
Finance field inventory	EUR/ha	2	1	2	2	2	1
Total direct cost	**EUR/ha**	**94**	**39**	**87**	**70**	**62**	**55**
Gross margin[1)]	**EUR/ha**	**166**	**78**	**152**	**147**	**176**	**114**
Labour	EUR/ha	38	13	37	38	50	26
Contractor	EUR/ha	0	2	0	0	0	1
Machinery	EUR/ha	67	4	66	67	102	36
Diesel	EUR/ha	9	1	9	9	18	6
Other	EUR/ha	2	1	1	1	1	1
Total operating cost	**EUR/ha**	**116**	**21**	**113**	**116**	**171**	**69**
Operating profit[2)]	**EUR/ha**	**50**	**57**	**38**	**31**	**6**	**45**
Building cost	EUR/ha	19	8	17	16	17	12
Total land cost	EUR/ha	49	49	49	49	49	49
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	49	49	49	49	49	49
Miscellaneous cost	EUR/ha	21	10	20	18	20	14
Total cost	**EUR/ha**	**299**	**127**	**286**	**268**	**319**	**199**
Profit[4)]	**EUR/ha**	**-39**	**-10**	**-47**	**-51**	**-80**	**-30**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A38: Profitability of single crops and farm average AU 2800CW (2006) -

Crop		Pasture	Wheat dual	Wheat	Barley (feed)	Wheat	Farm average
Previous Crop		Sheep	Barley	Barley	Wheat	Pasture	
Acreage	ha	1,200	10	290	300	300	2,100
Crop yield	t/ha		0.1	0.1	0.0	0.1	
Output price	EUR/t		192	192	177	192	
Market revenue	**EUR/ha**	**114**	**40**	**19**	**0**	**19**	**71**
Seed	EUR/ha	0	7	7	7	7	3
Nitrogen (N)	EUR/ha	0	8	6	6	6	3
Phosphorus (P)	EUR/ha	1	33	27	27	27	12
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	1	41	34	34	34	15
Herbicides	EUR/ha	0	44	44	28	21	13
Fungicides	EUR/ha	0	0	0	0	0	0
Insecticides	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	0	44	44	28	21	13
Crop establishment cost	**EUR/ha**	**1**	**92**	**85**	**69**	**61**	**31**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	36	0	0	0	0	21
Finance field inventory	EUR/ha	1	2	2	2	2	1
Total direct cost	**EUR/ha**	**38**	**95**	**87**	**70**	**63**	**53**
Gross margin[1)]	**EUR/ha**	**76**	**-54**	**-68**	**-70**	**-44**	**18**
Labour	EUR/ha	13	37	36	37	49	25
Contractor	EUR/ha	2	0	0	0	0	1
Machinery	EUR/ha	4	66	65	66	99	35
Diesel	EUR/ha	1	9	9	10	18	6
Other	EUR/ha	2	1	0	0	0	1
Total operating cost	**EUR/ha**	**22**	**113**	**111**	**113**	**167**	**68**
Operating profit[2)]	**EUR/ha**	**54**	**-168**	**-178**	**-183**	**-211**	**-51**
Building cost	EUR/ha	19	7	3	0	3	12
Total land cost	EUR/ha	48	48	48	48	48	48
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	48	48	48	48	48	48
Miscellaneous cost	EUR/ha	22	8	4	0	4	14
Total cost	**EUR/ha**	**149**	**270**	**252**	**231**	**285**	**195**
Profit[4)]	**EUR/ha**	**-35**	**-230**	**-233**	**-231**	**-265**	**-124**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A39: Profitability of single crops and farm average AU 2800CW (2007) -

Crop		Wheat dual	Barley (feed)	Wheat	Wheat	Pasture	Farm average
Previous Crop		Barley	Wheat	Barley	Pasture	Sheep	
Acreage	ha	100	300	200	300	1,200	2,100
Crop yield	t/ha	1.7	1.8	1.7	1.7		
Output price	EUR/t	242	226	242	242		
Market revenue	**EUR/ha**	**435**	**410**	**413**	**413**	**116**	**244**
Seed	EUR/ha	7	7	7	7	0	3
Nitrogen (N)	EUR/ha	8	6	6	6	0	3
Phosphorus (P)	EUR/ha	34	28	28	28	1	13
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	42	34	34	34	1	16
Herbicides	EUR/ha	45	29	45	21	0	14
Fungicides	EUR/ha	0	0	0	0	0	0
Insecticides	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	45	29	45	21	0	14
Crop establishment cost	**EUR/ha**	**94**	**70**	**87**	**63**	**1**	**32**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	37	21
Finance field inventory	EUR/ha	2	2	2	2	1	1
Total direct cost	**EUR/ha**	**96**	**72**	**89**	**64**	**39**	**55**
Gross margin[1)]	**EUR/ha**	**338**	**338**	**325**	**349**	**77**	**190**
Labour	EUR/ha	38	38	37	50	13	26
Contractor	EUR/ha	0	0	0	0	2	1
Machinery	EUR/ha	67	67	66	101	4	36
Diesel	EUR/ha	11	12	11	22	1	7
Other	EUR/ha	2	2	2	2	0	1
Total operating cost	**EUR/ha**	**119**	**119**	**116**	**175**	**21**	**71**
Operating profit[2)]	**EUR/ha**	**220**	**219**	**209**	**174**	**56**	**119**
Building cost	EUR/ha	22	20	21	21	6	12
Total land cost	EUR/ha	49	49	49	49	49	49
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	49	49	49	49	49	49
Miscellaneous cost	EUR/ha	25	23	23	23	7	14
Total cost	**EUR/ha**	**310**	**283**	**298**	**332**	**121**	**200**
Profit[4)]	**EUR/ha**	**125**	**127**	**116**	**81**	**-5**	**44**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A40: Profitability of single crops and farm average AU 2800CW (2008) -

Crop		Barley (feed)	Wheat dual	Wheat	Wheat	Pasture	Farm average
Previous Crop		Wheat	Barley	Barley	Pasture	Sheep	
Acreage	ha	300	200	100	300	1,200	2,100
Crop yield	t/ha	2.4	2.1	2.1	2.1		
Output price	EUR/t	129	143	143	143		
Market revenue	**EUR/ha**	**305**	**321**	**301**	**301**	**110**	**194**
Seed	EUR/ha	7	7	7	7	0	3
Nitrogen (N)	EUR/ha	8	10	8	8	0	4
Phosphorus (P)	EUR/ha	26	32	26	26	1	12
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	34	42	34	34	1	16
Herbicides	EUR/ha	30	43	43	20	0	13
Fungicides	EUR/ha	0	0	0	0	0	0
Insecticides	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	30	43	43	20	0	13
Crop establishment cost	**EUR/ha**	**71**	**91**	**83**	**61**	**1**	**32**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	35	20
Finance field inventory	EUR/ha	2	2	2	2	1	1
Total direct cost	**EUR/ha**	**72**	**93**	**85**	**62**	**37**	**53**
Gross margin[1)]	**EUR/ha**	**233**	**228**	**215**	**238**	**73**	**141**
Labour	EUR/ha	36	36	35	47	12	24
Contractor	EUR/ha	0	0	0	0	2	1
Machinery	EUR/ha	63	63	63	95	4	34
Diesel	EUR/ha	15	14	14	28	1	9
Other	EUR/ha	2	2	1	1	1	1
Total operating cost	**EUR/ha**	**115**	**115**	**113**	**171**	**20**	**69**
Operating profit[2)]	**EUR/ha**	**117**	**113**	**103**	**67**	**53**	**72**
Building cost	EUR/ha	18	19	18	18	6	11
Total land cost	EUR/ha	46	46	46	46	46	46
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	46	46	46	46	46	46
Miscellaneous cost	EUR/ha	21	22	20	20	7	13
Total cost	**EUR/ha**	**272**	**295**	**282**	**318**	**117**	**192**
Profit[4)]	**EUR/ha**	**33**	**26**	**19**	**-17**	**-7**	**2**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A41: Profitability of single crops and farm average AU 2800CW (2009) -

Crop		Pasture	Wheat dual	Barley (feed)	Wheat	Wheat	Farm average
Previous Crop		Sheep	Barley	Wheat	Barley	Pasture	
Acreage	ha	1,200	100	300	200	300	2,100
Crop yield	t/ha		1.6	1.7	1.6	1.6	
Output price	EUR/t		102	88	102	102	
Market revenue	**EUR/ha**	**108**	**182**	**151**	**162**	**162**	**130**
Seed	EUR/ha	0	6	6	6	6	3
Nitrogen (N)	EUR/ha	0	12	10	10	10	5
Phosphorus (P)	EUR/ha	2	63	51	51	51	23
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	2	75	61	61	61	28
Herbicides	EUR/ha	0	42	27	42	20	13
Fungicides	EUR/ha	0	0	0	0	0	0
Insecticides	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	0	42	27	42	20	13
Crop establishment cost	**EUR/ha**	**2**	**123**	**94**	**110**	**88**	**43**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	34	0	0	0	0	19
Finance field inventory	EUR/ha	1	3	2	3	2	2
Total direct cost	**EUR/ha**	**37**	**126**	**97**	**112**	**90**	**64**
Gross margin[1)]	**EUR/ha**	**71**	**56**	**54**	**50**	**72**	**66**
Labour	EUR/ha	12	35	35	34	46	24
Contractor	EUR/ha	2	0	0	0	0	1
Machinery	EUR/ha	4	62	62	61	93	33
Diesel	EUR/ha	1	10	10	10	20	6
Other	EUR/ha	1	1	1	1	1	1
Total operating cost	**EUR/ha**	**20**	**109**	**109**	**107**	**160**	**65**
Operating profit[2)]	**EUR/ha**	**51**	**-53**	**-55**	**-57**	**-88**	**1**
Building cost	EUR/ha	9	16	13	14	14	11
Total land cost	EUR/ha	46	46	46	46	46	46
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	46	46	46	46	46	46
Miscellaneous cost	EUR/ha	11	18	15	16	16	13
Total cost	**EUR/ha**	**122**	**315**	**280**	**295**	**326**	**199**
Profit[4)]	**EUR/ha**	**-15**	**-133**	**-129**	**-133**	**-164**	**-69**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A42: Profitability of single crops and farm average AU 2800CW (Scenario S-0) -

Crop		Barley (feed)	Wheat dual	Wheat	Wheat	Pasture	Farm average
Previous Crop		Wheat	Barley	Barley	Pasture	Sheep	
Acreage	ha	300	100	200	300	1,200	2,100
Crop yield	t/ha	1.8	1.7	1.7	1.7		
Output price	EUR/t	192	212	212	212		
Market revenue	**EUR/ha**	**345**	**373**	**352**	**352**	**116**	**217**
Seed	EUR/ha	9	9	9	9	0	4
Nitrogen (N)	EUR/ha	10	12	10	10	0	5
Phosphorus (P)	EUR/ha	58	71	58	58	2	26
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	68	83	68	68	2	31
Herbicides	EUR/ha	35	54	54	26	0	16
Fungicides	EUR/ha	0	0	0	0	0	0
Insecticides	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	35	54	54	26	0	16
Crop establishment cost	**EUR/ha**	**112**	**146**	**131**	**103**	**2**	**51**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	37	21
Finance field inventory	EUR/ha	3	4	3	3	1	2
Total direct cost	**EUR/ha**	**114**	**150**	**134**	**105**	**40**	**74**
Gross margin[1)]	**EUR/ha**	**231**	**223**	**217**	**246**	**76**	**143**
Labour	EUR/ha	38	38	37	50	13	26
Contractor	EUR/ha	0	0	0	0	2	1
Machinery	EUR/ha	67	67	66	101	4	36
Diesel	EUR/ha	18	18	17	34	2	11
Other	EUR/ha	2	2	2	2	1	1
Total operating cost	**EUR/ha**	**125**	**125**	**122**	**188**	**22**	**75**
Operating profit[2)]	**EUR/ha**	**105**	**99**	**95**	**59**	**55**	**68**
Building cost	EUR/ha	19	21	20	20	6	12
Total land cost	EUR/ha	49	49	49	49	49	49
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	49	49	49	49	49	49
Miscellaneous cost	EUR/ha	22	24	22	22	7	14
Total cost	**EUR/ha**	**330**	**368**	**347**	**384**	**124**	**224**
Profit[4)]	**EUR/ha**	**15**	**5**	**4**	**-32**	**-8**	**-6**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A43: Profitability of single crops and farm average AU 2800CW (Scenario S-1) -

Crop		Barley (feed)	Wheat dual	Wheat	Wheat	Pasture	Farm average
Previous Crop		Wheat	Barley	Barley	Pasture	Sheep	
Acreage	ha	300	100	200	300	1,200	2,100
Crop yield	t/ha	1.8	1.7	1.7	1.7		
Output price	EUR/t	192	225	212	212		
Market revenue	**EUR/ha**	**345**	**373**	**352**	**352**	**116**	**217**
Seed	EUR/ha	9	9	9	9	0	4
Nitrogen (N)	EUR/ha	10	12	10	10	0	5
Phosphorus (P)	EUR/ha	58	71	58	58	2	26
Potassium (K)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	68	83	68	68	2	31
Herbicides	EUR/ha	35	54	54	26	0	16
Fungicides	EUR/ha	0	0	0	0	0	0
Insecticides	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0
Pesticides (total)	EUR/ha	35	54	54	26	0	16
Crop establishment cost	**EUR/ha**	**112**	**146**	**131**	**103**	**2**	**51**
Dry energy cost	EUR/ha	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	37	21
Finance field inventory	EUR/ha	3	4	3	3	1	2
Total direct cost	**EUR/ha**	**114**	**150**	**134**	**105**	**40**	**74**
Gross margin[1)]	**EUR/ha**	**231**	**223**	**217**	**246**	**76**	**143**
Labour	EUR/ha	38	38	37	50	13	26
Contractor	EUR/ha	0	0	0	0	2	1
Machinery	EUR/ha	67	67	66	101	4	36
Diesel	EUR/ha	18	18	17	34	2	11
Other	EUR/ha	2	2	2	2	1	1
Total operating cost	**EUR/ha**	**125**	**125**	**122**	**188**	**22**	**75**
Operating profit[2)]	**EUR/ha**	**105**	**99**	**95**	**59**	**55**	**68**
Building cost	EUR/ha	19	21	20	20	6	12
Total land cost	EUR/ha	49	49	49	49	49	49
Decoupled payments	EUR/ha	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	49	49	49	49	49	49
Miscellaneous cost	EUR/ha	24	26	25	25	8	15
Total cost	**EUR/ha**	**332**	**370**	**349**	**386**	**125**	**225**
Profit[4)]	**EUR/ha**	**13**	**3**	**2**	**-34**	**-9**	**-8**

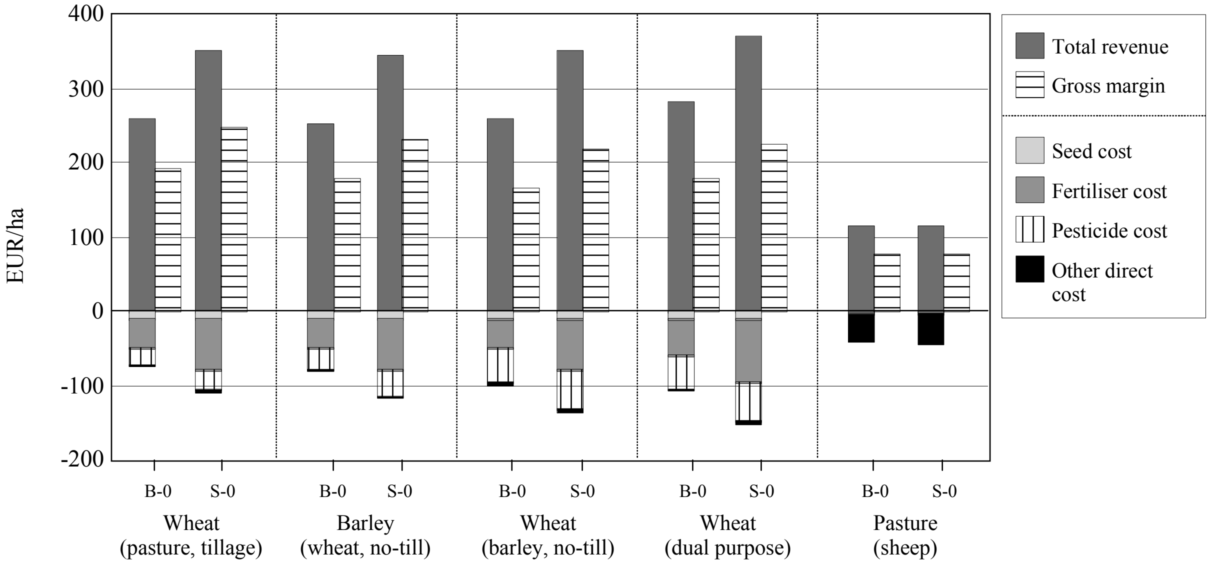
1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Table A44: Profitability of single crops and farm average AU 2800CW (Scenario S-2) -

Crop		Canola	Wheat	Barley (feed)	Wheat dual	Wheat	Pasture	Farm average
Previous Crop		Wheat	Pasture	Wheat	Barley	Barley	Sheep	
Acreage	ha	300	300	300	100	200	900	2,100
Crop yield	t/ha	1.5	2.0	2.2	2.0	2.0		
Output price	EUR/t	431	212	192	223	212		
Market revenue	**EUR/ha**	**638**	**424**	**414**	**445**	**424**	**116**	**322**
Seed	EUR/ha	1	9	9	9	9	0	4
Nitrogen (N)	EUR/ha	46	40	40	42	40	0	24
Phosphorus (P)	EUR/ha	64	58	58	71	58	2	35
Potassium (K)	EUR/ha	0	0	0	0	0	0	0
Other	EUR/ha	0	0	0	0	0	0	0
Fertilizer (total)	EUR/ha	110	98	98	113	98	2	59
Herbicides	EUR/ha	24	35	35	54	54	0	21
Fungicides	EUR/ha	0	5	5	5	5	0	2
Insecticides	EUR/ha	5	0	0	0	0	0	1
Other	EUR/ha	0	0	0	0	0	0	0
Pesticides (total)	EUR/ha	29	39	39	59	59	0	24
Crop establishment cost	**EUR/ha**	**140**	**146**	**146**	**181**	**166**	**2**	**87**
Dry energy cost	EUR/ha	0	0	0	0	0	0	0
Crop insurance (hail)	EUR/ha	12	0	0	0	0	0	2
Other	EUR/ha	0	0	0	0	0	37	16
Finance field inventory	EUR/ha	4	4	4	5	4	1	3
Total direct cost	**EUR/ha**	**156**	**150**	**150**	**185**	**170**	**40**	**107**
Gross margin[1)]	**EUR/ha**	**481**	**273**	**264**	**260**	**254**	**76**	**215**
Labour	EUR/ha	29	32	32	32	31	11	23
Contractor	EUR/ha	50	35	35	35	35	2	23
Machinery	EUR/ha	31	35	35	35	34	6	22
Diesel	EUR/ha	8	9	9	8	8	1	5
Other	EUR/ha	2	1	1	1	1	0	1
Total operating cost	**EUR/ha**	**121**	**113**	**113**	**112**	**110**	**19**	**74**
Operating profit[2)]	**EUR/ha**	**360**	**161**	**151**	**147**	**144**	**57**	**141**
Building cost	EUR/ha	24	16	15	17	16	4	12
Total land cost	EUR/ha	49	49	49	49	49	49	49
Decoupled payments	EUR/ha	0	0	0	0	0	0	0
Net land cost[3)]	EUR/ha	49	49	49	49	49	49	49
Miscellaneous cost	EUR/ha	31	21	20	22	21	6	16
Total cost	**EUR/ha**	**381**	**348**	**347**	**385**	**365**	**118**	**258**
Profit[4)]	**EUR/ha**	**257**	**75**	**66**	**60**	**58**	**-2**	**65**

1) Gross margin = Net revenue over direct cost. -
2) Operating profit = Net revenue over direct and operating cost. -
3) Net land cost = Total land cost reduced by decoupled payments. -
4) Profit = Net revenue over total cost. -
Source: Own calculation. -

Figure A25: Comparison of revenue, direct cost structure and gross margin (€/ha) of major crops on AU 2800CW, reference scenario (B-0) vs. high price scenario (S-0)



Gross margin response	+29%	+30%	+31%	+25%	-1%

Source: Own calculation.

Table A45: Comparison of production output potentials of typical farms

Typical farm	Scenario	Wheat				Rapeseed				Barley				Pulses			
		Acreage	Yield	Production	Change	Acreage	Yield	Production	Change	Acreage	Yield	Production	Change	Acreage	Yield	Production	Change
		ha	t/ha	t/a	% vs. B-0	ha	t/ha	t/a	% vs. B-0	ha	t/ha	t/a	% vs. B-0	ha	t/ha	t/a	% vs. B-0
DE1300MB	B0	812	8.22	6,671	--	325	4.02	1,307	--	--	--	--	--	--	--	--	--
	S0	812	8.22	6,671	--	325	4.02	1,307	--	--	--	--	--	--	--	--	--
	S1	812	8.32	6,752	+ 1 %	325	4.10	1,333	+ 1 %	--	--	--	--	--	--	--	--
	S2	812	8.62	6,996	+ 5 %	325	4.20	1,365	+ 5 %	--	--	--	--	--	--	--	--
AU4500SC	B0	1,400	2.66	3,724	--	1,000	1.80	1,800	--	1,400	3.00	4,200	--	400	1.58	632	--
	S0	1,400	2.66	3,724	--	1,000	1.80	1,800	--	1,400	3.00	4,200	--	400	1.58	632	--
	S1	1,400	2.95	4,130	+ 11 %	1,100	1.99	2,190	+ 22 %	1,400	3.25	4,550	+ 8 %	300	1.60	480	- 24 %
	S2	1,400	3.00	4,200	+ 13 %	1,000	2.05	2,050	+ 14 %	1,400	3.30	4,620	+ 10 %	400	1.60	640	+ 1 %
AU4000WB	B0	1,600	1.90	3,040	--	330	0.95	314	--	860	2.11	1,815	--	410	0.94	384	--
	S0	1,600	1.90	3,040	--	330	0.95	314	--	860	2.11	1,815	--	410	0.94	384	--
	S1	1,600	2.10	3,360	+ 11 %	400	0.95	380	+ 21 %	860	2.31	1,987	+ 9 %	340	0.97	331	- 14 %
	S2	1,600	2.20	3,520	+ 16 %	330	0.95	314	--	860	2.41	2,073	+ 14 %	410	0.94	384	--
AU2800CW	B0	600	1.66	996	--	--	--	--	--	300	1.80	540	--	--	--	--	--
	S0	600	1.66	996	--	--	--	--	--	300	1.80	540	--	--	--	--	--
	S1	600	1.66	996	--	--	--	--	--	300	1.80	540	--	--	--	--	--
	S2	600	2.00	1,200	+ 20 %	300	1.48	444	new	300	2.16	648	+ 20 %	--	--	--	--

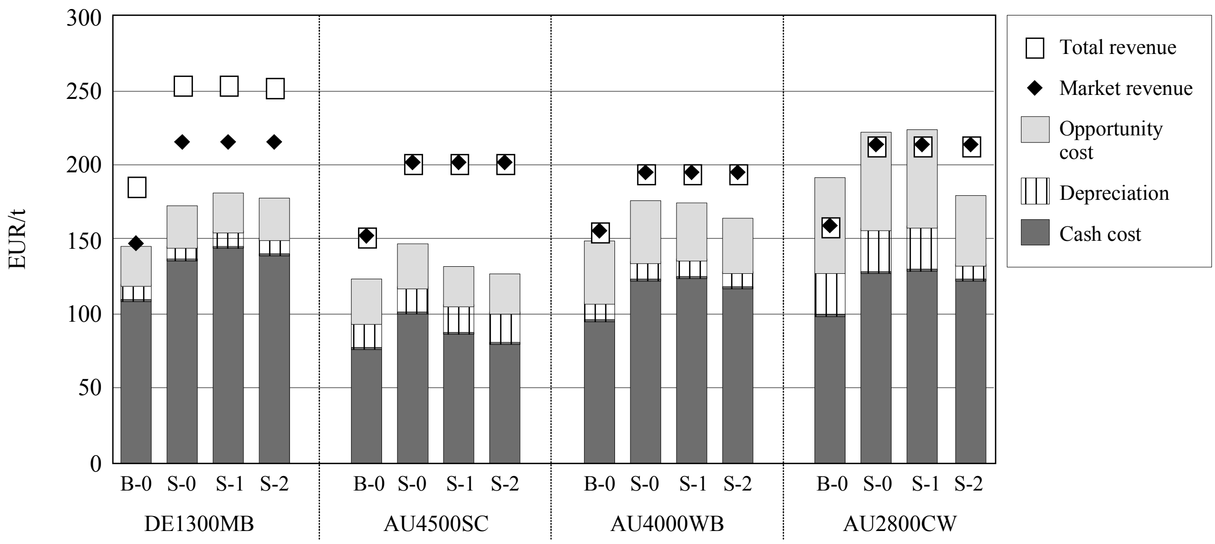
Source: Own calculation.

Table A46: Comparison of revenue, production cost and operating profit of winter wheat vs. corn for biogas plants on DE 1300MB (B-0)

Crop		Winter wheat	Corn for Biogas
Previous crop		wheat	wheat
Crop yield	t/ha	8	48
Output price	€/t	147	35
Market revenue	**€/ha**	**1,176**	**1,680**
Seed	€/ha	48	125
Fertiliser	€/ha	144	48
Pesticides	€/ha	135	85
Other direct cost	€/ha	21	12
Direct cost	**€/ha**	**348**	**270**
Gross margin	€/ha	828	1,410
Total operating cost	**€/ha**	**409**	**696**
Total direct & operating cost	**€/ha**	**757**	**966**
Operating profit	**€/ha**	**419**	**714**

Source: Nehring (2011); own calculation.

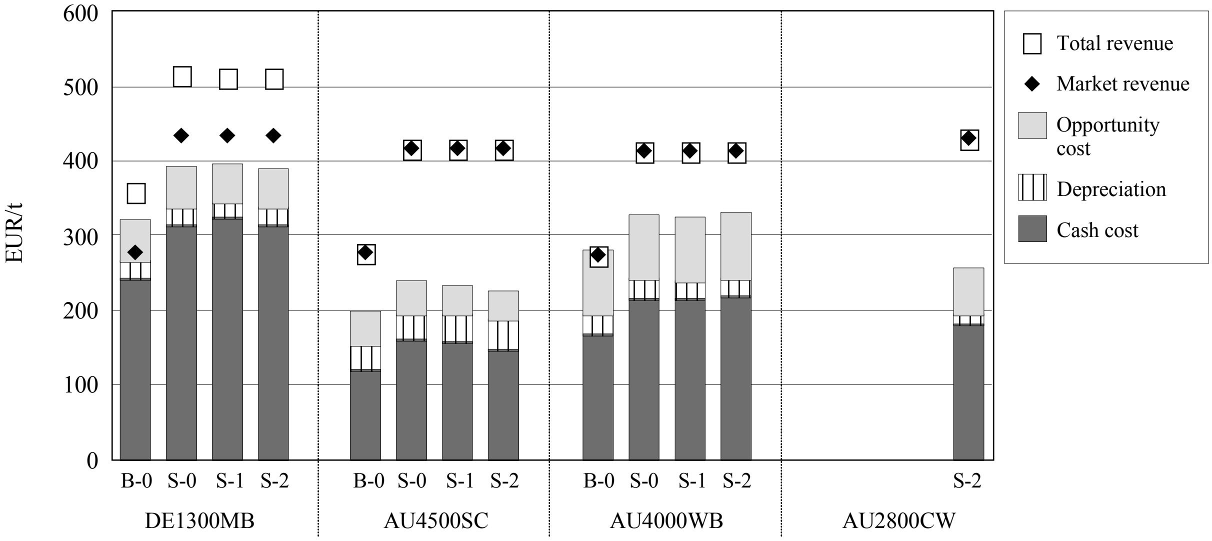
Figure A26: Implications of high commodity prices on the production cost of wheat (€/t) of typical farms



Notes: B-0 = Reference situation (average 2005-2009).
S-0 = High price scenario, no adjustments.
S-1 = High price scenario, agronomical adjustments.
S-2 = High price scenario, farm setup adjustments.

Source: Own illustration.

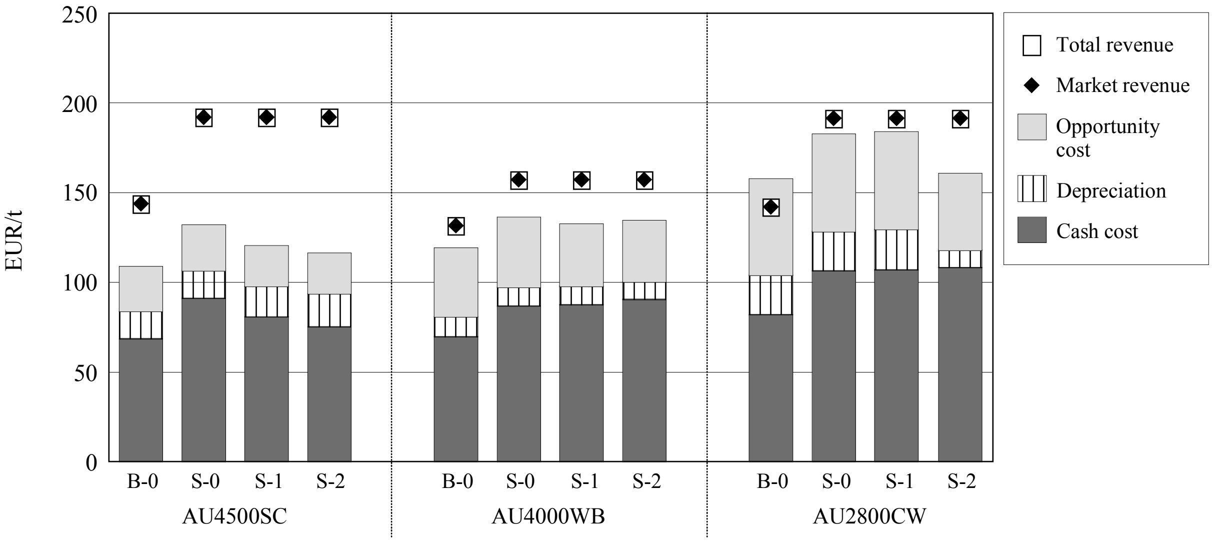
Figure A27: Implications of high commodity prices on the production cost of rapeseed (€/t) of typical farms



Notes: B-0 = Reference situation (average 2005-2009).
S-0 = High price scenario, no adjustments.
S-1 = High price scenario, agronomical adjustments.
S-2 = High price scenario, farm setup adjustments.

Source: Own illustration.

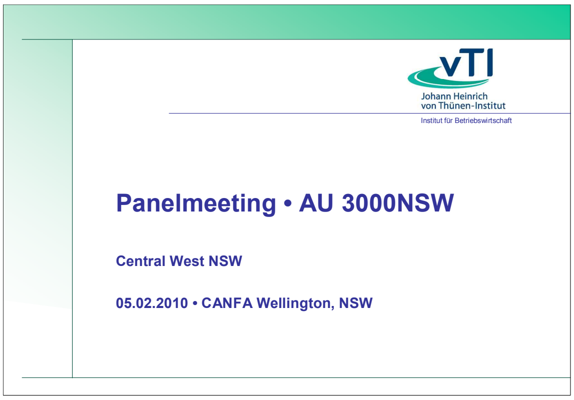
Figure A28: Implications of high commodity prices on the production cost of barley (€/t) of typical farms

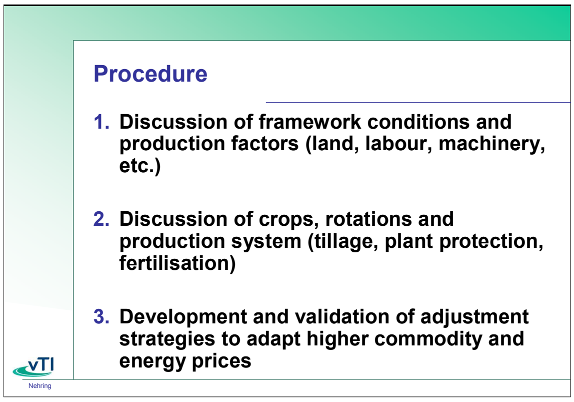


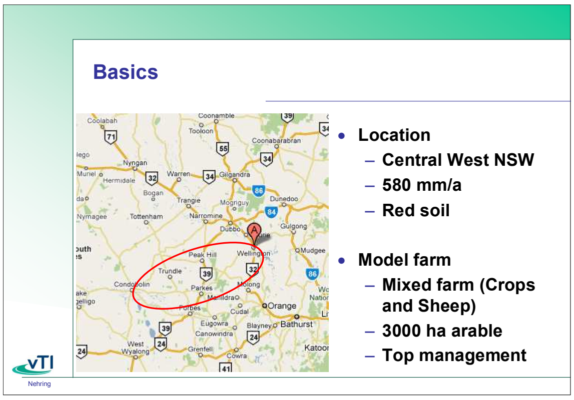
Notes: B-0 = Reference situation (average 2005-2009).
S-0 = High price scenario, no adjustments.
S-1 = High price scenario, agronomical adjustments.
S-2 = High price scenario, farm setup adjustments.

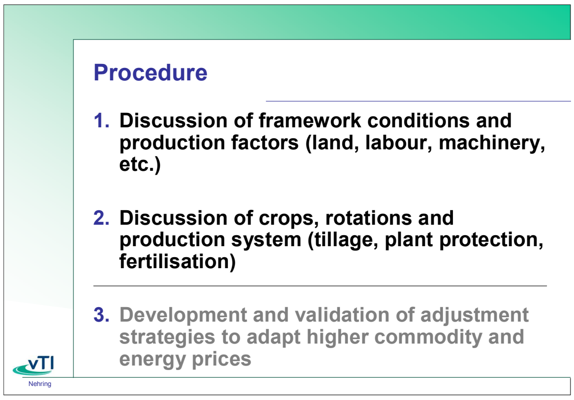
Source: Own illustration.

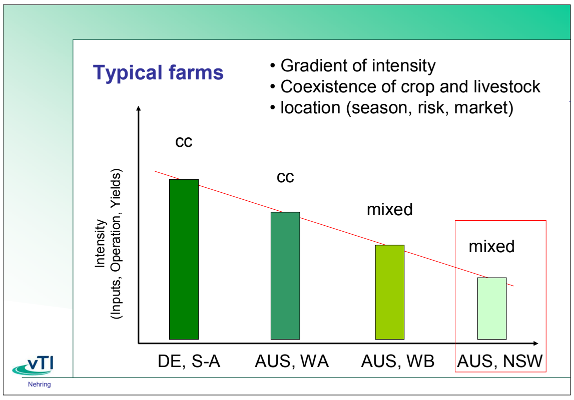
Figure A29: Stimulus presentation held at panel meetings -

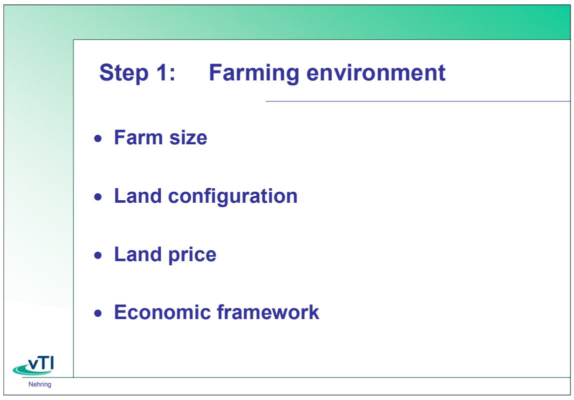












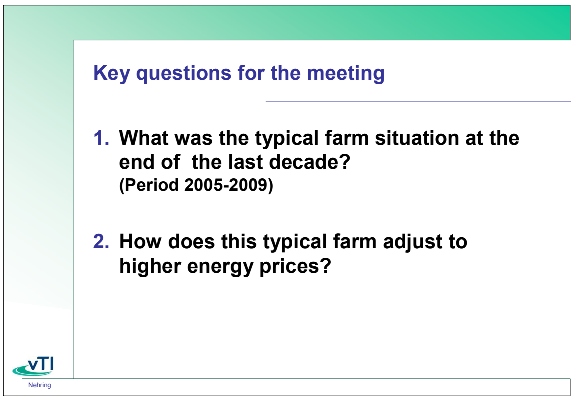


Figure A29: Stimulus presentation held at panel meetings **(cont.)**

Step 2: Production system

- Land use and yields
- Crop portfolio and rotations
- Production system of single crops
- Livestock management

Crude Oil price outlook (USD/barrel)

Projection	2010	2015	2020
EIA 2009 (Referenzscenario)	80	110	115
EIA 2009 (High price scenario)	91	157	183
EIA 2009 (Low price scenario)	58	50	50
IEA 2008 World Energy Outlook	100	100	110
EVA (Energy Ventures Analysis)	57	75	95
IHSGI	102	98	75
DB (Deutsche Bank)	47	72	66

Critical questions for step 1 & 2

- How solid is the production program?
- Is the Level of intensity subject to change with regard to rising/falling farm gate prices? What are the restrictions?
- What are the challenges of the actual situation?

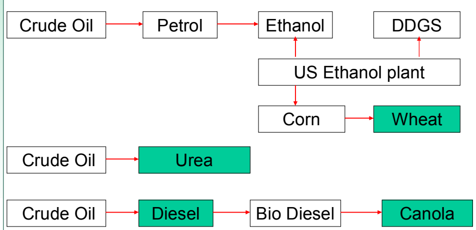
Further assumptions

- 2007 currency exchange rate (1 AUD = 0.83898 USD)
- Comparative static approach
  - No targeted time period
  - No time differentiation between buying and selling on farm

Procedure

1. Discussion of framework conditions and production factors (land, labour, machinery, etc.)
2. Discussion of crops, rotations and production system (tillage, plant protection, fertilisation)
3. **Development and validation of adjustment strategies to adapt higher commodity and energy prices**

Derivation



Scenario for Commodity and Energy prices

1. The minimum agricultural product prices can be derived from the oil price, as they can be transferred into biofuels to substitutes for petroleum products. (Bushel-Barrel-Correlation)
2. For grains rich in starch, ethanol production (particularly in the US due to the volume of the market) has the greatest impact on grain markets
3. The price for crude oil determines the price level for high energy agricultural inputs (Nitrogen, Diesel, Chemicals).
4. A higher crude oil price will be encountered with the recovery of the world economy and a renascent demand.

Scenario I

Commodities	Unit	Priceszenario NSW market	Priceszenario NSW farm gate
Crude Oil (WTI Spot Market)	USD/bbl	180	
Wheat (fob major ports)	USD/t	320	
Weizen	AUD/t	381	**356**
Barley	AUD/t	356	**331**
Triticale		341	**316**
Rapeseed (CIF)	USD/t	620	
Rapeseed	AUD/t	739	**704**
Chickpea	AUD/t		**690**
Field pea	AUD/t		
Lupins	AUD/t		
Corn (Iowa ethanol plant)	USD/t	240	
Soybean (CBOT)	USD/t	540	
	AUD/t	644	

Figure A29: Stimulus presentation held at panel meetings **(cont.)**

Scenario II

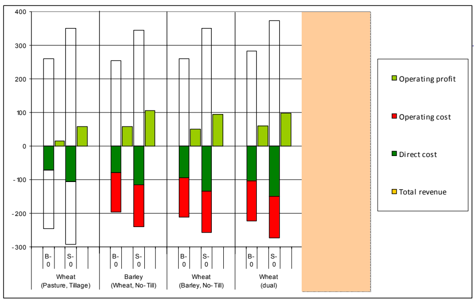
Fertilizer	Unit	Priceszenario NSW market	farm gate	
	USD/t	634		
Urea	AUD/t	756	1,64 $/kg N	
	USD/t	1000		
MAP	AUD/t	1192	2,11 $/kg P_2O_5	5,62 $/kg P
	USD/t	1200		
DAP	AUD/t	1430	2,47 $/kg P_2O_5	5,67 $/kg P

Potentials

- What are possible adjustments to the production system? What can be implemented realisticly?
- What are the effects on yields? Constraints for further intensification?
- What are the options to run livestock?
- What are the risks linked to higher prices?

Scenario III

Other inputs/straw	Unit	Priceszenario NSW market	farm gate
Rapeseed seed	AUD/kg		21
Wheat seed	AUD/kg		0,71
Chemicals			+20 %
	USD/Gal	5,43	
	AUD/l	1,71	1,80 $/l w/o tax
Diesel	AUD/l	2,20	2,27 $/l at pump
Org. fertilizer	AUD/t		
Wheat straw	AUD/t		160



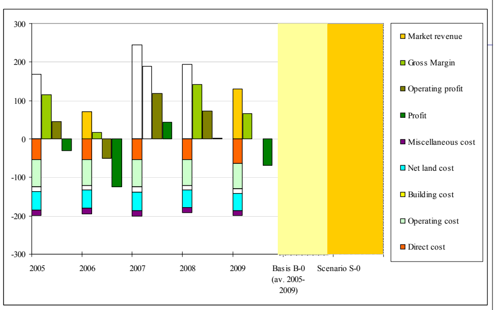


Table A47: Discussion guide line and data brochure for panel meetings -

Table 1		average 2005-2009
Mixed farm enterprise Central West NSW		
<u>Location</u>		
Shire		Wellington, Forbes, Parkes, Condobolin
Elevation	m	305
Relief		undulating
Average Temperature		
Max.	°C	23.4
Min	°C	10.9
Average Precipitation	l/year	580
Soil type		granite clay loam
Soil quality		
pH		5.5
<u>Business</u>		
Farm type		Mixed farm, cash crop and sheep
Other farm return (sheep)	$/year	180000
Tillage System		40 % tillage with cultivator
Reference years		Harvest 2004 - 2009

Table 2			average 2005-2009
Acreage & land price			
Total farm acreage	ha	3000	
Arable land	ha	1500	
thereof own land	ha	1425	
thereof rented land	ha	75	
Pasture	ha	1500	
Other	ha	0	
Landprice arable land	$/ha	2800	
Landrent old contracts (2/3)	$/ha	90	
Landrent new contracts* (1/3)	$/ha	80	
Calculated land cost	$/ha	87	
Governmental subsidy	$/ha or $/year		
Please specify type of subsidy			tax reduction on fuel 38 cent/l

* Opportunity cost own land

Table A47: Discussion guide line and data brochure for panel meetings **(cont.)**

Table 3 average 2005-2009

Crop portfolio

Typical crop rotation: Wheat - Barley - Wheat - Pasture (3 years)

	acreage	share	yield	price
Crop	[ha]	[%]	[t/ha]	[$/t]
Wheat (after pasture)	500	17%	1.40	244
Barley	500	17%	1.56	219
Wheat (after barley)	500	17%	1.40	244
Pasture (livestock)	1500	50%		
	3000	100%		

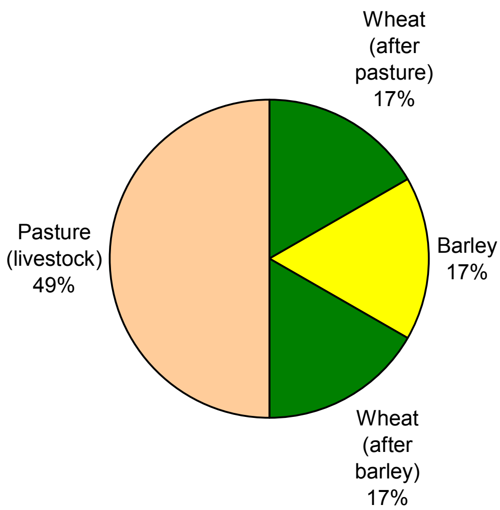


Table 4 average 2005-2009

Yields* and prices of main crops 2004 - 2009**

Year	Wheat		Barley		Oats		Triticale		Chickpea		Canola		Field Pea		Lupins	
	t/ha	AU$/t	**t/ha**	AU$/t	**t/ha**	AU$/t	**t/ha**	AU$/t	**t/ha**	AU$/t	**t/ha**	AU$/t	**t/ha**	AU$/t	**t/ha**	AU$/t
2005	**2.60**	140	**2.94**	115	**2.30**		**2.70**	100	**1.76**		**1.90**	350	**1.66**		**1.60**	
2006	**0.50**	320	**0.50**	295	**0.36**		**0.40**	280	**0.50**		**0.71**	600	**0.30**		**0.30**	
2007	**0.76**	395	**1.01**	370	**0.59**		**0.75**	355	**0.56**		**0.42**	700	**0.42**	650	**0.50**	
2008	**1.79**	248	**1.87**	223	**1.49**		**1.82**	208	**1.28**		**1.18**	585	**1.28**		**1.23**	
2009	**1.03**	180	**1.18**	155	**0.96**		**1.15**	140	**0.56**		**0.77**	360	**0.53**		**0.86**	
av.	**1.34**	257	**1.50**	232	**1.14**		**1.36**	217	**0.93**		**1.00**	519	**0.84**	650	**0.90**	

* average yields of typically grown varieties in selected regions

** all prices are farm gate prices for the respective harvest, averaging qualities and market period, excl. GST

Table A47: Discussion guide line and data brochure for panel meetings **(cont.)**

Table 5 average 2005-2009

Labour situation

	number	Input	Labour cost	Wage
Family labour		[h/year]	[AU$/a/AK]	[AU$/h]
Family member	2	2,500	62,500	25
Hired labour				
Casual worker	1	750	18,750	25

Number of workers		3
Labour density	Worker/100 ha	0.10
Labour input on farm	h/year	5,750
to crop enterprise	h/year	4,450
thereof hired labour	h/year	750
Labour cost incl. family labour	$/year	143,750
to crop enterprise	$/year	111,255
Labour input to crop enterprise	h/ha	3.0
	$/ha	48

Table A47: Discussion guide line and data brochure for panel meetings **(cont.)**

Table 6 average 2005-2009

Machinery

Position	Numbe	hp/m	Utilisation	Price	Purchase year	Depreciation period	Salvage value	Repurchase price
Tractors		PS	h/year	$		year(s)	$	$
2wd tractor + loader	1	120	500	140000	2005	10	14000	150000
4wd tractor	1	350	1200	280000	2000	10	28000	350000
Towed machinery		m	ha/year					
Boomspray towed	1	20	3000	80000	2005	12	7000	85000
Disc cultivator	1	6	1000	50000	1995	15	3500	0
Airseeder 40 ft.	1	12	1500	150000	2000	15	10000	150000
Selfpropelled machinery		PS/m	ha/year					
Utes	2	60	3000	20000	1995	20	1	30000
Truck	1	200	3000	60000	1995	30	6000	0
2388 Case Header	1	9	1500	350000	2005	8	44000	360000

Machinery new value	1,150,000	$
	383	$/ha*
Machinery current value	711,601	$
	237	$/ha*
Machinery depriciation	36	$/ha*
Repairs	24,000	$/year
	9	$/ha*

* per ha farmland

Table A47: Discussion guide line and data brochure for panel meetings **(cont.)**

Table 7 average 2005-2009

Buildings

Position	Construction year	Price	Depreciation period	Salvage value	Replacement cost
		$	year(s)	$	$
Farm buildings	1980	400000	75	1	400000
Bins (4)	1995	24000	20	1	0
Augers (3)	1995	20000	20	1	0
Silos (6)	1990	80000	20	1	0

Building's new value	524,000	$	
	175	$/ha*	
Building's current value	285,602	$	55% of new value
	95	$/ha*	
Depreciation	4	$/ha*	
Repairs	12,000	$/year	
	4	$/ha*	

* per ha farmland

Table A47: Discussion guide line and data brochure for panel meetings **(cont.)**

Tabelle 8 — Production system — average 2005-2009

Crop		**Wheat**
Acreage	ha	**500**
Yield	t/ha	**1.4**
Precrop		**Pasture**

Typical crop rotation: **Wheat** - Barley - Wheat - Pasture

Month	Operation	Capacity	Depth	Diesel	Seed	Fertilizer	N	P	K	CaO	Herbicide	Fungicide	Insekticide	other
---	---	ha/h	cm	l/ha	$/ha	---	kg/ha	kg/ha	kg/ha	kg/ha	$/ha	$/ha	$/ha	$/ha
mid 12	Tillage	8	5	6,25	0	---	0	0	0	0	0	0	0	0
end 02	Tillage	8	9	6,25	0	---	0	0	0	0	0	0	0	0
beg 05	Seeding	15	3	3,3	19	MAP	4,8	7,2	0	0	0	0	0	0
mid 07	Spraying	30	0	0,66	0	---	0	0	0	0	20	0	0	0
mid 08	Spraying	30	0	0,66	0	---	0	0	0	0	15	0	0	0
mid 11	Harvest	10	0	4	0	---	0	0	0	0	0	0	0	0

Tabelle 9 — Production system — average 2005-2009

Crop		**Barley**
Acreage	ha	**500**
Yield	t/ha	**1.56**
Precrop		**Wheat**

Typical crop rotation: Wheat - **Barley** - Wheat - Pasture

Month	Operation	Capacity	Depth	Diesel	Seed	Fertilizer	N	P	K	CaO	Herbicide	Fungicide	Insekticide	other
---	---	ha/h	cm	l/ha	$/ha	---	kg/ha	kg/ha	kg/ha	kg/ha	$/ha	$/ha	$/ha	$/ha
mid 12	Tillage	8	5	6,25	0	---	0	0	0	0	0	0	0	0
end 02	Tillage	8	9	6,25	0	---	0	0	0	0	0	0	0	0
beg 05	Seeding	15	3	3,3	19	MAP	4,8	7,2	0	0	0	0	0	0
mid 07	Spraying	30	0	0,66	0	---	0	0	0	0	20	0	0	0
mid 08	Spraying	30	0	0,66	0	---	0	0	0	0	15	0	0	0
mid 11	Harvest	10	0	4	0	---	0	0	0	0	0	0	0	0

Table A47: Discussion guide line and data brochure for panel meetings **(cont.)**

Tabelle 10 — Production system — average 2005-2009

Crop		**Wheat**
Acreage	ha	**500**
Yield	t/ha	**1.4**
Precrop		**Barley**

Typical crop rotation: Wheat - Barley - **Wheat** - Pasture

Month	Operation	Capacity	Depth	Diesel	Seed	Fertilizer	N	P	K	CaO	Herbicide	Fungicide	Insekticide	other
---	---	ha/h	cm	l/ha	$/ha	---	kg/ha	kg/ha	kg/ha	kg/ha	$/ha	$/ha	$/ha	$/ha
mid 12	Tillage	8	5	6,25	0	---	0	0	0	0	0	0	0	0
end 02	Tillage	8	9	6,25	0	---	0	0	0	0	0	0	0	0
beg 05	Seeding	15	3	3,3	19	MAP	4,8	7,2	0	0	0	0	0	0
mid 07	Spraying	30	0	0,66	0	---	0	0	0	0	20	0	0	0
mid 08	Spraying	30	0	0,66	0	---	0	0	0	0	15	0	0	0
mid 11	Harvest	10	0	4	0	---	0	0	0	0	0	0	0	0

Tabelle 11 — Production system — average 2005-2009

Crop		**Pasture**
Acreage	ha	**500/a**
Yield	t/ha	
Precrop		**Wheat**

Typical crop rotation: Wheat - Barley - Wheat - **Pasture**

Month	Operation	Capacity	Depth	Diesel	Seed	Fertilizer	N	P	K	CaO	Herbicide	Fungicide	Insekticide	other
---	---	ha/h	cm	l/ha	$/ha	---	kg/ha	kg/ha	kg/ha	kg/ha	$/ha	$/ha	$/ha	$/ha

Table A47: Discussion guide line and data brochure for panel meetings **(cont.)**

Tabelle 12 average 2005-2009

Gross margin calculation

	Unit	wheat	barley	wheat	pasture
Acreage	ha	500	500	500	
Yield	t/ha	1	1.56	1.40	
Return	$/ha	342	342	342	
Seed input	kg/ha	38.00	38	38	
Treatment	$/ha				
Seed total	**$/ha**	**19**	**19**	**19**	
Nitrogen (N)	kg/ha	5	5	5	
	$/ha	6	6	6	
Phosphorus (P)	kg/ha	7	7	7	
	$/ha	18	18	18	
Potassium (K)	kg/ha				
	$/ha				
Lime (CaO)	kg/ha				
	$/ha				
Other	$/ha				
Fertilizer total	**$/ha**	**24**	**24**	**24**	
Herbicide	$/ha	35	35	35	
Fungicide	$/ha				
Insekticide	$/ha				
Other	$/ha				
Plant Protection	**$/ha**	35	35	35	
Plant Establishment	**$/ha**	**78**	**78**	**78**	
Drying	$/ha				
Crop Insurance	$/ha				
Direct cost w/o finance	$/ha	78	78	78	
Direct Cost	**$/ha**	**80**	**80**	**80**	
Gross margin 1	**$/ha**	**261**	**261**	**261**	

Table A47: Discussion guide line and data brochure for panel meetings **(cont.)**

Tabelle 13 average 2004-2009

Operating cost, building, land, profit

	Unit	wheat	barley	wheat	pasture
Gross margin 1	**$/ha**	**261**	**261**	**261**	
Labour	Akh/ha	3	3	3	
	$/ha	74	74	74	
Contractor	$/ha				
Machinery	$/ha	117	117	117	
Diesel	$/ha	33	33	33	
Other	$/ha	0	0	0	
Operating cost	**$/ha**	**225**	**225**	**225**	
Direct + operating cost	$/ha	305	305	305	
Buildings	$/ha	17	17	17	
Land cost (rented and own land)	$/ha	115	115	115	
Other	$/ha				
Total cost	**$/ha**	**438**	**438**	**438**	
Profit w/o subsidy payment	**$/ha**	**-96**	**-96**	**-96**	
Subsidy payment	$/ha				
Return incl. subsidy payment	$/ha	342	342	342	
Profit	**$/ha**	**-96**	**-96**	**-96**	

Table A47: Discussion guide line and data brochure for panel meetings **(cont.)**

Table 14 — average 2005-2009

Overhead cost

Position	$/year	$/ha
Ground improvement (drainage, etc.)	0	0.00
Diesel (40.000 Liter @ $1,30 /l)	52000	17.33
Petrol	1000	0.33
Heating Gas	0	0.00
Electricity	2500	0.83
Water	5000	1.67
Insurance (Liability, Fire, ...)	2000	0.67
Insurance (Accident, …)	7000	2.33
Ground tax	25000	8.33
Consulting	2000	0.67
Bookkeeping	5000	1.67
Office	1500	0.50
Other	0	0.00

Table 15 — average 2005-2009

Finance

Equity share in current assets	100	%
Interest rate for short term loans (max. 1 year)	0	%
Equity share in fixed assets	65	%
Interest rate for long term loans (>5 years)	8,3	%
Duration of long term loans	10	year(s)
Interest rate for short term deposits (max. 1 year)	5	%
Interest rate for long term deposits (>5 years)	5	%

Figure A30: Invitation letter for panel meetings -

Johann Heinrich von Thünen-Institut
Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei

Dear participant,

Thank you very much for your willingness to attend the panel meeting with regard to the model farm in the Central West Region of NSW. The meeting will take place on

Friday, February 5th 2010, at 1:00 pm at the CANFA Office in Wellington.

The meeting has the following intended purpose:

- Discuss and approve the dataset of the model farm in Central West NSW based on your expertise and the existing figures for the years 2005-2009.
- Based on this reference situation we will then discuss adjustment strategies to adapt higher energy prices and their respective influences on agronomy, farm organisation and output for this typical farm. The price scenario for input and output prices are derived from the EIA oil price outlook. It will be introduces during the session.

You may find a summary of different key figures and production data for the model farm attached to this letter. It is based on yield statistics, farm comparison data and the research I have done so far in the area. To discuss these figures with you I would like to ask you to bring your latest records and summaries (crop and livestock records, machinery calculations, farm comparison and budgets) with you to the meeting.

I'm very happy to organise this farmer panel after working in this area initially two years ago and grateful for your ongoing support to my PhD project. Please don't hesitate to contact me on my mobile 0429 159850 in case there are any questions or remarks. Please find a preliminary program below.

Looking forward to meeting you on Friday.

Faithfully

Figure A30: Invitationletter for panel meetings **(cont.)**

Preliminary program

Topic	Time	Procedure
1. Regional characteristics and farm equipment	1:00 pm till 1:45 pm	Discussion of • Natural and economic framework conditions • Production factors (land, labour, machinery, etc.)
2. Production	1:45 pm till 2:30 pm	Discussion of • Crops and rotations • Production system (Tillage, plant protection, fertilisation)
3. Prediction of Potentials „On farm adjustment strategies for higher energy and commodity prices“	3:00 pm till 5:00 pm, time dependant on discussion	Introduction of the price scenario Discussion, development and validation of on farm strategies to adjust to higher energy and commodity prices. • Which adjustments are possible? What is realistic? • Which factors can drive/avoid intensification? • How do farm adaptation strategies affect yields and economic performance? • What are the risks of a higher price level? How can the risk be managed?

Figure A31: Handout for panel participants -

Scenario for Commodity and energy prices

Item		Unit	Reference years 2005	2006	2007	2008	2009	Avg.	Scenario Price	%-change Scenario vs. avg.
Crude Oil - WTI (Spot Market)		USD/bbl	57	66	72	100	62	**71**	**180**	+ 152
Products (farm gate)										
Wheat		AUD/t	140	320	395	248	180	**257**	**346**	+ 35
Barley (feed)		AUD/t	115	295	370	223	155	**232**	**313**	+ 35
Barley (malt)		AUD/t	--	--	--	--	--	**250**	**337**	+ 35
Canola		AUD/t	--	--	--	--	--	**450**	**704**	+ 56
Lupins		AUD/t	--	--	--	--	--	**270**	**323**	+ 20
Peas		AUD/t	--	--	--	--	--	**290**	**348**	+ 20
Oats		AUD/t	150	400	400	200	250	**280**	**330**	+ 18
Baled straw		AUD/t	--	--	--	--	--	**--**	**80**	
Inputs (farm gate)										
Seed	Cereal-seed	AUD/t	--	--	--	--	--	**280**	**400**	+ 43
	Canola-seed	AUD/t	--	--	--	--	--	**550**	**750**	+ 36
	All other crops		--	--	--	--	--	**--**	**--**	+ 20
Nitrogen (N)	Urea 46%N	AUD/kgN	1,00	1,07	1,07	1,37	1,78	**1,26**	**1,64**	+ 30
		AUD/t	459	491	490	630	819	**578**	**786**	+ 36
	Flexi-N[1] 32%N	AUD/kgN	--	--	--	--	--	**1,39**	**2,14**	+ 54
	NS-41[2] 35%N, 9%S	AUD/kgN	--	--	--	--	--	**1,19**	**1,80**	+ 51
Phosphate (P)	MAP[3] 11%N 22%P	AUD/kgP	2,10	2,21	2,21	2,21	4,41	**2,63**	**4,60**	+ 75
	DAP[4] 17%N 20%P	AUD/kgP	1,89	2,02	2,02	1,88	4,02	**2,37**	**4,22**	+ 78
	TSP[5] 20%P	AUD/kgP	--	--	--	--	--	**3,08**	**5,53**	+ 80
Potassium (K)	MOP[6] 50%K	AUD/kgK	--	--	--	--	--	**1,71**	**2,49**	+ 46
All pesticides			--	--	--	--	--	**--**	**--**	+ 20
Diesel fuel (EUR/l)		AUD/l	0,77	0,80	0,97	1,27	0,92	**0,95**	**1,50**	+ 59

Notes:
1) Flexi-N = Liquid N-fertiliser: 32% N in solution of ammonium nitrate and urea
2) NS-41 = 35% N of ammonium, 9% S of sulphate
3) MAP = Monoammonphosphate: 52% P_2O_5 = 22% P, 11% N of amminium
4) DAP = Diammonphosphate: 46% P_2O_5 = 20% P; 17% N of ammonium
5) TSP = Triplesuperphosphate: 46% P_2O_5 = 20% P
6) MOP = Muriate of Potash: 60% K_2O = 50% K

Table A48: Annual average currency exchange rates (2005–2009) -

AUD to EUR Year	AUD	EUR			
2005	1.00	0.61327	Average (365 Tage): 0.61327	Max: 0.64240	Min: 0.57630
2006	1.00	0.60027	Average (365 Tage): 0.60027	Max: 0.62600	Min: 0.57610
2007	1.00	0.61212	Average (365 Tage): 0.61212	Max: 0.64600	Min: 0.57270
2008	1.00	0.57743	Average (366 Tage): 0.57743	Max: 0.62780	Min: 0.47250
2009	1.00	0.56644	Average (365 Tage): 0.56644	Max: 0.62690	Min: 0.48730
Scenario	1.00	0.61212	Average (365 Tage): 0.61212	Max: 0.64600	Min: 0.57270

Source: www.oanda.com.

Table A49: Overview farm gate prices (DE 1300MB) in the reference situation (harvest 2005–2009) vs. scenario

Item		Unit	2005	2006	2007	2008	2009	Avg.	Price	%-change Scenario vs. avg.
			Reference years						Scenario	
Crude Oil - WTI (Spot Market)		USD/bbl	57	66	72	100	62	**71**	**180**	+ 152
Products (farm gate)										
Wheat		EUR/t	100	144	219	152	120	**147**	**215**	+ 46
Barley (feed)		EUR/t	90	130	197	137	108	**132**	**195**	+ 47
Rye		EUR/t	80	115	175	122	96	**118**	**170**	+ 45
Rapeseed		EUR/t	214	232	257	404	283	**278**	**433**	+ 56
Corn		EUR/t	95	137	208	144	114	**140**	**205**	+ 47
Sugarbeet (quota)		EUR/t	46	37	37	38	36	**39**	**39**	ceteris paribus
Sugarbeet (ethanol)		EUR/t	--	--	25	27	25	**26**	**31**	+ 20
Baled straw		EUR/t	--	--	--	--	--	--	**60**	
Inputs (farm gate)										
Seed	Wheat-seed	EUR/t	--	--	--	--	--	**338**	**486**	+ 44
	Rapeseed-seed	EUR/unit	--	--	--	--	--	**180**	**252**	+ 40
	Sugarbeet-seed	EUR/unit	--	--	--	--	--	**214**	**256**	+ 20
Nitrogen (N)	Urea 46 % N	EUR/kg N	0.50	0.51	0.47	0.63	0.93	**0.61**	**1.10**	+ 80
		EUR/t	232	234	217	289	430	**280**	**505**	+ 80
	AHL[1)] 28 % N	EUR/kg N	0.47	0.54	0.52	0.61	1.00	**0.63**	**1.20**	+ 91
	SSA[2)] 21 % N, 24 % S	EUR/kg N	0.50	0.51	0.47	0.63	0.93	**0.61**	**1.20**	+ 97
Phosphate (P)	TSP[3)] 20 % P	EUR/kg P	0.97	0.90	0.90	1.74	3.73	**1.65**	**2.86**	+ 73
Potassium (K)	K-40[4)] 33 % K	EUR/kg K	0.39	0.41	0.39	0.45	1.15	**0.56**	**0.96**	+ 71
Organic fertiliser	Dry Chicken Manure	EUR/t	18	18	17	20	24	**19**	**35**	+ 84
	Meat and Bone Meal	EUR/t	--	--	--	--	--	**51**	**130**	+ 155
	Compost		--	--	--	--	--	--	**30**	
All pesticides			--	--	--	--	--	--	--	+ 20
Diesel fuel		EUR/l	0.84	0.80	0.75	0.92	0.88	**0.84**	**1.59**	+ 89
Heating oil		EUR/l	0.45	0.50	0.48	0.63	0.43	**0.50**	**1.17**	+ 134

Notes: - 1) AHL = Liquid N-fertiliser: 28 % N of ammonium nitrate and urea.
2) SSA = Sulphate of ammonia: 21 % N of ammonium, 24% S of sulphate.
3) TSP = Triple-superphosphate: 46 % P2O5 = 20 % P.
4) K-40 = Chloride of potash: 40 % K2O = 33 % K.

Source: EIA (2009a), BMWI (2009), Walther et al. (2009), Paneldata (2009); own illustration.

Table A50: Overview farm gate prices (AU 4500SC) in the reference situation (harvest 2005–2009) vs. scenario

Item		Unit	Reference years						Scenario	
			2005	2006	2007	2008	2009	**Avg.**	**Price**	%-change Scenario vs. avg.
Crude Oil - WTI (Spot Market)		USD/bbl	57	66	72	100	62	**71**	**180**	+ 152
Products (farm gate)										
Wheat		EUR/t	110	125	236	152	119	**141**	**187**	+ 32
Barley (feed)		EUR/t	98	132	207	129	79	**122**	**165**	+ 35
Barley (malt)		EUR/t	110	150	238	146	116	**144**	**191**	+ 32
Canola		EUR/t	193	266	332	326	235	**258**	**388**	+ 50
Lupins		EUR/t	134	179	180	166	142	**153**	**179**	+ 17
Peas		EUR/t	--	--	--	--	--	**166**	**202**	+ 22
Oaten hay		EUR/t	--	--	--	--	--	**103**	**136**	+ 32
Baled straw		EUR/t	--	--	--	--	--	--	**45**	
Inputs (farm gate)										
Seed	Cereal-seed	EUR/t	--	--	--	--	--	**159**	**227**	+ 43
	Canola-seed	EUR/t	--	--	--	--	--	**312**	**425**	+ 36
	All other crops		--	--	--	--	--	--	--	+ 20
Nitrogen (N)	Urea 46 % N	EUR/kg N	0.55	0.58	0.59	0.72	0.91	**0.65**	**0.99**	+ 54
		EUR/t	255	267	272	329	420	**296**	**457**	+ 54
	Flexi-N[1)] 32 % N	EUR/kg N	--	--	0.65	0.77	0.97	**0.78**	**1.20**	+ 54
	NS-41[2)] 35 % N, 9 % S	EUR/kg N	0.55	0.58	0.59	0.72	0.91	**0.65**	**0.99**	+ 54
Phosphate (P)	MAP[3)] 11 % N, 22 % P	EUR/kg P	1.29	1.33	1.35	1.28	2.50	**1.49**	**2.58**	+ 74
	DAP[4)] 17 % N, 20 % P	EUR/kg P	1.07	1.10	1.12	1.00	2.14	**1.24**	**2.29**	+ 85
Potassium (K)	MOP[5)] 50% K	EUR/kg K	0.88	0.92	0.92	1.00	1.06	**0.92**	**1.41**	+ 54
All pesticides			--	--	--	--	--	--	--	+ 20
Diesel fuel		EUR/l	0.41	0.42	0.53	0.68	0.46	**0.48**	**0.82**	+ 71

Notes: - 1) Flexi-N = Liquid N-fertiliser: 32 % N in solution of ammonium nitrate and urea.
2) NS-41 = 35 % N of ammonium, 9 % S of sulphate.
3) MAP = Monoammonphosphate: 52 % P2O5 = 22 % P, 11 % N of amminium.
4) DAP = Diammonphosphate: 46 % P2O5 = 20 % K; 17 % N of ammonium.
5) MOP = Muriate of Potash: 60 % K20 = 50 % K.

Source: EIA (2009a), BMWI (2009), Walther et al. (2009), Paneldata (2010); own illustration.

Table A51: Overview farm gate prices (AU 4000WB) in the reference situation (harvest 2005–2009) vs. scenario

Item		Unit	Reference years						Scenario	
			2005	2006	2007	2008	2009	**Avg.**	**Price**	%-change Scenario vs. avg.
Crude Oil - WTI (Spot Market)		USD/bbl	57	66	72	100	62	**71**	**180**	+ 152
Products (farm gate)										
Wheat		EUR/t	110	127	230	188	101	**144**	**181**	+ 26
Barley (feed)		EUR/t	92	132	180	115	77	**113**	**133**	+ 17
Barley (malt)		EUR/t	110	--	211	--	110	**136**	**167**	+ 23
Canola		EUR/t	196	288	--	329	244	**255**	**382**	+ 50
Lupins		EUR/t	123	165	186	159	113	**142**	**173**	+ 22
Peas		EUR/t	135	147	196	202	130	**155**	**195**	+ 26
Oaten hay		EUR/t	101	107	105	118	95	**101**	**132**	+ 31
Baled straw		EUR/t	--	--	--	--	--	--	**45**	
Inputs (farm gate)										
Seed	Cereal-seed	EUR/t	--	--	--	--	--	**159**	**227**	+ 43
	Canola-seed	EUR/t	--	--	--	--	--	**312**	**425**	+ 36
	All other crops		--	--	--	--	--	--	--	+ 20
Nitrogen (N)	Urea 46 % N	EUR/kg N	0.58	0.61	0.62	0.75	0.96	**0.68**	**0.97**	+ 43
		EUR/t	268	281	286	346	442	**312**	**445**	+ 43
	Flexi-N[1)] 32 % N	EUR/kg N	--	--	0.65	0.77	0.97	**0.78**	**1.20**	+ 54
	NS-41[2)] 35 % N, 9 % S	EUR/kg N	0.55	0.58	0.59	0.72	0.91	**0.65**	**0.99**	+ 54
Phosphate (P)	MAP[3)] 11 % N, 22 % P	EUR/kg P	1.29	1.33	1.35	1.28	2.50	**1.49**	**2.58**	+ 74
	DAP[4)] 17 % N, 20 % P	EUR/kg P	1.13	1.16	1.18	1.06	2.25	**1.30**	**2.36**	+ 81
	TSP[5)] 20 % P	EUR/kg P	1.50	1.54	1.57	1.40	3.00	**1.73**	**3.13**	+ 81
Potassium (K)	MOP[6)] 50 % K	EUR/kg K	0.88	0.92	0.92	1.00	1.06	**0.92**	**1.41**	+ 54
All pesticides			--	--	--	--	--	--	--	+ 20
Diesel fuel		EUR/l	0.44	0.45	0.56	0.70	0.49	**0.51**	**0.82**	+ 62

Notes: 1) Flexi-N = Liquid N-fertiliser: 32 % N in solution of ammonium nitrate and urea.
2) NS-41 = 35 % N of ammonium, 9 % S of sulphate.
3) MAP = Monoammonphosphate: 52 % P_2O_5 = 22 % P, 11 % N of amminium.
4) DAP = Diammonphosphate: 46 % P_2O_5 = 20 % K; 17 % N of ammonium.
5) TSP = Triplesuperphosphate: 46 % P_2O_5 = 20 % P.
6) MOP = Muriate of Potash: 60 % K_20 = 50 % K.

Source: EIA (2009a), BMWI (2009), Walther et al. (2009), Paneldata (2010); own illustration.

Table A52: Overview farm gate prices (AU 2800CW) in the reference situation (harvest 2005–2009) vs. scenario

Item		Unit	Reference years						Scenario	
			2005	2006	2007	2008	2009	**Avg.**	**Price**	%-change Scenario vs. avg.
Crude Oil - WTI (Spot Market)		USD/bbl	57	66	72	100	62	**71**	**180**	+ 152
Products (farm gate)										
Wheat		EUR/t	86	192	242	143	102	**145**	**196**	+ 35
Barley (feed)		EUR/t	71	177	226	129	88	**131**	**177**	+ 35
Barley (malt)		EUR/t	--	--	--	--	--	**142**	**191**	+ 35
Canola		EUR/t	--	--	--	--	--	**255**	**399**	+ 56
Lupins		EUR/t	--	--	--	--	--	**153**	**183**	+ 20
Peas		EUR/t	--	--	--	--	--	**164**	**197**	+ 20
Oats		EUR/t	92	240	245	115	142	**159**	**187**	+ 18
Baled straw		EUR/t	--	--	--	--	--	--	**45**	
Inputs (farm gate)										
Seed	Cereal-seed	EUR/t	--	--	--	--	--	**159**	**227**	+ 43
	Canola-seed	EUR/t	--	--	--	--	--	**312**	**425**	+ 36
	All other crops		--	--	--	--	--	--	--	+ 20
Nitrogen (N)	Urea 46 % N	EUR/kg N	0.61	0.64	0.65	0.79	1.01	**0.71**	**0.93**	+ 30
		EUR/t	281	295	300	364	464	**327**	**445**	+ 36
	Flexi-N[1)] 32 % N	EUR/kg N	--	--	--	--	--	**0.79**	**1.21**	+ 54
	NS-41[2)] 35 % N, 9 % S	EUR/kg N	--	--	--	--	--	**0.67**	**1.02**	+ 51
Phosphate (P)	MAP[3)] 11 % N, 22 % P	EUR/kg P	1.29	1.33	1.35	1.28	2.50	**1.49**	**2.61**	+ 75
	DAP[4)] 17 % N, 20 % P	EUR/kg P	1.16	1.21	1.24	1.09	2.28	**1.34**	**2.39**	+ 78
	TSP[5)] 20 % P	EUR/kg P	--	--	--	--	--	**1.74**	**3.13**	+ 80
Potassium (K)	MOP[6)] 50 % K	EUR/kg K	--	--	--	--	--	**0.97**	**1.41**	+ 46
All pesticides			--	--	--	--	--	--	--	+ 20
Diesel fuel		EUR/l	0.47	0.48	0.59	0.73	0.52	**0.54**	**0.85**	+ 59

Notes: 1) Flexi-N = Liquid N-fertiliser: 32 % N in solution of ammonium nitrate and urea.
2) NS-41 = 35 % N of ammonium, 9 % S of sulphate.
3) MAP = Monoammonphosphate: 52 % P_2O_5 = 22 % P, 11 % N of amminium.
4) DAP = Diammonphosphate: 46 % P_2O_5 = 20 % K; 17 % N of ammonium.
5) TSP = Triplesuperphosphate: 46 % P_2O_5 = 20 % P.
6) MOP = Muriate of Potash: 60 % K_20 = 50 % K.

Source: EIA (2009a), BMWI (2009), Walther et al. (2009), Paneldata (2010); own illustration.

Table A53: Germany – Production ('000 t) of major agricultural commodities from 1990–2009

Commodity/ Year	Wheat	Barley	Rape-seed	Corn	Rye	Triticale	Oats	Peas, dry	Lupins	Sunflower seed	Lin-seed -
1990	15,242	13,992	2,088	1,552	3,988	389	2,105	122	10	74	4
1991	16,612	14,494	2,972	1,937	3,323	717	1,867	75	4	126	12
1992	15,542	12,197	2,617	2,139	2,422	890	1,314	74	1	161	70
1993	15,767	11,006	2,848	2,656	2,984	1,147	1,724	134	1	214	30
1994	16,539	10,903	2,896	2,446	3,451	1,125	1,663	151	--	311	27
1995	17,763	11,891	3,103	2,395	4,521	1,643	1,420	216	--	111	46
1996	18,922	12,074	1,970	2,913	4,214	2,128	1,606	301	--	103	74
1997	19,827	13,399	2,867	3,188	4,580	2,621	1,599	400	--	85	116
1998	20,188	12,512	3,388	2,781	4,775	2,814	1,279	589	--	85	194
1999	19,615	13,301	4,285	3,257	4,329	2,374	1,339	610	--	84	160
2000	21,622	12,106	3,586	3,324	4,154	2,800	1,087	409	--	64	90
2001	22,838	13,495	4,160	3,505	5,133	3,395	1,151	560	--	54	32
2002	20,818	10,928	3,849	3,738	3,666	3,068	1,016	413	--	52	10
2003	19,260	10,490	3,634	3,422	2,277	2,480	1,202	392	110	73	15
2004	25,427	12,993	5,277	4,213	3,830	3,290	1,186	464	90	70	23
2005	23,693	11,614	5,052	4,083	2,794	2,676	964	346	95	67	25
2006	22,428	11,967	5,337	3,220	2,644	2,237	830	288	85	62	14
2007	20,828	10,384	5,321	3,809	2,698	2,061	728	177	65	51	6
2008	25,989	11,967	5,155	5,106	3,744	2,381	793	141	50	49	4
2009	25,190	12,288	6,307	4,527	4,270	2,514	826	166	60	57	4

Source: FAOSTAT (2011); own illustration.

Table A54: Australia – Production ('000 t) of major agricultural commodities from 1990–2009

Commodity/ Year	Wheat	Barley	Sorghum	Rape-seed	Oats	Pota-toes	Seed cotton	Lupins	Triti-cale	Cotton-seed	Chick peas	Maize	Peas, dry	Cotton lint	Rice
1990	15,066	4,108	946	98	1,530	1,178	798	758	183	493	190	219	318	305	924
1991	10,557	4,530	751	170	1,690	1,136	1,133	1,047	175	686	222	194	473	447	787
1992	14,739	5,397	1,447	178	1,937	1,150	1,304	1,195	278	749	175	269	456	555	1,122
1993	16,479	6,668	548	305	1,647	1,129	937	1,480	262	528	193	199	558	409	955
1994	8,961	2,913	1,084	264	924	1,185	833	1,076	182	466	69	204	240	368	1,082
1995	16,504	5,823	1,273	557	1,875	1,122	849	1,559	469	474	287	242	530	375	1,137
1996	23,702	6,696	1,592	623	1,653	1,308	1,016	1,522	674	595	288	325	454	421	951
1997	19,224	6,482	1,425	855	1,634	1,286	1,470	1,561	633	860	200	398	316	610	1,388
1998	22,108	5,987	1,081	1,690	1,798	1,372	1,607	1,696	708	941	188	271	298	666	1,331
1999	24,757	5,043	1,891	2,426	1,118	1,327	1,740	1,968	764	1,024	230	338	357	716	1,390
2000	22,108	6,743	2,116	1,775	1,050	1,200	1,787	1,055	841	1,046	162	406	456	741	1,101
2001	24,299	8,280	1,935	1,756	1,434	1,302	1,959	1,215	860	1,140	258	345	512	819	1,643
2002	10,132	3,865	2,021	871	957	1,333	1,757	726	327	1,054	129	454	178	703	1,192
2003	26,132	10,382	1,465	1,703	2,018	1,247	933	1,180	826	546	199	310	487	387	438
2004	21,905	7,740	2,009	1,542	1,283	1,310	843	937	610	494	135	395	289	349	553
2005	25,173	9,483	2,011	1,436	1,688	1,288	1,557	1,285	676	912	123	420	585	645	339
2006	10,822	4,257	1,932	573	748	1,250	1,464	470	199	844	232	380	140	597	973
2007	13,569	7,160	1,283	1,214	1,502	1,212	721	662	450	388	313	240	268	301	163
2008	21,420	7,997	3,790	1,844	1,160	1,400	304	708	363	188	443	387	238	133	190
2009	21,656	8,098	2,692	1,910	1,244	1,179	802	614	545	465	445	376	356	329	270

Source: FAOSTAT (2011): own illustration.

Table A55: Barley production and export ('000 t) of major global producing and exporting countries from 2006 to 2008

Production ('000 tonnes) -					Export ('000 tonnes)				
Country	Rank (2008)	Year 2006	2007	2008	Country	Rank (2008)	Year 2006	2007	2008
Russian Fed.	1	18,037	15,559	23,149	Ukraine	1	4,569	2,521	5,741
Ukraine	2	11,341	5,981	12,612	France	2	4,262	5,101	5,025
France	3	10,401	9,474	12,172	**Australia**	**3**	**2,563**	**4,054**	**3,891**
Germany	**4**	**11,967**	**10,384**	**11,967**	Canada	4	1,514	1,950	2,347
Canada	5	9,573	10,984	11,781	**Germany**	**5**	**1,971**	**2,783**	**1,663**
Spain	6	8,136	11,945	11,261	Russian Fed.	6	1,268	1,873	1,496
Australia	**7**	**4,257**	**7,160**	**7,997**	Argentina	7	390	523	960
United Kingdom	8	5,239	5,079	6,144	Romania	8	119	140	645
Turkey	9	9,551	7,307	5,923	Kazakhstan	9	379	647	645
USA	10	3,923	4,575	5,230	USA	10	379	733	592
Poland	11	3,161	4,008	3,619	United Kingdom	11	566	471	558
Denmark	12	3,270	3,104	3,396	Denmark	12	498	516	538
China	13	3,369	2,788	2,823	Bulgaria	13	182	181	495
Czech Republic	14	1,898	1,893	2,244	Hungary	14	310	364	479
Belarus	15	1,831	1,911	2,212	Lithuania	15	329	228	316
World		139,493	134,118	154,715	World -		24,024	23,605	27,182

Source: FAOSTAT (2011); own illustration.

Table A56: Pea production and export ('000 t) of major global producing and exporting countries from 2006 to 2008

Production ('000 tonnes) -					Export ('000 tonnes)				
Country	Rank (2008)	Year 2006	2007	2008	Country	Rank (2008)	Year 2006	2007	2008
Canada	1	2,520	2,935	3,571	Canada	1	2,333	2,188	1,918
Russian Fed.	2	1,151	863	1,257	USA	2	431	483	499
China	3	1,013	1,080	1,100	France	3	439	350	279
India	4	710	800	750	**Australia**	**4**	**138**	**141**	**137**
USA	5	599	739	557	Ukraine	5	270	80	77
Ukraine	6	653	268	455	Belgium	6	29	60	73
France	7	1,016	594	451	Tanzania	7	25	10	72
Australia	**8**	**140**	**268**	**238**	Russian Fed.	8	92	21	41
Ethiopia	9	182	210	232	Malawi	9	5	21	35
Germany	**10**	**288**	**177**	**141**	Argentina	10	63	37	34
Spain	11	190	160	138	Netherlands	11	15	20	27
United Kingdom	12	145	130	91	**Germany**	**12**	**51**	**43**	**20**
Pakistan	13	52	71	64	Denmark	13	11	15	18
Myanmar	14	45	56	60	Hungary	14	11	13	13
Colombia	15	38	46	54	New Zealand	15	13	15	13
World -		9,811	9,312	10,040	World		4,172	3,652	3,360

Source: FAOSTAT (2011): own illustration.

Table A57: Lupin and chickpea production ('000 t) of major global producing countries from 2006 to 2008

Production ('000 tonnes)					Export ('000 tonnes)				
Country	Rank (2008)	2006	Year 2007	2008	Country	Rank (2008)	2006	Year 2007	2008
Australia	**1**	**437**	**665**	**632**	India	1	5,575	6,334	5,749
Belarus	2	54	47	81	Pakistan	2	480	838	475
Germany	**3**	**85**	**65**	**50**	Turkey	3	552	505	518
Poland	4	28	56	40	**Australia**	**4**	**241**	**222**	**506**
Chile	5	70	51	32	Myanmar	5	260	330	348
Russian Fed.	6	14	17	22	Ethiopia	6	211	254	287
South Africa	7	14	13	18	Iran	7	325	329	113
Ukraine	8	7	8	14	Mexico	8	163	148	165
Peru	9	8	8	9	Canada	9	163	225	67
Lithuania	10	5	8	7	USA	10	70	69	51
France	11	17	11	7	Syrian Rep.	11	52	50	27
Morocco	12	7	6	6	Malawi	12	35	40	38
Italy	13	6	5	5	Yemen	13	54	63	58
Spain	14	7	6	4	Tanzania	14	31	31	34
Egypt	15	3	3	2	Morocco	15	66	33	38
World		801	972	1,008	World		8,458	9,747	8,604

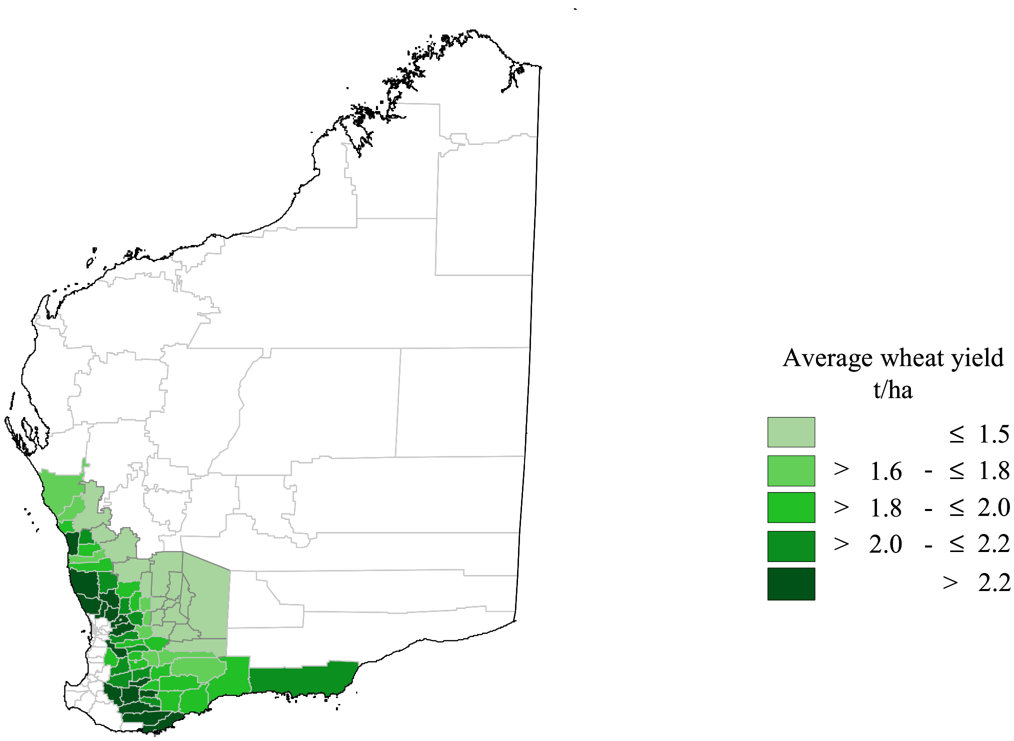
Source: FAOSTAT (2011); own illustration.

Table A58: Selected soil parameters of investigation regions -

	Location	Nitrogen			
		NitrateN mg/100g	AmmoniumN mg/100g	kg N/ha	PlantAccesN kg N/ha
DE-SA	Magdeburger Börde	0.07	1.84	96	76
AU-WA	South Coast (heavy)	2.54	2.06	230	184
AU-WA	South Coast (light)	1.46	1.98	172	138
AU-WA	Wheatbelt (heavy)	0.16	2.05	110	88
AU-WA	Wheatbelt (light)	0.09	1.79	94	75
AU-NSW	Central West	0.48	2.25	137	109
		Sulfur			
		SO4 mg/100g	S kg/ha	N/S ratio	
DE-SA	Magdeburger Börde	0.44	22	4.3	
AU-WA	South Coast (heavy)	1.78	89	2.6	
AU-WA	South Coast (light)	0.92	46	3.7	
AU-WA	Wheatbelt (heavy)	0.31	16	7.1	
AU-WA	Wheatbelt (light)	0.51	26	3.7	
AU-NSW	Central West	0.63	32	4.3	
		Phosphorus			
		mg/100g	Class		
DE-SA	Magdeburger Börde	8.5	D		
AU-WA	South Coast (heavy)	5.8	C		
AU-WA	South Coast (light)	3.4	B		
AU-WA	Wheatbelt (heavy)	2.0	A		
AU-WA	Wheatbelt (light)	1.5	A		
AU-NSW	Central West	2.5	A		
		Potassium			
		mg/100g	Class		
DE-SA	Magdeburger Börde	15	D		
AU-WA	South Coast (heavy)	12	D		
AU-WA	South Coast (light)	39	E		
AU-WA	Wheatbelt (heavy)	36	E		
AU-WA	Wheatbelt (light)	2	A		
AU-NSW	Central West	82	E		
		Magnesium			
		mg/100g	Claas		
DE-SA	Magdeburger Börde	10.2	E		
AU-WA	South Coast (heavy)	21.2	E		
AU-WA	South Coast (light)	13.0	E		
AU-WA	Wheatbelt (heavy)	21.3	E		
AU-WA	Wheatbelt (light)	7.3	E		
AU-NSW	Central West	31.0	E		
		Magnesium			
		mg/100g	Claas		
DE-SA	Magdeburger Börde	10.2	E		
AU-WA	South Coast (heavy)	21.2	E		
AU-WA	South Coast (light)	13.0	E		
AU-WA	Wheatbelt (heavy)	21.3	E		
AU-WA	Wheatbelt (light)	7.3	E		
AU-NSW	Central West	31.0	E		
		Humus content			
		%			
DE-SA	Magdeburger Börde	2.5			
AU-WA	South Coast (heavy)	4.8			
AU-WA	South Coast (light)	4.8			
AU-WA	Wheatbelt (heavy)	2.1			
AU-WA	Wheatbelt (light)	2.1			
AU-NSW	Central West	4.7			

Source: ENTSORGUNGSGESELLSCHAFT ELBE UMWELTLABOR GMBH (Magdeburg, Germany).

Figure A32: Wheat yield in the cropping zones of Western Australia (Average 2004–2008)



Source: ABS (2010c); own illustration.

Lieferbare Sonderhefte / Special issues available

318	Yelto Zimmer, Stefan Berenz, Helmut Döhler, Folkhard Isermeyer, Ludwig Leible, Norbert Schmitz, Jörg Schweinle, Thore Toews, Ulrich Tuch, Armin Vetter, Thomas de Witte *(2008)* **Klima- und energiepolitische Analyse ausgewählter Bioenergie-Linien**	14,00 €
319	Ludger Grünhage and Hans-Dieter Haenel *(2008)* **Detailed documentation of the PLATIN (PLant-ATmosphere Interaction) model**	10,00 €
320	Gerold Rahmann und Ulrich Schumacher (Hrsg.) *(2008)* **Praxis trifft Forschung — Neues aus der Ökologischen Tierhaltung 2008**	14,00 €
321	Bernd Degen (Editor) *(2008)* **Proceedings of the international workshop “Fingerprinting methods for the identification of timber origins”, Bonn, October 8-9 2007**	18,00 €
322	Wilfried Brade, Gerhard Flachowsky, Lars Schrader (Hrsg) *(2008)* **Legehuhnzucht und Eiererzeugung - Empfehlungen für die Praxis**	12,00 €
323	Christian Dominik Ebmeyer *(2008)* **Crop portfolio composition under shifting output price relations – Analyzed for selected locations in Canada and Germany –**	14,00 €
324	Ulrich Dämmgen (Hrsg.) *(2009)* **Calculations of Emissions from German Agriculture – National Emission Inventory Report (NIR) 2009 for 2007** **Berechnungen der Emissionen aus der deutschen Landwirtschaft – Nationaler Emissionsbericht (NIR) 2009 für 2007**	8,00 €
324A	**Tables** **Tabellen**	8,00 €
325	Frank Offermann, Martina Brockmeier, Horst Gömann, Werner Kleinhanß, Peter Kreins, Oliver von Ledebur, Bernhard Osterburg, Janine Pelikan, Petra Salamon *(2009)* **vTI-Baseline 2008**	8,00 €
326	Gerold Rahmann (Hrsg.) *(2009)* **Ressortforschung für den Ökologischen Landbau 2008**	8,00 €
327	Björn Seintsch, Matthias Dieter (Hrsg.) *(2009)* **Waldstrategie 2020** Tagungsband zum Symposium des BMELV, 10.-11. Dez. 2008, Berlin	18,00 €
328	Walter Dirksmeyer, Heinz Sourell (Hrsg.) *(2009)* **Wasser im Gartenbau –** Tagungsband zum Statusseminar am 9. und 10. Februar 2009 im Forum des vTI in Braunschweig. Organisiert im Auftrag des BMELV	8,00 €
329	Janine Pelikan, Martina Brockmeier, Werner Kleinhanß, Andreas Tietz, Peter Weingarten *(2009)* **Auswirkungen eines EU-Beitritts der Türkei**	8,00 €
330	Walter Dirksmeyer (Hrsg.) *(2009)* **Status quo und Perspektiven des deutschen Produktionsgartenbaus**	14,00 €
331	Frieder Jörg Schwarz, Ulrich Meyer *(2009)* **Optimierung des Futterwertes von Mais und Maisprodukten**	12,00 €
332	Gerold Rahmann und Ulrich Schumacher (Hrsg.) *(2009)* **Praxis trifft Forschung — Neues aus der Ökologischen Tierhaltung 2009**	8,00 €
333	Frank Offermann, Horst Gömann, Werner Kleinhanß, Peter Kreins, Oliver von Ledebur, Bernhard Osterburg, Janine Pelikan, Petra Salamon, Jürn Sanders *(2010)* **vTI-Baseline 2009 – 2019: Agrarökonomische Projektionen für Deutschland**	10,00 €

334 Hans-Dieter Haenel (Hrsg.) *(2010)* 12,00 €
Calculations of Emissions from German Agriculture - National Emission Inventory Report (NIR) 2010 for 2008
Berechnung der Emissionen aus der deutschen Landwirtschaft - Nationaler Emissionsbericht (NIR) 2010 für 2008

335 Gerold Rahmann (Hrsg.) *(2010)* 8,00 €
Ressortforschung für den Ökologischen Landbau 2009

336 Peter Kreins, Horst Behrendt, Horst Gömann, Claudia Heidecke, Ulrike Hirt, Ralf Kunkel, Kirsten Seidel, Björn Tetzlaff, Frank Wendland *(2010)* 22,00 €
Analyse von Agrar- und Umweltmaßnahmen im Bereich des landwirtschaftlichen Gewässerschutzes vor dem Hintergrund der EG-Wasserrahmenrichtlinie in der Flussgebietseinheit Weser

337 Ulrich Dämmgen, Lotti Thöni, Ralf Lumpp, Kerstin Gilke, Eva Seitler und Marion Bullinger *(2010)* 8,00 €
Feldexperiment zum Methodenvergleich von Ammoniak- und Ammonium-Konzentrationsmessungen in der Umgebungsluft, 2005 bis 2008 in Braunschweig

338 Janine Pelikan, Folkhard Isermeyer, Frank Offermann, Jürn Sanders und Yelto Zimmer *(2010)* 10,00 €
Auswirkungen einer Handelsliberalisierung auf die deutsche und europäische Landwirtschaft

339 Gerald Schwarz, Hiltrud Nieberg und Jürn Sanders *(2010)* 14,00 €
Organic Farming Support Payments in the EU

340 Shrini K. Upadhyaya, D. K. Giles, Silvia Haneklaus, and Ewald Schnug (Editors) *(2010)* 8,00 €
Advanced Engineering Systems for Specialty Crops: A Review of Precision Agriculture for Water, Chemical, and Nutrient - Application, and Yield Monitoring

341 Gerold Rahmann und Ulrich Schumacher (Hrsg.) *(2010)* 8,00 €
Praxis trifft Forschung — Neues aus der Ökologischen Tierhaltung 2010

342 Claus Rösemann, Hans-Dieter Haenel, Eike Poddey, Ulrich Dämmgen, Helmut Döhler, Brigitte Eurich-Menden, Petra Laubach, Maria Dieterle, Bernhard Osterburg *(2011)* 12,00 €
Calculation of gaseous and particulate emissions from German agriculture 1990 - 2009
Berechnung von gas- und partikelförmigen Emissionen aus der deutschen Landwirtschaft 1990 - 2009

343 Katja Oehmichen, Burkhard Demant, Karsten Dunger, Erik Grüneberg, Petra Hennig, Franz Kroiher, Mirko Neubauer, Heino Polley, Thomas Riedel, Joachim Rock, Frank Schwitzgebel, Wolfgang Stümer, Nicole Wellbrock, Daniel Ziche, Andreas Bolte *(2011)* 16,00 €
Inventurstudie 2008 und Treibhausgasinventar Wald

344 Dierk Kownatzki, Wolf-Ulrich Kriebitzsch, Andreas Bolte, Heike Liesebach, Uwe Schmitt, Peter Elsasser *(2011)* 10,00 €
Zum Douglasienanbau in Deutschland – Ökologische, waldbauliche, genetische und holzbiologische Gesichtspunkte des Douglasienanbaus in Deutschland und den angrenzenden Staaten aus naturwissenschaftlicher und gesellschaftspolitischer Sicht

345 Daniel Heinrich Brüggemann *(2011)* 14,00 €
Anpassungsmöglichkeiten der deutschen Rindermast an die Liberalisierung der Agrarmärkte

346 Gerold Rahmann (Hrsg.) *(2011)* 8,00 €
Ressortforschung für den Ökologischen Landbau 2010

347 Hiltrud Nieberg, Heike Kuhnert und Jürn Sanders *(2011)* 12,00 €
Förderung des ökologischen Landbaus in Deutschland – Stand, Entwicklung und internationale Perspektive – 2., überarbeitete und aktualisierte Auflage

348 Herwart Böhm (Hrsg.) *(2011)* 12,00 €
Optimierung der ökologischen Kartoffelproduktion

349 Klaus Nehring *(2011)* 18,00 €
Farm level implications of high commodity prices – An assessment of adaptation strategies and potentials in selected regions in Australia and Germany –

Johann Heinrich
von Thünen-Institut

Landbauforschung
vTI Agriculture and Forestry Research

Sonderheft 349
Special Issue

Preis / Price 18 €

ISBN 978-3-86576-089-0

9 783865 760890