# Sustainable Development in Agriculture - Global Key Issues -

NASIR EL BASSAM

Institute of Crop Science

## 1 Introduction

High demographic pressure, a growing rural exodus, and change in food consumption practices associated in part with urbanization and rapid deterioration of natural resources in developing countries are drastic in scale and impact both locally and globally. The improvement and modification of agricultural production systems in these countries is a determining factor also for their economic development.

In addition, agriculture in developed countries is facing a period of uncertainty and change. Intensive farming has led to over-production associated with contamination and deterioration of soil, water and vegetation. There is an increasing awareness that excessive use of fossil fuels and the gas emissions from various industrial activities ($CO_2$, $NH_4$, $NO_x$, ...) may be causing global climate change with their effects on range and intensity of temperatures, precipitation and winds, generated by the global warming effects. This influences, to a large extent, the sustainability of natural production systems. Large landscapes have been affected in recent years by severe floods, hurricanes, long drought periods, fires etc. El niño is the most popular phenomenon in this context. These effects might serve as a source for migration and conflict between generations and communities.

Sustainable development has been defined by the World Commission on Environment and Development in, "Our Common Future" (Brundtland, 1987) as a strategy that meets the needs of the present without compromising the ability of future generations to achieve their own requirements. The key concept is to promote the conservation and the sustainable use of natural resources, which allows long term economic growth and enhancement of productive capacity, along with being equitable and environmentally acceptable.

So far so good! But what are the key issues of sustainability in agricultural production systems to ensure a global food security and sustainable resource management. "Food for all" is a vision or a realistic target, especially if we know that:

- more than 800 million people suffer from hunger and malnutrition in Africa, Asia, Latin America and even in Europe and the USA,
- one and a half billion people suffer from a shortage or inadequate supply of water,
- more than 2 billion people have no access to modern energy sources,
- increasing indications that "global warming" is becoming reality,
- depletion of fossil energy resources,
- each year ca. 11.2 million hectares of forest disappear,
- about 2000 million hectares of land have been degraded globally.

These are the real sources of conflict, instability and migration and represent a great challenge to us all.

## 2 Key issues of sustainability

Fundamentals of sustainability in agricultural production systems could be summarized in 5 major elements (See also **Figure 1**):

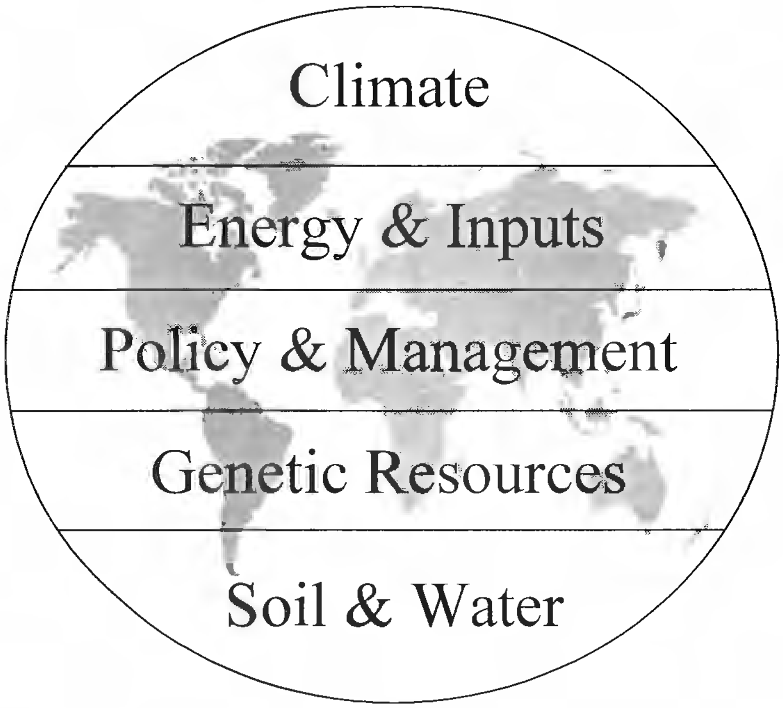


**Figure 1:** Fundamentals of sustainability in agriculture

1. Policy and management: political dimensions including economical, cultural and social issues, research and development as well as population control policy.
2. Energy and inputs: energy resources, fertilizers, plant protection, ecological farming, techniques and technology.
3. Genetic resources: identification, evaluation, and utilization of genetic resources.
4. Climate: constraints and impacts.
5. Soil and water: resources and requirements.

## 2.1 Policy and Management

Sustainability is above all a mental question. It reflects a major issue in our understanding of the necessity and of who is responsible for whom and for what in making sure that the world functions in a productive and effective way into the future.

Lombardi (1994) stated, "sustainability, I've discovered, is the effort to make sure that nobody else in the world pursues the same policy towards profitability and prosperity as the United States did." This has to a large extent validity also to other industrialized countries. He also states that, "we have diverted streams and rivers and irrigated the desert in order to make the most productive food area that there is any place, while on the other hand, we want the Brazilians to not develop by not cutting down their trees because we want to breathe. They want to do it because they want to eat, we do not want to let them do what we did." In this statement, Lombardi tried to reflect the recent form of contracting discussion between representatives of the "Northern" an "Southern" hemispheres.

It should be fully understood that we are one earth, one humanity and one future. Our way of thinking is to be changed from, "I, Here and Now" to "We, Everywhere for Today and Tomorrow." Unless we become the responsible stewards of current and future generations, we will face more unprecedented and severe regional and global changes and environmental inequities (Declaration of Braunschweig, 1998).

It is the responsibility of the nations to ensure the development of a policy which takes into account the above mentioned aspects. Such a policy has to consider cultural, social and economical dimensions which have been discussed in detail in the following chapters of this book. Dialogue, cooperation and research are the tools to overcome the major challenges of humanity and to ensure sustainable development for the current and future generations.

If we will succeed in shifting our common sense of understanding toward the necessity of sustainable management of the natural resources as a global responsibility it will be possible to develop long-term policies.

## 2.2 Energy and inputs

Energy is directly related to the most critical social issues which affect sustainable development: poverty, jobs, income levels, access to social services, gender disparity, population growth, agricultural production, climate change and environmental quality, and economic and security issues. Without adequate attention to the critical importance of energy to all of these aspects, the global social, economical and environmental goals of sustainability cannot be achieved. Indeed, the magnitude of change needed is immense, fundamental and directly related to the energy produced and consumed internationally.

The importance of energy in agricultural production, food preparation and consumption is evident and essential (UNDP, 1997). The world still continues to seek energy to satisfy its needs without giving due consideration to the social, environmental, economical and security impacts of its uses. It is now clear that current approaches to energy are unsustainable. It is the responsibility of political institutions to ensure that research and the development of technologies supporting sustainable systems be transferred to the end users. Scientists must bear the responsibility to understand the earth as an integrated whole and the impact of our actions on the global environment in order to ensure sustainability and to avoid disorder in the natural life cycle.

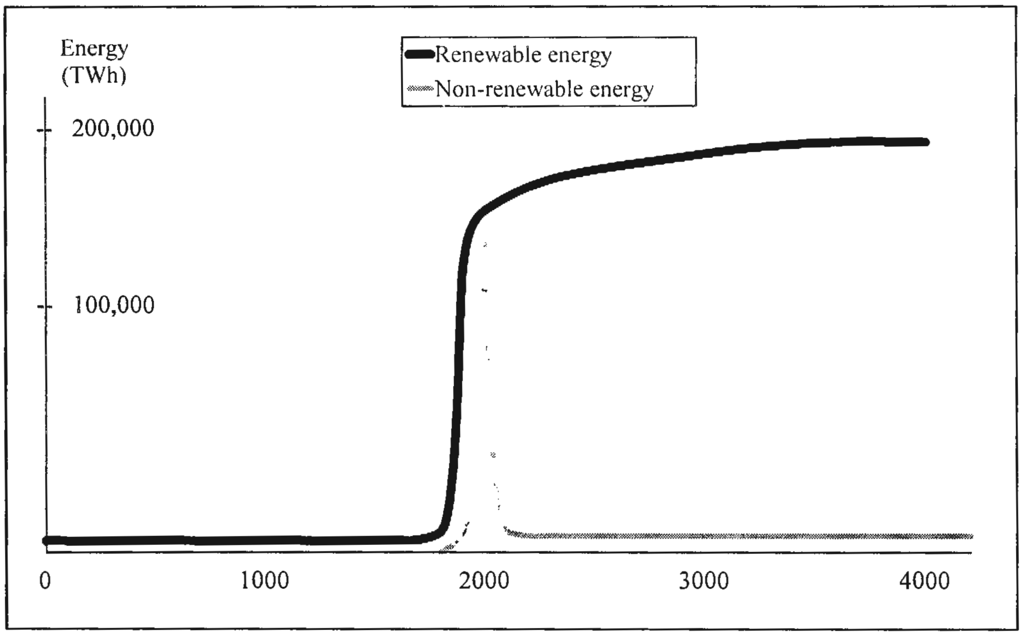


**Figure 2:** Past, present and future energy sources

The key challenge to realizing these targets is to overcome the lack of commitment and to develop the political will to protect people and the natural resource base. Failure to take action will lead to continuing degradation of natural resources, increasing conflicts over scarce resources and widening gaps between the rich and poor. We must act while we still have choices. Implementing sustainable energy strategies is one of the most important levers humankind has for creating a sustainable world. Most present trends in energy indicate a deteriorating situation (UNDP, 1997). Furthermore, current energy patterns are aggravating this process by an over-preoccupation with centralized energy supply and fossil fuels to the detriment of energy efficiency, decentralized supply and renewable energy (See **Figure 2**). Business-as-usual energy patterns and conventional approaches to energy are contributing to the unsustainability. Thus, any attempt to tackle the social, environmental, economical and security issues as done by the UN Conference in Rio, must pay full attention to the energy aspects.

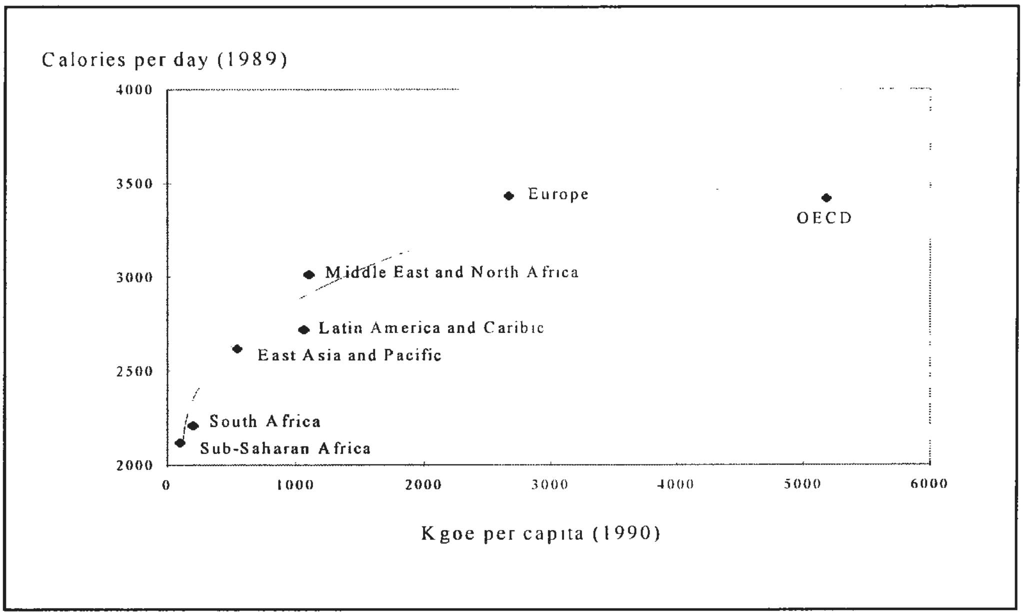


**Figure 3:** Future energy requirements of Africa's agriculture (FAO, 1995)

Economic development is closely correlated to the availability and utilization of modern energy sources. Also, the production and consumption of food is linked to the amount of energy used (See **Figure 3**). In 1990, the per capita consumption of modern energy for 21 African countries was less than 100 Kgoe (World Bank, 1992). In many of these countries daily per capita caloric supply is below 2000 calories. Food production is unlikely to grow without greater access to modern energy (FAO, 1995).

We are dramatically approaching the end of the availability of fossil energy resources, especially oil (Declaration of Braunschweig, 1998). Renewable energy sources offer the possibility to ensure energy supply in the future. Biomass, among all renewable energy sources, has the highest potential for substitution of fossil fuels in various regions of the world. Advanced technology in bioenergy would facilitate decentralized rural electrification and thereby promote rural development.

We need to conserve some of the fossil fuel resources for the future and create adequate substitutes in quantities which could meet the requirements of the people and enable future development. Brundtland (1987) wrote in the report to the UN, "every effort should be made to develop the potential for renewable energy sources which

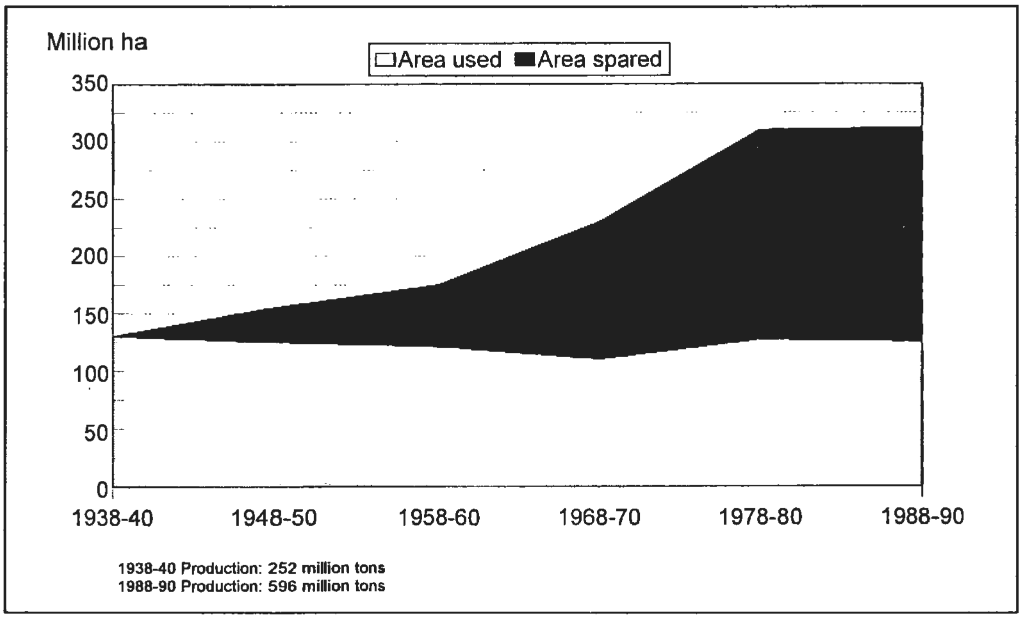


**Figure 4:** USA total crop area spared by application of improved technology on 17 food, feed and fiber crops in the period from 1938-40 to 1988-90

should form the foundation of the global energy structure."

Adequate use of other inputs such as fertilizers, herbicides, pesticides, improved seeds, equipment and various technical means, as well as adequate post harvest storage, transport and distribution facilities are essential to enhance acreage yield and reduce the area needed for food production (See **Figure 4**) (Borlaug and Dowswell, 1996).

The area required for the production of food, water and oxygen has been identified for biological life support systems under controlled environments (El Bassam, 1998):

| Major supplies | Area required |
|---|---|
| Food | 15-20 $m^2$ per person |
| Oxygen | 6-10 $m^2$ per person |
| Water | 3-6 $m^2$ per person |

This can be achieved if innovative technical means and efficient material recycling systems would be implemented.

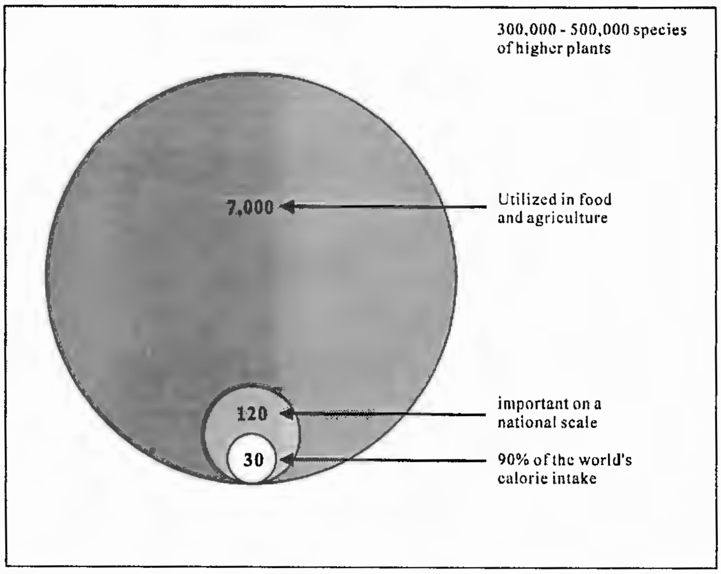


**Figure 5:** Estimated number of food crop species (FAO, 1996)

## 2.3 Genetic Resources

Plant genetic resources as a distinct part of biodiversity comprise the genetic materials which exist in primitive forms and wild species, traditional varieties and modern cultivars as well as bacteria, fungi and viruses. Plant genetic resources for food and agriculture include resources which contribute to people's livelihood by providing food, feed, fiber, fuel, shelter, and medicine etc. It has been estimated that there are 300,000 - 500,000 species of higher plants, of which approximately 250,000 have been identified or described. About 30,000 are edible and about 7000 have been cultivated or collected by humans for food during the history of mankind. Thus, several thousand species may be considered to contribute to food security. Today, only 30 crops deliver 90 % of the world's caloric intake (rice 26 %, wheat 23 %, maize 7 % and millet & sorghum 4 %) (See **Figure 5**).

It would be a vital task to increase the number of plant species which might be grown for food, feed and feedstocks for energy and industry. This can be done by identification,

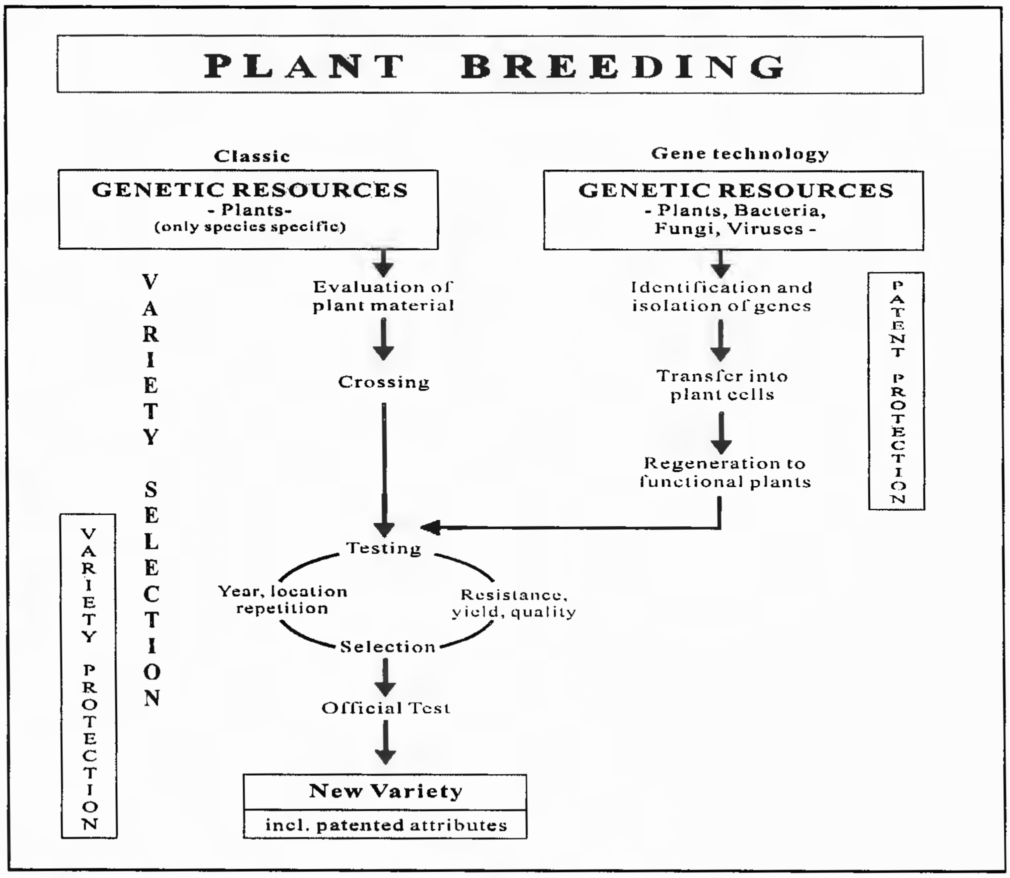


**Figure 6:** Breeding new plant varieties through classic and gene technology approaches (Büchting, 1997)

screening, adaptation and breeding a part of the large potential of plant genetic resources. The introduction of new plant species to agriculture will lead to an improvement of the biological and environmental conditions, soils, water, vegetation and landscapes. This can be achieved through increasing the biodiversity to substitute the present monoculture production systems.

The development and introduction of biotechnology and gene technology could offer new chances to accelerate and support the traditional plant breeding procedures (See **Figure 6**). This can be possible especially in development of new resistant cultivars and cultivars with special qualitative features for human and animal nutrition, as well as for the development of various chemical compounds and biochemical products.

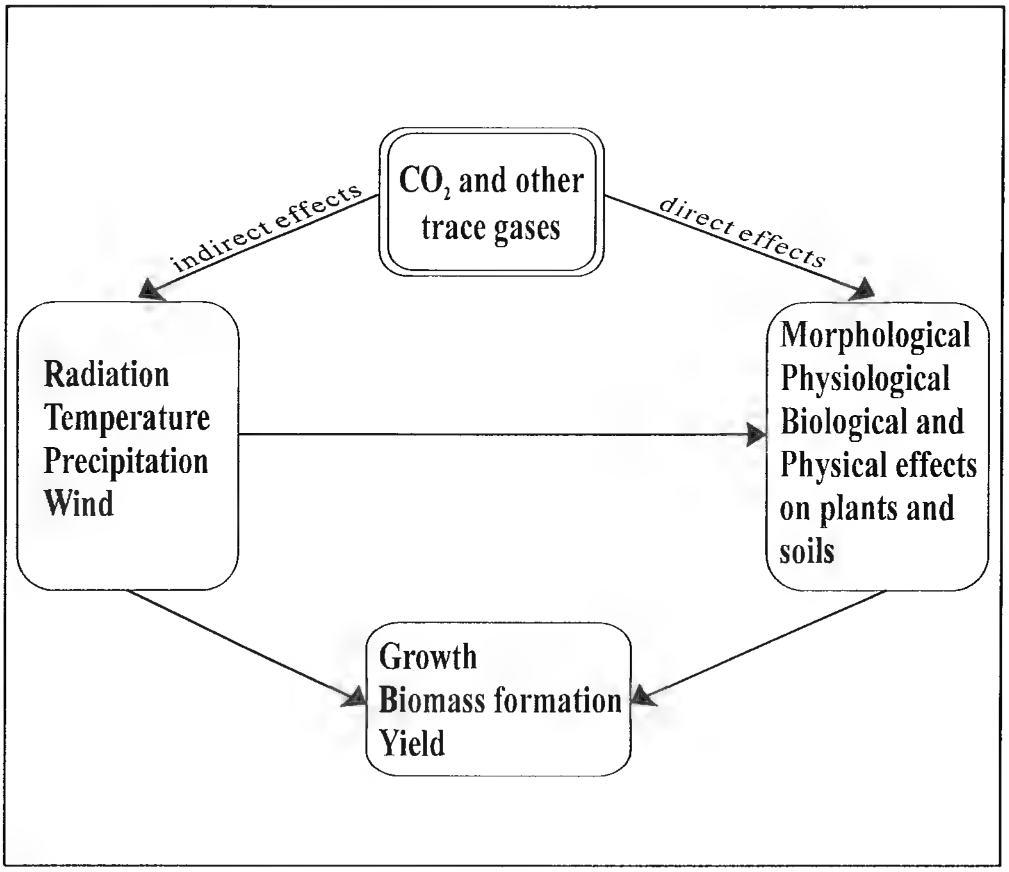


**Figure 7:** Effects of an increase in "Greenhouse" gases on biomass primary production

The improvement of stability and increasing of yields of various crops is related to the interaction and function of a larger number of genes (Büchting, 1997). To achieve a breakthrough in this context it would be necessary to launch specific research actions on the following aspects:

- Increasing the photosynthesis efficiency.
- Improvement of the nutrient and water use efficiency and uptake (development of low input cultivars).
- Modification of the transport mechanism of assimilation within plants.

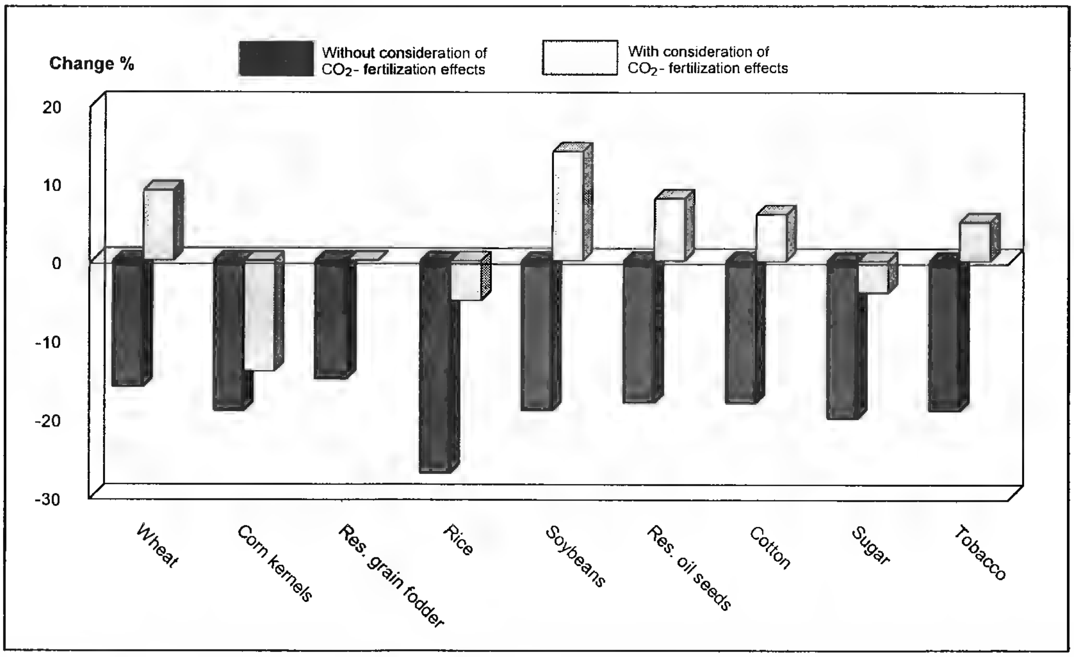


**Figure 8:** Global yield changes of plant products with and without consideration of $CO_2$ - fertilizer effects ($CO_2$ - doubling = 555 ppm). Favorable version

Various studies on wild landraces, old, intermediate and new genotypes of cereals showed that the new varieties produced higher grain yields than old varieties, and were also more efficient in using nutrients. It seems possible that a special breeding program of crop cultivars for low nutrient conditions could be successful. Improved cultivar response to nutrients will help to reduce inputs and hence protect the environment. Use of modern biotechnological tools, such as RAPDs, RFLPs and PCRs can facilitate fast and reliable screening of available germplasm in cereals and selection for NUE in segregating populations, as well as to help develop low-input varieties (El Bassam, 1997).

The plant genetic resources represent a source for the production of new cultivars, either through traditional plant breeding or through biotechnology and are a reservoir of genetic adaptability which acts against potentially harmful environmental and economic changes. The erosion of these resources poses a severe threat to the world's food security in the long term. Although often undervalued, the need to conserve and utilize the genetic resources as a safeguard against an unpredictable future is evident (FAO, 1996). International cooperation is the most effective tool towards proper utilization of these resources for the welfare of humanity and this earth.

The increased number of applications for patents of newly developed cultivars, especially of those produced via gene transfer, represents negative indications in the strategies, "food for all" and increase the dependency of developing countries and create greater discrepancy between north and south. Effective public support of research activities might be an adequate measure to deal with such undesirable effects.

## 2.4 Climate

The concentration of $CO_2$ in the atmosphere during the pre-industrial age was approximately 280 ppm of air by volume. This concentration reached 340 in 1980 and is expected to double to 560 between the middle and end of the next century. Other gases (chlorofluorocarbons $CFC_5$, methane $CH_4$ and nitrous oxide $N_2O$) also play an important role in the "greenhouse effect" whereby solar radiation is trapped near the ground, warming the globe and changing the climate. But if the present trends continue, a doubling of $CO_2$ from pre-industrial levels could occur as early as the 2030s and could lead to increased global mean temperatures greater than any in man's history. Climate researchers at the University of East Anglia, London stated that the year 1997 was the warmest year since the beginning of climate monitoring. Also the 5 warmest years have been recorded between 1990 and 1997. In September of 1997, a "World Scientists' Call for Action at Kyoto" hosted by the Union of Concerned Scientists (UCS) in Washington was published. The declaration states that:

- Global warming is underway and our overuse of fossil fuels is partly to blame.
- Climate change is projected to raise sea levels; increase the likelihood of more intense rainfall, floods and droughts; and endanger human health by greater exposure to heat waves and encroachment of tropical diseases to higher latitudes.
- Climate change is likely to exacerbate food shortages and spread malnutrition by adversely affecting water supplies, soil conditions, temperature tolerances and growing seasons.

There are direct and indirect impacts on vegetation growth (See **Figure 7**). Direct effects on different physiological mechanisms of plants can result from the influence of enhanced concentrations of $CO_2$ and other phytotoxica such as $O_3$ and UV rays. But there are also considerable impacts through indirect effects which are more complex. Such environmental and climatic changes will lead to a decreased regional agricultural production.

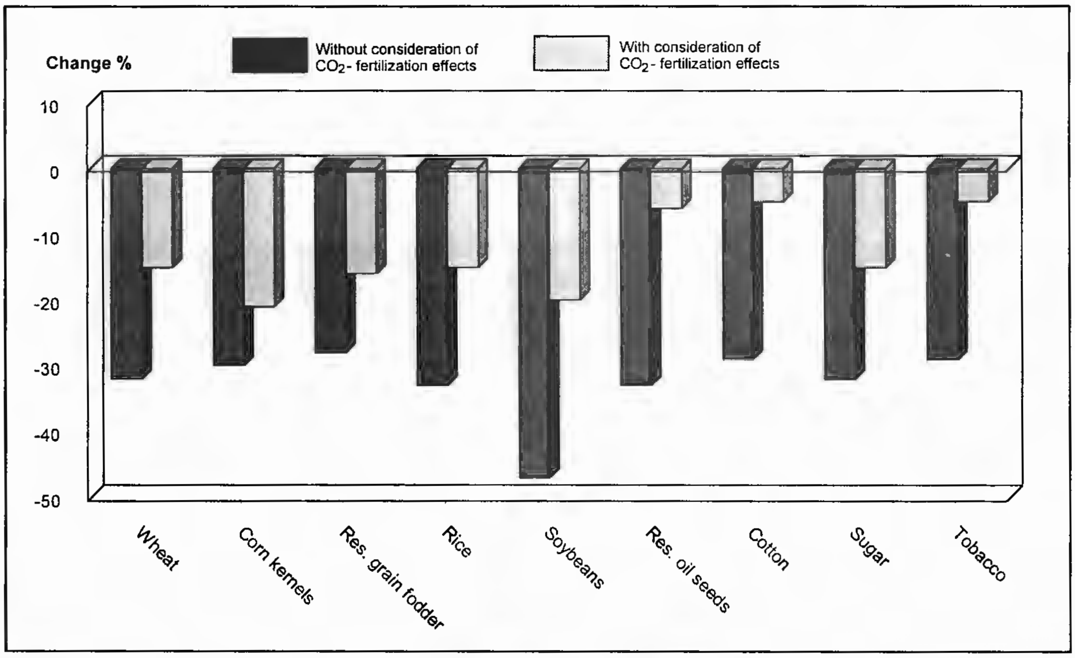


**Figure 9:** Global yield changes of plant products with and without consideration of $CO_2$ - fertilizer effects ($CO_2$ - doubling = 555 ppm). Less-favorable version

Based on data concerning modeling crop response to environmental changes of different institutions: Goddard Institute for Space Studies (GISS) and United Kingdom Meteorological Office (UKMO); Schumacher (1993) explored the potential response of crops to climate changes in 2 versions: favorable (**Figure 8**) and less-favorable (**Figure 9**). Both versions indicate that the yield of the major plant products will decrease considerably in global terms, especially if the expected $CO_2$ fertilisation would not be effective.

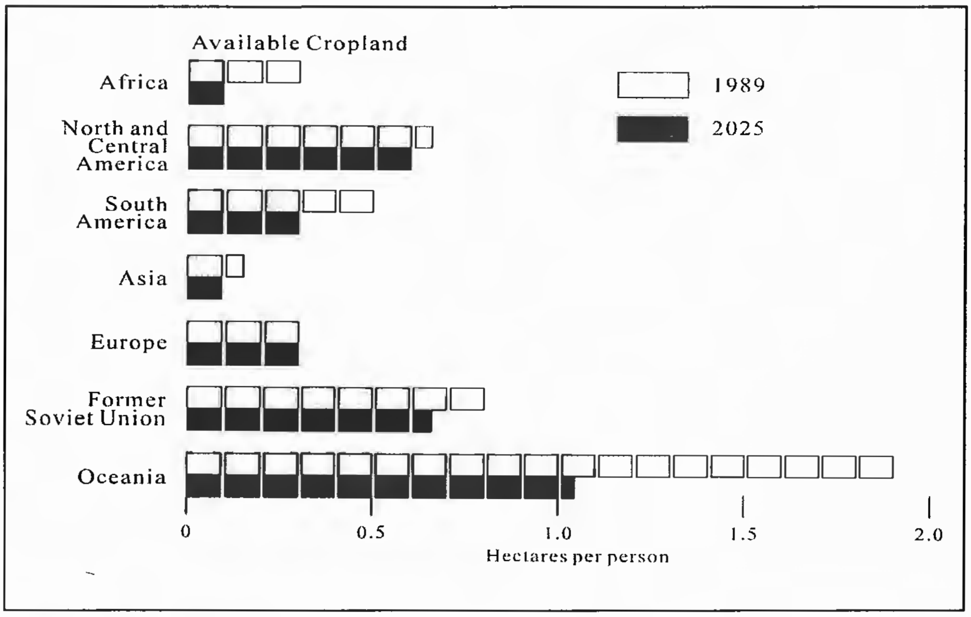


**Figure 10:** Cropland per person in the year 1989 and estimated for 2025 (World Resource Institute, 1990)

## 2.5 Soil and Water

Approximately 71 % of the Earth is covered with water. Statistically, the global availability of arable land per capita was 0.35 hectare in 1974. Twenty years later this has diminished to only 0.26 and in some regions only 0.11 to 0.12 hectares. Forest area in 1990 covered about 3.51 billion hectares. The forest area has decreased by the year 1995 to 3.45 billion hectares. Each year around 11.2 million hectares of forest disappear. Such figures demonstrate that our resources are limited and that the damage represents a threat to our survival. The availability of arable land within the next several decades will be diminished in extensive regions (See **Figure 10**). About 2000 million hectares of land have been globally degraded - an area equal to more than one third of all cropland and forested land. Some 300 million hectares are under such severe stress conditions that damage can be considered irreversible. If left unchecked, most of the remaining degraded land is likely to reach similar conditions. Land continues to be degraded at rates that are high by historical standards. The major causes of land degradation are deforestation, shifting cultivation practices in agriculture, over-grazing and the use of bush fires for short-term gains. Land degradation now affects the lives of hundreds of millions of people and is hampering the development of countries. Stopping land degradation is a high priority in many areas of the world (UNDP, 1997).

Two-thirds of the world's degraded lands are found in Asia and Africa, but human-induced degradation is most severe in Africa, where 30 % of the agricultural land, pastures, forests, and woodlands are degraded, followed by Asia (27 %) and Latin America (18 %). Most of the degradation

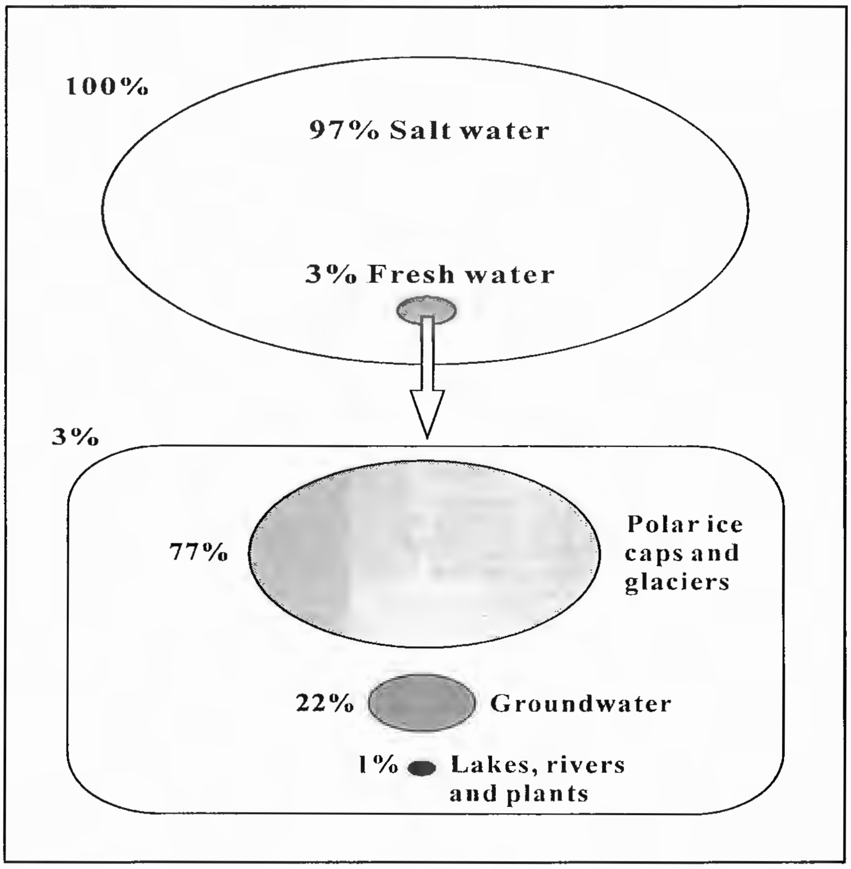


**Figure 11:** The worldwide water sources

is taking place on agricultural and pasture lands, which are major sources of food, incomes, and employment for rural people in many developing countries. Soil degradation has affected 75% of agricultural lands in Central America and 65 % in Africa, compared with 25 % in Europe and North America. Most of the degradation is taking place in the "bread-basket" areas (salinization), densely populated rainfed farming areas (nutrient depletion and erosion), and areas with important environmental roles (water erosion in upper watersheds).

Only 3 % of the world water resources are freshwater, with 2.31 % being fixed as glaciers and permafrost in the poles and not available for consumption and about 0.69% available in rivers, lakes, soil, swamps, groundwater and vegetation (See **Figure 11**). This means that approximately 9000 $km^3$ per year, equivalent to 1800 $m^3$ per capita are available. Theoretically enough freshwater is available worldwide to meet the needs for the foreseeable future if it were evenly distributed and appropriately used. But water is poorly distributed across countries and regions and throughout seasons. Virtually all developing countries, even those with adequate water in the aggregate, suffer from debilitating regional and seasonal shortages (IFPRI, 1995).

Food production is highly dependent on water availability and water use management. The information in **figure 12** can be used for appropriate utilization in a water management program. Globally about two thirds of the consumed water is being used for irrigation purposes. In Africa only 10 % of the agricultural land is under irrigation, in Indonesia 50 %, in China 70 % and in Pakistan up to 80 %. About 235 million hectares (16 % of the global agricultural land) are being irrigated, and worldwide contribute to produce 30 - 40 % of the food. The efficiency of water use in irrigation amounts to only 40 %. Between 0.3 and 1.5 million hectares of land are lost each year worldwide from waterlogging and salinization. About 10 % of irrigated soils suffer from salinization.

Forests are also important for food security. Forestry products such as wood, rattan, fibers, rubber, cork, wild fruits, roots, nuts and berries are important sources for income as well as energy, feed, food, vitamins and medicines. Forests are reserves for biological diversity, the environment for an enormous variety of animal and plant species. It is estimated that 30 to 40 million herdsmen use natural forest pastures and plants for their cattle, goat and sheep herds. Hunting and gathering is an important source of income for approximately 300 million people. Two billion people need wood for cooking.

## 3 Conclusions and measures

Today we face immense pressure in the global environment resulting from industrial emissions of greenhouse gases, the continual growth of the world population and the depletion of natural resources. The recognition of the necessity for actions and the intention and the will are vital evolutionary steps towards sustainability, but they would mean nothing if they could not be considered in practical measures and in appropriate governmental policies.

Business-as-usual policy and conventional approaches to major global problems are making the world unsustainable. Climate change is not expected to challenge global, but regional food productivity in the next 20 years (See **Figure 13**). Human behavior during this time will influence the extent and the affect of climate change well beyond the year 2020 (IFPRI, 1995). Possible movements of rainfall, mean temperatures, crops, etc., and the displacement of populations due to flooding, drought, fire, and changed economic circumstances will be the cause of significant concern also during this period.

We still have the means and economic possibilities through appropriate policies and market incentives for sound management of natural resources and agricultural

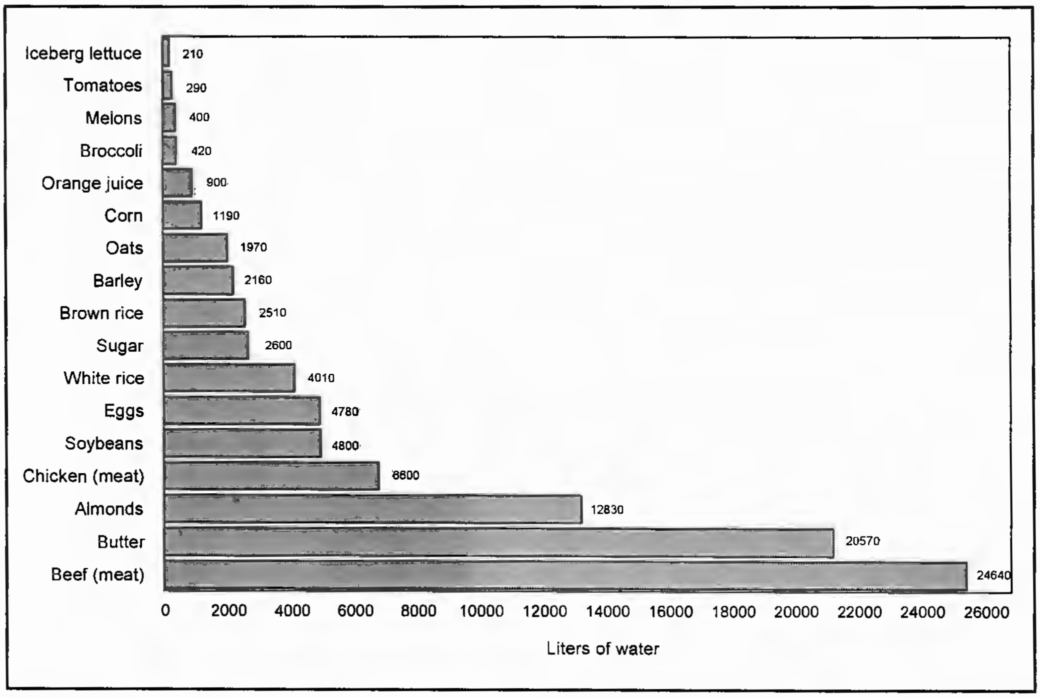


**Figure 12:** The amount of water in liters necessary to produce one kilogram of food (Water Education Foundation, 1992)

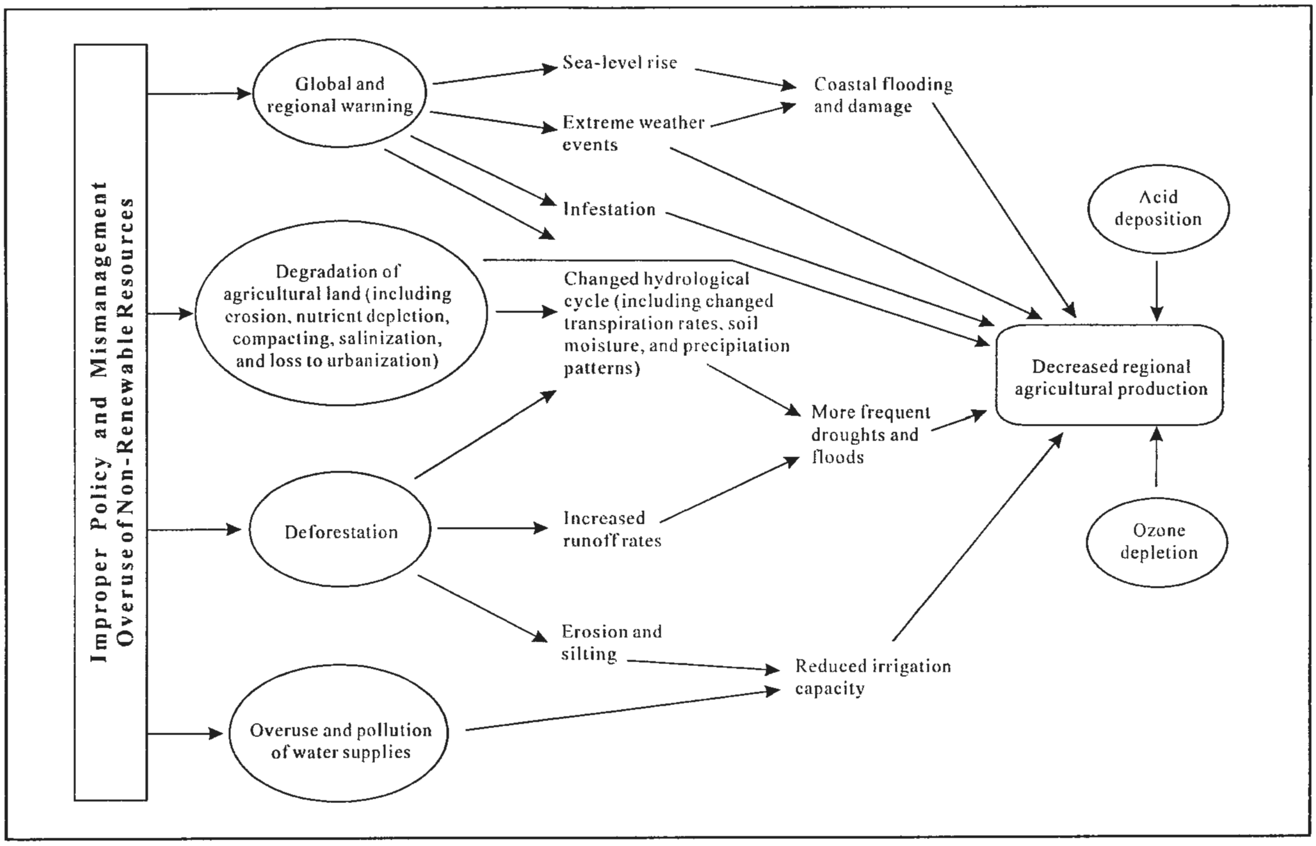


**Figure 13:** Possible effects of improper policy and mismanagement on climate, environment and agricultural production

inputs. Development of technologies in renewable energy and saving natural resources such as water, fuel and minerals will not only open huge opportunities of economical and social relevance, but will make the world less unsustainable and will secure "food for all" in dignity and peace for humanity and with nature. Brundtland (1987) stated that we live in an era in the history of nations when there is greater need than ever for coordinated political action and responsibility. "Individuals alone cannot provide these answers. We must work together to achieve the goal of global, long-term sustainability. In essence, we must recognize that the earth belongs to all people, that we all have a stake in achieving global sustainability and that no particular privileged group or country should dominate and benefit" (Declaration of Braunschweig, 1997).

It can not always be advised and demanded that "Developing Countries" reduce their population growth rates without insisting that "Developed Countries" drastically reduce their: consumption of energy and food, overuse of non-renewable resources, and production of industrial emissions causing global warming with their adverse effects such as the El Niño phenomenon. If development could be steered and directed by means of proper positive balances (output : input) of energy and other raw material resources, sustainability would be achievable.

Dialogue and cooperation between communities and countries, between different economical branches and sectors, as well as more efforts in research, technology and development are the tools to overcome the major challenges of humanity and to ensure sustainability for the current and future generations.

An important source on measures of achievement of sustainability in various disciplines of agriculture production systems is offered by the publication, "Sustainable Agriculture for Food, Energy and Industry" (El Bassam and Prochnow, 1998).

## Nachhaltigkeit in der Landwirtschaft aus globaler Sicht

Das Konzept der Nachhaltigkeit von Produktionssystemen wird zunehmend zu einem Erfordernis, um die Lebensgrundlagen der Menschen zu erhalten. Die nachhaltige Bewirtschaftung der natürlichen Ressourcen sowohl in der Industrie als auch in der Landwirtschaft beinhaltet die Strategie, unter der Beachtung der Interessen der Gegenwart die Voraussetzungen zu erhalten, daß die künftigen Generationen alle notwendigen Bedingungen vorfinden, um ihre Bedürfnisse befriedigen zu können. Das Schlüsselkonzept besteht darin, die nachhaltige Nutzung natürlicher Ressourcen sowie den Umweltschutz zu fördern. Die Umsetzung dieses Prinzips trägt zu einem langfristigen Wirtschaftswachstum unter den Bedingungen bei, die für eine umweltgerechte und ressourcenschonende Produktion annehmbar sind.

Das System der nachhaltigen Wirtschaftsweise spielt in der Landwirtschaft eine besondere Rolle, da zahlreiche und komplexe Faktoren die Grundlagen der Produktion auf diesem Gebiet bilden. Die Schlüsselelemente der Nachhaltigkeit in der Landbewirtschaftung sind:

1. Politische Strategien und Management einschließlich der ökonomischen, sozialen, kulturellen und bevölkerungspolitischen Rahmenbedingungen sowie Forschungs- und Entwicklungsstrategien
2. Energie und Inputs u. a. Pflanzenschutz, Nährstoffe, ökologische Landbewirtschaftung, Technik und Technologie
3. Genetische Ressourcen: Identifikation, Evaluierung und Nutzung pflanzengenetischer Ressourcen durch Züchtung, Bio- und Gentechnologie
4. Klimafaktoren und deren Auswirkungen
5. Boden und Wasser

Wissenschaftliche Erkenntnisse und das steigende Umweltbewußtsein verstärken die Einsicht, daß die Ausbeutung fossiler Energiequellen und anderer nicht erneuerbarer Rohstoffe zu den Ursachen der Klimaveränderungen zählen. Gerade in der Diskussion um den „Treibhauseffekt" wird deutlich, wie davon die Nachhaltigkeit von natürlichen Produktionssystemen beeinflußt werden kann. Die Verwendung nachwachsender und regenerativer Rohstoffe im energetischen und industriellen Bereich schließt jedoch den Kreislauf einer nachhaltigen Produktionsweise.

Die Entwicklung des Prinzips einer nachhaltigen Produktion gilt nicht nur für die hochentwickelten Industriestaaten, sondern in besonderer Weise für die Fortführung des Entwicklungsprozesses in Osteuropa und den Ländern der Dritten Welt. Das Wachstum der Bevölkerung, die Änderungen der Ernährungsgewohnheiten, und die Landflucht mit dem rapiden Anstieg der Bevölkerungszahlen in den Städten führt zu einer Verknappung natürlicher Ressourcen wie Boden, Wasser und Luft, der dringend gestoppt werden muß. In diesem Zusammenhang ist die Entwicklung effektiver landwirtschaftlicher Produktionssysteme zwingend notwendig für die Entwicklung dieser Länder.

Um das Prinzip der nachhaltigen Bewirtschaftung realisieren zu können, bedarf es einer sehr komplexen Betrachtungsweise zwischen verschiedenen Disziplinen von landwirtschaftlichen Produktionssystemen.

Die Nachhaltigkeit ist in erster Linie eine mentale Frage. Ohne Erfassung der Notwendigkeit und den Willen zur Bewußtseinsänderung wird es uns nicht gelingen, das Prinzip der Nachhaltigkeit in der Landwirtschaft zu realisieren. Die Entscheidungsträger in der Politik sind gefordert, Rahmenbedingungen und Voraussetzungen für eine nachhaltige Entwicklung in der Landwirtschaft zu schaffen. Dafür dürfen globale Verflechtungen nicht außer Acht gelassen werden. Die Nachhaltigkeit reflektiert unser Verständnis über die Notwendigkeit und die Verantwortlichkeit: für wen, wofür und wie die Produktion in effektiver Weise umweltverträglich und ressourcenschonend in die Zukunft gesteuert werden kann.

Ein einzelner allein wird diese Probleme nicht lösen können. Wir müssen gemeinsam auf das Ziel einer globalen, langfristigen Nachhaltigkeit zugehen. Wir müssen endlich erkennen, daß die Erde allen Menschen gehört und daß es unser aller ureigenes Interesse ist, weltweit Nachhaltigkeit zu entwickeln. Die Erde darf nicht so behandelt werden, als würde sie keinem oder nur privilegierten Gruppen und Ländern gehören. Handeln nach dem Prinzip „business as usual" bietet keine Perspektiven für eine gesicherte Ernährung der Weltbevölkerung in der Zukunft.

Strategien für die nachhaltige Landbewirtschaftung aus verschiedenen Regionen der Erde sind im Proceedings-Band „Sustainable Agriculture for Food, Energy and Industry" dargestellt.

**References**

Borlaug, N. E. and C. R. Dowswell (1996): The acid lands: one of agriculture's last frontiers. - In: Proceedings of the 4th International Symposium on Plant-Soil Interactions at Low pH. Belo Horizonte, Brazil.

Brundtland, G. H. (1987): Our Common Future - The World Commission on Environment and Development. - Oxford University Press.

Büchting, A. J. (1997): Geschäftsbericht 1997. - Gemeinschaft zur Förderung der privaten deutschen Pflanzenzüchtung e. V. (GFP). Bonn, Germany. 48 pp.

Declaration of Braunschweig (1998): - In: El Bassam, N. and Prochnow, B. (eds.) Sustainable Agriculture for Food, Energy and Industry. James & James Science Publishers, London.

El Bassam, N. (1997): A concept of selection for 'low input' wheat varieties. - In: H.-J. Braun et al. (eds.), Wheat: Prospects for Global Improvement. Kluwer Academic Publishers. pp. 153-158.

El Bassam, N. (1998): Biological life support systems under controlled environments. - In: El Bassam, N. and Prochnow, B. (eds.) Sustainable Agriculture for Food, Energy and Industry. James & James Science Publishers, London.

El Bassam, N. and Prochnow, B. (1998): Sustainable Agriculture for Food, Energy and Industry. - James & James Science Publishers, London.

FAO (1996): The State of the World's Plant Genetic Resources for Food and Agriculture. - Food and Agriculture Organization of the United Nations, Rome. 336 pp.

FAO (1995): Future Energy Requirements for Africa's Agriculture. - FAO, Rome. 96 pp.

IFPRI, (1995): A 2020 Vision for Food, Agriculture, and the Environment: The Vision, Challenge, and Recommended Action. International Food Policy Research Institute. 50 pp.

Lombardi, J. (1994): The role of universities in addressing issues of sustainability and productivity growth. - In: Final report of the workshop - Reconciling Sustainability with Productivity Growth, Gainesville, Florida USA, May, 1993.

Schumacher, H. (1993): Modellhafte Überlegungen zu potentiellen Auswirkungen der sich verändernden Klimabedingungen auf die Weltversorgungslage mit Nahrungsmitteln. - Diss. Univ. Bonn.
UNDP, (1997): Energy After Rio - Prospects and Challenges, Executive Summary. - United Nations Development Programme. 35 pp.
Water Education Foundation (1992): Water requirements for food production. - In: Hamburger Abendblatt Nr. 202/92.
World Bank, (1992): World Development Report 1992. - Washington: The World Bank.

Author: El Bassam, Nasir, Dr. agr., Institute of Crop Science, Federal Agricultural Research Centre (FAL) Braunschweig-Völkenrode, Head in charge: Prof. Dr. Friedrich Weissbach.