Why should the world be concerned about sustainable resource management in Agriculture?*

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Abstract
Agricultural food production is one of the bases for human development. At the moment world food production would be sufficient to feed the actual population and hunger is more a problem of distribution and access to food. However, in view of the growing human population there is an urgent need to increase food production in order to keep pace with the demand. This will require additional resources, some of them are limited, and others are even being degraded as a result of increased agricultural production. This paper is taking a look at some of the most important resources required for agricultural food production. The limitations are shown and possible solutions to overcome the limitations through conservation agriculture are explained.

Background – the MDGs

Agricultural production was, and still is, the base for human development. With the increase of human population, the production of food and other raw material had to become more organized and finally technified. The ability to safely produce more and more food with a decreasing number of people involved was one of the foundations of the actual developments of human societies. However, mankind is actually facing serious challenges: feeding the increasing world population within a limited resources resource base. The actual food production might be enough to feed every human on this planet, but nevertheless there are still about 800 Million people starving. Hunger is therefore at present not so much a problem of food production but a problem of social disparities and access to food.
But even though the world population is increasing at decreasing growth rates, the growth rate still exceeds the one of agricultural food production. This is particularly true for the African continent. By 2030 the food production has to double to keep pace with demand. In addition to food production, the production of renewable resources is becoming ever more important, due to the increased awareness on sustainability. Therefore countries that are actually producing a food surplus might in future focus more and more on the production of profitable renewable raw material for industrial products and energy rather than simply on the production of food (FAO 2002).

* The views expressed in this paper are the personal opinion of the author and do not necessarily quote the official policy of FAO

As a consequence there can be little doubt that world agriculture will have to produce more in future – more food and more other renewable resources. Over the last few decades the increase in agricultural production has mainly come from yield increase and only to a lesser extent from expansion of area. In fact, the available agricultural land per capita is expected to decline in future (FAO, 2002) while revolutionary technologies that would result in significant increase of the production potential do not seem to be in sight. In high intensity agricultural production areas further yield increase seems to reach a ceiling. Increased use of inputs results in only marginal additional production. Fortunately major quantum leaps in yield increases can still be expected in those areas where the actual production potential has not even remotely been reached. This is especially the case in Africa.
With this background the United Nations Millennium Development Goals have been formulated. FAO is likewise committed to their accomplishment. These goals combine socio economic concerns with sustainable resource management as they refer, for example in goal number one to the eradication of poverty and hunger and in goal number seven to environmental sustainability (UN, 2005).

Resources for Agricultural Production

In view of this scenario there is no question that agricultural production is facing a major challenge in future. It depends on a variety of resources, some of them being finite, others being renewable. However, the planet is basically a defined environment with limited resources. The management of these resources will determine whether humanity can arrange a permanent life on this planet or whether it will destroy the life base hoping for some miracle salvation in future. This should be reason enough to be concerned about sustainable resource management in agriculture. However, being concerned is not enough; it should result in focussed action.

Human Resources

One of the most important resources for agricultural production is the rural people engaged in agriculture – women, men, young people, and elderly people. In many countries, and particularly in Africa, a considerable percentage of the population is engaged in agricultural production and has a quite close relation to it. However, the trend is that more and more people are leaving the country side looking for alternative jobs outside agriculture. In industrialized nations there is only 2% of the population still engaged in agricultural production (FAO, 2004), and the numbers are still declining with many old farmers not finding young people to take over their farms and many male farmers not finding a wife willing to share the life on a farm. But also in so called developing countries migration to urban centres is ongoing and the predictions are that even there within the next ten years more than 50% of the population will be urban (FAO 2002). Rural life is just not attractive and work in agriculture even less so. Especially the younger people are migrating to the cities, leaving behind children and elderly people (Mrema 1996).
While the reduction of the rural population in numbers is already alarming, the impact on the actual capacity to carry out agricultural work is even worse; this is the case particularly in those societies, where agriculture is still labour intensive and not mechanized. This general trend is seriously aggravated by the HIV/AIDS pandemic, which is striking many countries in Asia and particularly Africa very hard. The actual effect of this pandemic is that it affects mostly the economically active and physically strongest part of the population (FAO 2002).

While these are loosing their physical strength to work, they leave behind children and elderly people, not only with the task to carry on with the agricultural production, but often also with the burden to care for those affected by the pandemic. Already now there are an increasing number of households headed by orphan children. And a long term effect of this situation is that children who have to work on the farm in order to survive cannot visit schools and receive good education.
Agricultural work is often unpleasant and mostly hard and requires a lot of physical strength. That is especially the case when the work is done by hand or with draft animals. But also in a fully mechanized agriculture physical strength is helpful. For this reason in Sub-Saharan Africa there is already potentially productive farmland falling fallow due to the lack of farm power – of people who can farm it. This is happening on a continent which is actually going through a period of hunger and food production deficit. It is high time to care for those human resources; otherwise the future will be gloomy.

Natural Resources

Besides the human resources there are especially the natural resources, namely water, soil and land, of concern for agricultural production, many of them being limited.

Water

One of the most precious resources is fresh water. It is necessary directly for humans to survive, but it is also used for many other purposes. With 70% of the actual water use, agriculture accounts for a major part of the "blue water" consumption, not always efficiently (FAO 2002). The actual fresh water resources are declining and water might be the cause for future wars. The predictions are that by 2025 the water consumption will exceed the available "blue water" if the current trends continue (Ragab and Prudhomme, 2002). The decline of fresh water resources is not only due to increased consumption, but also due to a careless management of this precious resource. More and more landscapes are sealed off, not allowing the rainwater to infiltrate and to restore the ground water reserves. Instead the water is drained and channelled directly back to the oceans without being properly used. Agriculture is increasingly part of the problem: intensive agriculture is sealing and compacting the soils so that the water cannot anymore infiltrate. Increasing numbers of flood catastrophes are one symptom of this (DBU 2002). Especially in those world regions, where water is already now the limiting factor for agricultural production, this wasteful practice is seriously threatening the sustainability of agriculture. Increasing temperatures and hence increased evapotranspiration rates combined with more erratic rainfall aggravate the water problems in many areas of rain fed agriculture (Met Office 2005).

Soil

The resource which makes land productive is actually the soil. Soil does not only impact on production, but has also an influence on the management of other natural resources, such as water. It is not just a mineral body, but it is a habitat consisting of minerals, water, air, organic matter and a wide spectrum of life organisms. Soil fertility does not only refer to the chemical fertility, but more than anything else, to the physical properties, such as the soil structure. Soil structure is strongly correlated to the organic matter content and to the soil life. Organic matter structures the soil, provides feed to the soil life and acts as a sponge for soil water. With intensive tillage based agriculture, the organic matter of soils is steadily decreasing, leading first to a decline in productivity, later to the visible signs of degradation and finally to desertification (Shaxson & Barber 2003).

Unfortunately agricultural production has all over the world led to soil degradation. This is more pronounced in tropical regions, but also in moderate climatic zones soil degradation can be noticed. The world map of degraded soils indicates that nearly all agricultural soils show some levels of soil degradation (FAO 2000). Soil degradation is a process, during which the soil gradually looses the fertility and with this the production potential.

Land

Land is the base for agricultural production. Due to urbanization and other non agricultural land use the availability of farm land is declining particularly in highly populated world regions. In the developing world alone it is expected that until 2010 another 20 Million ha of agricultural land will be lost for non-agricultural purposes (Alexandratos 1995). But also vast areas of land are lost for agricultural production due to unsustainable production methods. Large areas are lost to desertification and salinization, some of them with a limited scope for recovery. While in some world regions, such as in Africa, there might be still land resources available for an expansion of agricultural production, globally the scope for an increase of farmland is limited. In view of the increasing world population the available agricultural land per person is steadily declining. At world average this value is already below 1 ha/person (FAO 2002).

Other Production Resources and Inputs

Besides the human and natural resources there are other relevant resources for agricultural production, which all give reasons for concern. Some of them because they are becoming a limiting factor to production due to high costs, others because they might be a limited resource and again others because their unreflected use in agriculture is causing environmental impacts which make agricultural production unsustainable in the long run.

Farm Power

The term of farm power is often not well understood in the context of agricultural production resources. It describes the power which is necessary to carry out the different tasks for agricultural production. This power can come from different power sources, namely human power, draft animal power or motorized power. As the availability of human farm power in agriculture is declining, other power sources are introduced. The availability of farm power determines, whether agricultural operations can be carried out in time and to the desired quality standard. The limitations for human power have been discussed. The replacement of human power by draft animals is not necessarily easy and there have been many failures in the attempt of introducing draft animals. But also motorized farm power has limitations. First of all it requires high investment in machinery, which is rarely available. Also the feasibility of such investment is not always guaranteed, particularly in view of the lack of after sales services for motorized farm equipment. Secondly the world wide increasing energy costs are forcing for a more efficient use of motorized farm power.

Equipment

Regardless whether agriculture is done by hand, draft animal or tractor, there are always some tools, equipment and machinery required to carry out the work. These tools, their quality and performance are getting more and more important as the production intensity increases. They also determine very much whether the other production inputs such as seeds, farm chemicals and fertilizer, can be efficiently used to their full potential. Unfortunately in many world regions the availability of suitable farm tools and equipment together with appropriate farm

power sources are still a limiting factor for the agricultural development. This is particularly true for the African continent.

Farm chemicals
The use of farm chemicals in agricultural production is particularly in countries of the developing world still expected to rise (FAO 2002) and their rational use appears to be required to assure high production levels. However, irrational and careless use of farm chemicals is causing significant damage to human health and to the environment worldwide (Matthews at al. 2003). A rational use of these inputs will not only become an economic necessity but will determine very much the sustainability of our production systems.

Fertilizer
Even fertilizer as production resources should be handled with more care, as wastage is not only prohibitive from an economic point of view. Some mineral fertilizers and soil enhancement substances, such as phosphates and lime, are actually limited resources, others like nitrogen and again phosphates have a high potential for environmental pollution or can be converted to green house gases depending on their use. Eutrophication of water bodies as a result of excessive fertilizer application is a common problem in industrialized countries. However, fertilizer use is also in developing countries on the rise. High application rates which do not match the actual uptake capacities of the plants are main reasons for the eutrophication, but also the erosion of topsoil contributes considerably to the problem (FAO 2002).

Sustainable Resource Management through Conservation Agriculture

The above examples have shown that the sustainability of agricultural production in view of the actual resource base and the current resource management is not at all guaranteed. The underlying causes behind the problems of the different resources are of completely different nature and it is unlikely that a magic solution can solve them all. However, since the different resources interact with each other, they are all necessary to eventually secure the food production for the coming generations. In the following chapters it is explained, how Conservation Agriculture would respond to the problems of the specific resources and with which result. Sustainable agriculture in the final analysis would only be possible if each single production resource is managed in a sustainable way.

Human Resources

While Conservation Agriculture is reducing farm power requirements in general, this means for a farmer working with her or his hands, that she/he can save 30 – 50 % of the time usually spent for farming. Particularly the heavy work of hoeing and weeding is significantly reduced or even eliminated. With this CA is giving especially weaker people a chance to carry out farming and to maintain their livelihoods from the farm. CA cannot fight HIV/AIDS, but it can help the affected people and mitigate the impact of the disease on their farming income (Bishop-Sambrook 2003). In general CA makes agriculture less unattractive, as it removes the drudgery and improves the farm profit. Since it improves the options for diversification of the farm enterprises CA has also a potential to revert the migration to the urban centres by providing the young generation with new opportunities.

The availability of extra time allows investing into more profitable occupations other than agriculture. This is particularly important for small farmers who cannot make sufficient profit from their farm for a comfortable life. The extra time might also be used for value adding and processing activities within the agricultural production and food chain. The overall income of CA farmers increases and allows them the purchase of household goods or even better houses which improves their lives significantly. In many rural areas where CA has been introduced this is an important factor of empowerment for the rural women. Last but not least, the extra time might allow sending children to school that would normally have to work on the farm (Lange 2005).

Natural Resources

Water

The soils under conservation agriculture improve the water efficiency. The increased amount of continuous vertical macropores facilitates the infiltration of rain water into the ground and hence a recharge of the aquifer. The increased soil organic matter levels improve the availability of water accessible to plants. 1% of organic matter in the soil profile can store 150 m^3 water per hectare. The permanent soil cover and the avoidance of mechanical soil tillage reduce the unproductive evaporation of water. With this the water use efficiency is increased and the water requirements for a crop can be reduced by about 30%, regardless whether under irrigation or rain fed conditions (Bot & Benites 2005).

In addition to the quantitative benefits the reduced leaching of soil nutrients and farm chemicals together with the reduced soil erosion leads to a significant improvement of the water quality in watersheds applying Conservation Agriculture (Bassi 2000, Saturnino & Landers 2002).

Soil

Under CA the levels of soil erosion are inferior to the build up of new soil. In average the soil under CA "grows" at a rate of 1 mm per year due to the accumulation of soil organic matter. This growth continues until a new point of saturation is reached in the soil which takes between 30 and 50 years (Crovetto 1999). The organic matter levels rise by 0.1-0.2 % per year due to the residues remaining on the soil surface, to the remaining root biomass and due to the reduced mineralization in absence of mechanical soil tillage. Within a crop rotation different root systems structure different soil horizons and improve the efficiency of the soil nutrient use. In general the soil structure becomes more stable and degradation and erosion is reduced to levels below the natural soil recovery (Bot & Benites 2005).

Land

Conservation Agriculture cannot defeat the conversion of agricultural land into other uses. However, CA can improve the sustainability of the agricultural land use to conserve the actually available land resources. It can also by increasing the productivity, reduce the pressure on land use. This is particularly important in areas where unsustainable land use leads to abandoning fields after few years and to the expansion of the agricultural land into areas which should be protected as natural reserves. This is of particular importance where the agricultural frontier due to unsustainable practices of land use is expanding into tropical rainforest or other natural reserve areas (Saturnino & Landers 2002).

Other Production Resources - Inputs

Conservation agriculture can reduce the overall requirement for farm power and energy for field production by up to 60% compared to conventional farming (Doets et al. 2000). This is due to the fact that the most power intensive operations, such as tillage, are eliminated. Also in terms of equipment investment there are savings, particularly at motorized mechanization level. The number and size of tractors to farm a given area is significantly reduced (Bistayev 2002). This advantage obviously does not account for a farmer who is fully equipped and has to convert to conservation agriculture type equipment, but it is of direct benefit for all those areas, where equipment is not existing or obsolete and where investments into agricultural equipment are envisaged to increase agricultural production.

Long term experiences with CA show a decline in the use of agrochemicals due to enhanced natural control processes. Natural control of pests and diseases are improving over time and also the experience in weed management through crop rotations facilitates this long term decline in agrochemical use (Saturnino & Landers 2002). The same is true for mineral fertilizer. Less fertilizer is lost through leaching and erosion, the different rooting systems recycle more soil nutrients from a larger soil volume and with this the overall efficiency of fertilizer use is improved in the long term. This is reflected in significant reduction of the fertilizer requirements to maintain the production and soil nutrient levels over the crop rotation (Saturnino & Landers 2002).

Climate and Climate Change

Although climate is not directly a "resource" for agricultural production, it is definitively a factor which is determining agricultural production very much. All production systems and actually the plant growth in general depend on specific climatic characteristics. If these change, the growing conditions change as well. If the climate becomes less reliable, with more extreme and unforeseeable events, agricultural production becomes more risky and hence more difficult. There seems to be a general trend over the last decades that extreme climatic events become more frequent and more extreme. This includes extreme precipitations as well as extended drought periods or extreme temperatures (Met Office 2005). Agricultural production systems are extremely vulnerable to those changes. Sustainable agriculture and hence a sustainable management of agricultural resources will therefore also have to improve the resilience of cropping systems.

Conservation Agriculture can first of all assist in this adaptation to climate change, by improving the resilience of agricultural cropping systems and hence by making them less vulnerable to extreme climatic situations. As an example, the better soil structure and higher water infiltration rates reduce the danger of flooding and erosion catastrophes after high intensity rainstorms (Saturnino & Landers 2002). Increased soil organic matter levels improve the water holding capacity and enable to get through extended drought periods. In general the yield variations under Conservation Agriculture in extreme years, regardless whether dry or wet, are less pronounced than under conventional agriculture (Shaxon & Barber 2003, Bot & Benites 2005).

But Conservation Agriculture can also contribute to mitigate against climate change, at least as far as the global warming and the release of green house gases is concerned. With the increasing soil organic matter, the soils under Conservation Agriculture can actually sequester carbon dioxide and store it safely for long periods of time. This carbon sequestration will continue for 25 to 50 years before reaching a new plateau of saturation (Reicosky 2001). The consumption of fossil fuel for agricultural production is significantly reduced under CA and

burning of crop residues is completely eliminated, which also contributes to a reduction of green house gas release. Besides the carbon sequestration, soils under no-tillage depending on the management might also emit less nitrous oxide (Izaurralde et al. 2004). In addition to this the change of cropping systems under CA, such as paddy rice production towards reduced water use might have also a beneficial effect on the release of other green house gases (Belder 2005).

Conclusions

Agricultural production plays an important if not critical role in the development of the human civilization. As this production is based on resources, some of which are limited, a careful management of these resources will determine how much future humans have on this planet.

Conservation Agriculture is not a magic solution for all problems. But it is a practical concept for an agricultural production without any so far known negative side effects. CA is based on natural sciences and it combines different principles of good agricultural practice. Modern engineering and technological developments have made it possible that the key principles – permanent soil cover, no-mechanical soil tillage and diversified crop rotation – can be applied simultaneously achieving synergies which make CA an example of sustainable agriculture. Farmers getting acquainted with this new way of farming like it and turn out to be its best promoters. This is particularly true for those farmers, who due to difficult climatic conditions, natural catastrophes or health problems would not have been able to carry on farming if they had not changed to CA.

Conservation Agriculture is also a relevant concept helping to achieve several of the MDGs. Through better productivity, higher profitability and reduction of drudgery CA contributes to improved food security and improved livelihoods and with this to MDG number 1. With the environmental benefits CA also clearly improves the sustainability of farming and contributes therefore to achieving MDG number 7. But also to some of the other MDGs there are at least indirect contributions. The time savings in agriculture can release labour from farm work. If this labour is provided by children, they might get an opportunity to visit a school instead of working in the field (MDG number 2). Labour saving technologies as applied under CA are particularly interesting for women farmers (MDG number 3). At the same time the labour saving technologies under CA assist to mitigate the impact of HIV/AIDS as they allow even people with reduced physical strength to do farming (MDG number 6). Last but not least the history of the CA development has been a history of partnerships. Between farmers and institutions, between countries and continents and the fact that the world CA community is already celebrating the third world congress on conservation agriculture with participation from around the world and across different levels of society demonstrates the strong partnership for development (MDG number 8).

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