Conservation Agriculture: Impact on farmers' livelihoods, labour, mechanization and equipment*

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Abstract

Conservation Agriculture (CA) is defined as a concept for resource-saving agricultural crop production that strives to achieve acceptable profits, high and sustained production levels while concurrently conserving the environment. It is regarded as sustainable land management tool for agricultural lands. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals, nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with or disrupt the biological processes. In some cases external inputs are reduced to zero. CA is characterized by three principles which are linked to each other, namely:

1. minimum mechanical soil disturbance throughout the entire crop rotation
2. permanent organic soil cover,
3. diversified crop rotations in case of annual crops or plant associations in case of perennial crops

With the increased adoption of conservation agriculture the experience with the system grew and other implications and benefits were noted. These benefits impact directly on the livelihoods of the farmer through the effect on profitability of farming and especially the largely reduced labour requirements. Especially for a small scale family farm a vulnerable households with limited labour resources the introduction of conservation agriculture can lead to significant improvements in the livelihood through stabilizing the natural resource base and at the same contributing to more stable yields even in drought affected years.

By changing some key operations the approach has also an impact on the agricultural mechanization and the equipment choices and hence influences in the long term the agricultural machinery supply sector. Dealers and sales points in rural areas will likely to be encouraged to adjust their outlets if increased demand for CA relevant equipment gets more evident.

The paper will briefly explain the features of conservation agriculture which lead to these changes and then report in more detail experiences which have been observed in the long term after the introduction of conservation agriculture on the livelihood of farmers, labour requirements, mechanization and equipment use.

Keywords: conservation agriculture, livelihood, labour saving, mechanization

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

Background – history of conservation agriculture

Conservation Agriculture has its origin in conservation tillage, which was developed to respond to the dramatic degradation of agricultural production resources. This was mainly soil erosion through wind and rain water impact. Closely connected to soil is the water resource, which is also addressed by conservation agriculture and is of particular importance for dry lands. In that respect the 'in-field' water management aspects are also addressed here.

Reducing the intensity of tillage for economic reasons (leading to minimum tillage) or for environmental reasons (leading to conservation tillage and finally to zero tillage practices) is not a new idea. One of the first references in modern agriculture to no-till farming is probably Edward Faulkner's "Ploughman's Folly" (1945). Over the last few decades the practice of minimum and no-tillage had its ups and downs. In some situations it worked well, in others less well. Minimum tillage, conservation tillage and zero tillage were all applied as practices within conventional concepts of agriculture and therefore were not universally applicable. However, there appears to exist evidence that no-tillage can be successfully incorporated into a new concept of truly sustainable agriculture. In this case not tilling the soil mechanically becomes one underlying principle of a completely new understanding of agriculture. This concept shows in at least one world region over the last decade a consistent and exponential adoption curve. During the last few years it is, under the name of Conservation Agriculture (CA), gaining popularity all over the world (Derpsch, 2001).

Conservation Agriculture might well base on old, well known principles. But it combines these principles in a new way achieving synergies which had not been considered in the past and which only recently are being understood and investigated. The main objective in Conservation Agriculture changes towards providing a favourable microclimate for soil life by protecting the soil surface from sun, rain and wind as well as providing feed for the soil micro and macro organisms. These organisms forming the soil life in CA are substituting biological tillage for mechanical tillage. While conventional agriculture is "cultivating the land", using science and technology to dominate nature, conservation agriculture tries to "least interfere" with natural processes. Similar thoughts have been developed over the past 50 years also in the Far East by Masanobu Fukuoka (1975). While Fukuoka rejects even mechanization, this extreme is not justifiable in view of the requirements of modern agricultural production. But the approach naturally has implications for the required engineering interventions in agriculture and as such in the technical solutions offered.

During the last decade Conservation Agriculture (CA) has been gaining popularity all over the world. It is now applied on about 95 million hectares (Derpsch, 2005). Together with other organizations and stakeholders FAO has been promoting and introducing CA in several countries in Latin America, Africa and Asia. Applying these three principles conservation agriculture has been adapted to different climatic conditions from the equatorial tropics to the vicinity of the polar circle and to different crops and cropping systems, including vegetables, root crops and paddy rice. Today conservation agriculture in its different applications is increasingly seen as a way to practice sustainable agriculture. It is becoming increasingly popular where conventional agriculture is facing serious problems due to land degradation and increasingly unreliable climatic conditions. In this way it is becoming also a popular concept in rehabilitation responses to emergencies caused by natural disasters.

The key element which CA is focussing on is soil organic matter which stabilizes soil and increases water holding capacity. This particular characteristic makes CA so important particularly for dry lands. Water is one of the most precious natural resources for agricultural production. Agriculture accounts for 70 % of the actual water use (FAO, 2002). The predictions are that by 2025 the water consumption will exceed the available "blue water" if the current trends continue (Ragab & Prudhomme, 2002). In the Indian state of Punjab, characterized by intensive irrigated agriculture, the ground water table is falling at a rate of 0.7 m per year (Aulakh, 2005). The decline of fresh water resources is not only due to increased consumption,

but also due to a careless management of this precious resource. Agriculture is part of the problem by wasting water and by sealing and compacting the soils so that the excess water cannot anymore infiltrate and recharge the aquifer. 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 threatening the sustainability of agriculture. Rising temperatures and evapotranspiration rates combined with more erratic rainfall aggravate the water problems in rain fed agriculture (Met Office, 2005).
Soil does not only impact on production, but has also an influence on the management of other natural resources, such as water. Soil structure is strongly correlated to the organic matter content and to the soil life. Organic matter stabilizes soil aggregates, provides feed to soil life and acts as a sponge for soil water. With intensive tillage based agriculture, the organic matter of soil is steadily decreasing, leading first to a decline in productivity, later to the visible signs of degradation and finally to desertification (Shaxson & Barber, 2003). The lack of yield response to high fertilizer dose in the Indo Gangetic Plains can be attributed to deteriorated soil health as a result of over exploitation (Aulakh, 2005). In the Indian states of Uttaranchal or Haryana the organic carbon content in soils reaches minimum values below 0.1 % (PDCSR, 2005). Agricultural production has all over the world led to soil degradation, more pronounced in tropical regions, but also in moderate climatic zones. The world map of degraded soils indicates that nearly all agricultural lands show some levels of soil degradation (FAO, 2000).

What is conservation agriculture?

Conservation Agriculture (CA) is defined as a concept for resource-saving agricultural crop production that strives to achieve acceptable profits, high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals, nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with or disrupt the biological processes. CA is characterized by three principles which are linked to each other, namely:

1. minimum mechanical soil disturbance throughout the entire crop rotation
2. permanent organic soil cover,
3. diversified crop rotations in case of annual crops or plant associations in case of perennial crops

Zero tillage

These principles lead to the following effects on the soil. Since the soil is never tilled soil structure changes. A system of continuous macro pores is established, facilitating water infiltration and aeration of the soil as well as root penetration into deeper zones. At the same time the soil bulk density might be higher than on conventionally tilled soils, since the soil matrix provides a firm structure. Tillage mixes air into the soil which leads to a mineralization (oxidation) of the soil organic matter. In absence of soil tillage this mineralization is reduced. If organic matter in the form of roots and residues is added, soil organic matter contents increases with higher values near the surface, gradually declining at increased depth. Soil macro and micro fauna and flora is re-established resulting in better soil fertility.

Soil cover

The permanent soil cover through crops, mulch or green manure cover crops complements the zero tillage effects by supplying substrate for soil organic matter build up and for the soil life which is facilitated by not disturbing the soil. Through protection of the soil surface the mulch is reducing evaporation and avoiding crusting. It also suppresses weed growth. Problems experienced in direct seeding or zero tillage when applied in isolation are reduced in this way. On the other side the application of zero tillage and direct seeding technology facilitates the management of residues which in conventional systems are often considered a problem. In very dry regions where water is the most limiting factor to crop production it is often difficult to maintain a permanent full soil cover. Nevertheless, even with incomplete soil cover conservation agriculture practices are still valid, as long as sufficient organic matter is supplied to the system to build up soil organic matter and to increase productivity. However, the weed control function of the soil cover cannot be achieved in this case. When livestock is competing for the residues it is important especially in the first years of transition to strike a balance between the different uses for the residues. Once the productivity is increased as a result of the increased soil organic matter, the system often delivers sufficient material to feed both, soil and animals.

Crop rotations
Also the crop rotations serve different purposes in the system and are linked to the other two principles. Besides the phytosanitary and weed management objectives, crop rotations serve to open different soil horizons with different rooting types. Applying a diversified crop rotation increases the overall productivity of the cropping system and as such also the long term profitability, compared to monocropping of economically attractive cash crops which in the long term always proves not sustainable. The crop rotation becomes at the same time part of the soil cover and residue management strategy with the objective to keep the soil constantly covered either under a live crop or dead residue mulch. On the other side allows the shorter turn over of no-tillage and direct seeding to apply crop rotations which under conventional agriculture would be impossible, for example to add an additional cash, forage or cover crop.

Other resource conserving technologies
The three basic principles of CA can be complemented with other technologies providing additional synergetic benefits.

Bed planting would provide the benefits of water saving in systems where surface irrigation is applied. Under conservation agriculture the beds would be converted into permanent beds whereas any soil tillage would be limited to a periodic cleaning and reshaping of the furrows. The same permanent bed system would be applicable under conservation agriculture also for crop rotations, which include crops grown on beds, for example for drainage purposes. All crops of the rotation would be grown on the same beds, regardless whether they are row crops or small grain cereals. Water savings compared to flat surfaces of 26 % for wheat and 42 % for transplanted rice have been reported, with yield increases at the same time of 6.4 % for wheat and 6.2 % for rice (RWC-CIMMYT, 2003). However, the precondition for such a permanent bed system is the harmonization of the furrow distances and bed width for all crops in the rotation and for all mechanized traffic operations. In this way a permanent bed system leads also to controlled traffic taking additional advantage of that resource conserving technology.

Controlled traffic farming restricts any traffic in the field to always the same tracks. While these tracks are heavily compacted, the rooting zone never receives any compaction resulting in better soil structure and higher yields. Through border effects the area lost in the traffic zones is easily compensated by better growth of plants adjacent to the tracks so that the overall yields are usually higher than in conventional systems with random traffic (Kerr, 2001). Obviously controlled traffic farming is the ideal complement to zero tillage systems since soil compaction due to machine traffic in the cropping zone is completely avoided. Other benefits are fuel savings since the traction is more efficient when tyres work on compacted tracks (RWC-CIMMYT, 2003).

Direct seeding is another complement to conservation agriculture. Although transplanting of crops, including paddy rice, is possible under zero tillage, direct seeding is preferable for the reasons mentioned above. In addition direct seeding results in less soil movement than transplanting, which often involves some sort of strip tillage. At the same time conservation agriculture facilitates direct seeding by reducing a number of problems, such as surface crusting or weed control, encountered when direct seeding is applied in isolation.

Laser levelling provides the same benefits to conservation agriculture as to conventional agriculture under surface irrigation conditions. However, since it involves significant soil movement in the beginning, it would be considered as an initial investment before converting to a permanent zero tillage cropping system as conservation agriculture is. The benefit of such a strategy is that the investment in laser levelling would last much longer than in conventional systems, since under CA no further soil tillage would be applied which could upset the levelling of the field.

Effects of conservation agriculture

Land and water

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 30 to 50 years (Crovetto, 1999). The organic matter levels rise by 0.1-0.2 % per year due to the residues left on the soil surface, the remaining root biomass and the reduced mineralization. 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 (Bot & Benites, 2005). At the same time 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 water at a rate of 150 m^3 ha^{-1}. 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).

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).

In addition to these on farm 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 where CA is applied (Bassi, 2000) (Saturnino & Landers, 2002).

Climate and climate change

There seems to be a general trend over the last decades that extreme climatic events become more frequent and stronger. This includes extreme precipitations as well as extended drought periods or extreme temperatures (Met Office, 2005). Agricultural production systems are highly vulnerable to those changes.

Conservation Agriculture can assist in the adaptation to climate change, by improving the resilience of agricultural cropping systems and hence by making them less vulnerable to abnormal climatic situations. 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. 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 release of green house gases is concerned. With the increasing soil organic matter, the soils under Conservation Agriculture can retain carbon from 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). Particularly in paddy rice the change to no-till systems and adequate water management can positively influence the release of other green house gases such as methane and nitrous oxides (Belder, 2005) (Gao, 2006).

Impact of conservation agriculture on farm power and labour

One of the most noticeable changes for the farmer by introducing CA is the reduced requirement for farm power and labour. 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. Additionally equipment investment, particularly the number and size of tractors, is significantly reduced (Bistayev, 2002). This effect applies equally to small scale farmer using only hand labour or animal traction.
Options exist for direct sowing by hand, draft animal power (DAP) or tractor. Leaving the soil protected with surface vegetation requires a change in mind set that will demand greater management ability, especially for weed and cover crop control (de Freitas, 2000). Equipment for controlling the surface vegetation is principally DAP and tractor powered and includes mechanical (e.g. knife rollers) as well as chemical (herbicide) control measures. In general the time and power requirements for field operations related to crop establishment and crop husbandry are reduced. This flattens especially the traditional labour and power bottleneck during land preparation. Also the labour requirements for weeding are generally reduced, particularly if herbicides are used. However, during the learning period and especially during the first two years and in systems without the use of herbicides new labour peaks for weed control can occur. New labour peaks can also occur during harvest time, especially when the introduction of CA results in significant yield increases which eventually can happen already during the first years.
A study on the impact of conservation tillage and cover crops on soil fertility and crop production in Karatu and Hanang districts in Northern Tanzania (Mariki, 2003) verified that the labour requirements for no-tillage maize plus cover crops went down from 72 person-days/season in the first year to 34.7 person-days/season in year four. The control plot for conventional tillage maize remained stable at about 65 person-days/season. This indicates a saving of labour days through the adoption conservation agriculture (CA) practices by 54% in the fourth year of implementing no-tillage maize with cover crops.

A study of the energy cost of tractor–powered crop production with conventional tillage and direct seeding (Doets *et al*., 2000) estimated that total inputs are 40-50% lower for conservation agriculture. This is primarily caused by reduced absolute amounts of input: herbicide (in the cases studied), machinery and fuel. Machinery energy inputs are generally 20-40% lower with conservation agriculture which is logically due to the elimination of the need to plough. The systems studied showed reductions of over 60% in fuel consumption and this would be an equivalent figure for both human-powered and DAP systems. This saving in energy will be of particular interest to small-holder farmers looking to invest less time in agricultural production and more in pursuit of off-farm jobs; or wishing to expand their cropped area.

Impact of conservation agriculture on farmers' livelihood

The effects of conservation agriculture described above such as higher and more stable yields with lower input costs and a better adaptation to dangers of climate change clearly have a positive impact on farmers' livelihood. But there are also more direct impacts which have potential to turn around the daily and seasonal calendar and on the long term change the rhythm of farmers' family because of the reduced labour requirements for tillage, land preparation and weeding likely to occur. Especially women may be released from weeding tasks that traditionally were a 'woman's task. More time availability offers real opportunities for diversification options such as for example poultry farming or on-farm sales of produce, or other off-farm small enterprise developments that now (with time available) are a 'real' opportunity. An IFAD/FAO joint study that explored the potential of conservation agriculture as a labour saving practice found out that the labour inputs in the CA system could be reduced by 75% (in the hand labour/hoe system) when a jab planter was used compared to hand hoe. In the draught animal powers category the CA system (with knife roller and direct seed drill) the labour reduction was 80% (IFAD/FAO, 2004). Farming without ploughing can in this context indeed also mitigate the labour shortages that affect small-scale farmers in the sub-Saharan region due to rural-urban migration and the rapid spread of HIV/AIDS.

A long term study of small scale farmers at manual or draft animal mechanization level adopting CA in Paraguay showed significant changes in the farmers' livelihoods. The study analysed farmers with 7 to 10 years experience in CA comparing them with conventional farmers and with their initial situation before adopting CA. All farms had increasing crop yields after the change to CA due to the rapidly improving soil fertility. In addition to this most farmers introduced new crops and diversified their crop rotations, which could have been done also under conventional farming but is more likely to happen under CA. These effects lead to increased farm income which combined with the reduced production costs resulted in significantly higher net income. Depending on the farmer's choice of the production system and the geographic region the increases in net income over the period of observation ranged from 50 to more than 600% (Lange, 2005). Further and as a result of the saved time and labour, most of the farms introduced other alternative sources of income such as forestry, bee-keeping,, fish-farming, fruit and vegetable production, breeding of small animals and the related value adding activities.

The more visible impacts on the livelihoods of the farm families resulting from the increased farm income were that 50% of the farmers replaced their original wooden shacks with stone houses; one even bought a house in a nearby town. All purchased TVs, fridges, motorcycles horses and carts. The school age kids attended school at a regular base since their work input was not anymore required on the farm and the farmers could pay the school fees. Migration processes were stopped and even reverted since the farms provided sufficient income without the need for the farmer or the elder sons to look for off-farm work in the cities (Lange, 2005).

Similar experiences have been reported from Santa Catarina/Brazil, where the introduction of CA resulted in increased economic activities in rural areas dedicated to animal production and value adding (de Freitas, 2000).

Mechanization needs of conservation agriculture

Conservation agriculture obviously has equipment needs different from conventional farming. Specialized equipment is needed to carry out tasks under completely different conditions, such as direct seeding into unprepared soil under a mulch cover. In other cases the operations are carried out with a different objective, such as residue management not to accelerate decomposition but to slow it down to provide soil cover. On the other hand tillage equipment is not anymore needed while operation and adjustments of general equipment like tractors or harvesting equipment might also change, as is the case in controlled traffic systems.

Direct seeding

There are many simple tools already in use which enable crop seeds to be sown through vegetation on the soil surface. These range from the planting stick with a sharpened point or a metal tip to the *pioche* or pick which is a small hoe designed to make a hole big enough for seeding. Many more sophisticated jab planters have been developed over the years but have met with little success in terms of adoption. One exception is the *matraca* which has enjoyed widespread adoption in South America. The *matraca* has recently been introduced into SSA and has generated enthusiasm amongst farmers and artisans. It is yet to be proven if it achieves the same popularity as it receives in the American continent but there are signs that the demand is increasing in areas where CA is being adopted.

DAP pulled direct seeders have been developed by farmers and commercial manufacturers over the last 15 or so years in Brazil. Some examples have performed well also in SSA and direct seeders for tractors, both large and small, have also been developed both by farmers and entrepreneurs. They generally incorporate both seed and fertilizer metering units and cut the surface vegetation with a disc, often fluted.

Seeders and planters have been developed to cope with high amounts of residues and to place the seed reliably at a uniform depth even in difficult soil conditions, while always minimizing the soil movement (Baker *et al*., 2006).

Residue management

Residue and cover crop management corresponds in CA to the land preparation for seeding. Ideally this operation takes place at harvest time and in many CA cropping systems the seeder is following the harvesting machine directly. The objective is to leave as much residues as possible in order to increase soil organic matter and to spread them as evenly as possible. Especially in environments where decomposition is fast and where the amount of residues is low it is not recommended to chop the residues. Instead it is better to leave them as long as possible which has the additional benefit of saving the energy required for chopping. Leaving crop residues anchored in the soil instead of cutting them, for example by harvesting grain crops with a stripper type header, facilitates the subsequent seeding operation. However, in order to achieve the weed control function it is not recommended to leave the residue standing, but to roll them down (Baker *et al.*, 2006b). Exceptions might be irrigated systems with a relay crop undersown before harvest. In this case high standing stubble can reduce the risk of suppression of the seed by a thick layer of residue and it can also prevent the residue from floating and gathering in one part of the field.

A very useful tool specifically developed for the residue and cover crop management under CA is the knife roller, which flattens the residues and breaks the plants so that they eventually die.

Applied at the right time and on the right cover crop this equipment could replace the use of herbicides for crop establishment (Baker *et al.,* 2006b).

Supply and access to equipment

Change is risky and it is possible that yields are not maintained at the same or even a higher level during the adoption and learning period. On the other side there are quite substantial investment costs associated with the acquisition of CA technology. Since a no-till seeder is considerably more expensive than a comparable conventional seeder. Farmers will need assistance to calculate the expected financial impacts of change. They may also need help to soften the financial impact of acquiring the necessary technology. This could be by means of machinery pools, grace periods on loan repayments; or other means of ameliorating the financial burden such as special term finance arrangement.

Although it is perfectly acceptable to promote the CA concept in a new region through the use of imported equipment, there will eventually be calls for local manufacture. However, in an initial phase the import of completely knocked down equipment with local assembly could be a suitable intermediate step between importation and local manufacturing. It would reduce the cost and facilitate the technology transfer for local production. As the farmer has to learn the farming operations under CA, the equipment manufacturer has to learn likewise how to construct good quality no-till seeders which have requirements completely different to conventional equipment. Simple equipment, such as rippers and jab planters could quite easily be made by local artisans. However the role of artisans is probably best kept to repair and the provision of replacement wearing parts such as chisel points and jab-planter beaks. Batch production should be the responsibility of better equipped, larger scale manufacturers who are able to control quality and ensure product uniformity. In SSA this has proved to be difficult as potential manufacturers almost unanimously ask for evidence of demand or require a pre-paid firm order before producing for an unknown, risky, market. The development of locally adapted equipment depends also on the active participation of all stakeholders in the process. The success of CA for small and medium scale farmers in Brazil has been due to the synergistic interactions of farmers, researchers and manufacturers. It is vital to have an active and healthy R&D capacity to facilitate adaptations to local conditions. The most likely venue for this kind of activity will be universities and agricultural research stations. However, these must be encouraged to apply themselves to R&D relevant to the realities of the local situation by working with farmer and manufacturer groups, rather than working in isolation as is too often the case at the moment.

Recently there ahs been a surge of interest in contract farming as a mechanism to govern linkages between farmers and agribusiness (da Silva, 2005). Supply chain management principles have found in the agri-food sector fertile ground for their application. Contracting is seen as a means to facilitate the integration of small farmers in supply chains and certainly has great potential with regard to the application of CA equipment.

National agricultural mechanization strategies aim to chart the development of this sector in a country-wide context. Strategies provide a range of possible options to farmers so that they can make sensible choices in the context of their own situation. Mechanization strategies need to look at the local manufacturing situation and to include measures which will stimulate it to provide such a range of choices. These could include the initial purchase of batches of equipment for subsequent distribution and cost recuperation. However, in view of the specific equipment needs of CA on one side and the implications of CA on the general mechanization on the other side, it is important for a government embarking on both, sustainable land management and mechanization, to include the CA concept into the mechanization strategies in order to give coherent signals to farmers and input supply sector (FAO, 2006, 1997).

A new German-funded FAO project aims to practically deal with all those challenges of CA relevant input supply and farmer innovation systems. Ultimately the project aim is to improve food security in Kenya and Tanzania through the promotion of conservation agriculture. The three-year project will help promote the adoption of conservation agriculture practices by smallholder farmers in the two East African countries through an expanded network of farmer field schools and by increasing the availability of conservation agriculture equipment. Because of reasons outlined above, the project will bring in manufacturers and suppliers from Brazil, where wide-scale adoption of conservation agriculture techniques has spurred a vibrant small-scale manufacturing sector for this specialized equipment which has gradually evolved, with increased demand, to include larger commercial manufacturers. Brazil – East Africa South-South technology and innovation exchange is envisaged for the benefit of both Brazil and East African entrepreneurs, business firms and farmers .Brazil manufacturers will benefit from access to the East African market, while potential producers in Kenya and Tanzania will receive training in manufacturing and marketing the equipment to bring elements of the Brazilian success story to bear on the East African situation (FAO, 2007).

Conclusions

Conservation agriculture is a holistic concept for sustainable management of agricultural lands. It achieves to a high degree environmental and economic sustainability of farming and provides many benefits also for the non-farming rural population.

However by reducing labour requirements and drudgery of farming and by increasing the farm income it improves significantly the livelihoods of farmers and their families.

An important element for the adoption of conservation agriculture, regardless whether the farms are operating at manual level, with animal traction or at tractor level is the accessibility of affordable and good quality equipment suited for the local needs of farmers, producers and entrepreneurs with intention to go towards conservation agriculture practices. In many cases where CA is newly introduced the establishment of a commercial supply chain for this equipment does not happen spontaneously and requires special attention including technical assistance from FAO and other development partners world wide.

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