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3. Conservation Agriculture in India, History, Status, Implications and Sustainability Uses

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Abstract:

Conservation agriculture (CA) technologies involve minimal soil disturbance, permanent soil covers through crop residues or cover crops, and crop rotations to increase productivity. Efforts in India to develop, refine, and disseminate conservation-based agricultural technologies have been ongoing for nearly two decades and have made significant progress since then, despite several constraints that impede CA adoption. In particular, tremendous efforts have been made in the Indo-Gangetic plains to achieve no-till wheat under a rice-wheat rotation. There are more payoffs than tradeoffs for CA adoption, but the balance between the two was understood by both adopters and promoters. CA technologies offer opportunities to reduce production costs, save water and nutrients, increase yields, diversify crop production, improve resource efficiency, and benefit the environment. However, there are still barriers to CA technology promotion, such as a lack of appropriate seeders, particularly for small and medium-scale farmers, crop residue competition between CA use and livestock feeding, crop residue burning, the availability of skilled and scientific manpower, and overcoming the bias or mindset about tillage.

To promote CA in the region, it is critical to develop a policy framework and strategies. This article examines the emerging concerns caused by the continued adoption of conventional agriculture systems, as well as the constraints, prospects, policy issues, and research needs for conservation agriculture in India.

Keywords:

Conservation agriculture, Conventional agriculture, Principles, Constraints, Prospects, Implications and Sustainability uses.

3.1 Introduction:

The concept of conservation agriculture is relatively using of new and modern cultivation practices. Conventional agricultural practices promote the extensive soil tillage, burning of crop residues and external inputs Such practices lead to soil degradation through loss of organic matter, soil erosion and compaction. In India more than 70-75% farmers are small land holding farmer they are still using traditional farm practices and are major contributor in total food production.

Yet, for many, farming is a struggle often with only rudimentary tools and implements available. Conservation Agriculture is a method of planning and managing sustainable and resource-conserving agricultural systems (CA).

It aims to improve, preserve, and make better use of natural resources through integrated management of soil, water, crops, and other biological resources in conjunction with selected external inputs. Agriculture could be resource-saving and effective, while also improving production in a sustainable manner, with such a technological setup.

Conservation agriculture includes direct planting through crop residue, minimum tillage, organic soil cover, improved on-farm water management, and appropriate crop rotations to prevent disease and pest issues.

Burning crop wastes (as in the rice-wheat cropping system) contributes to pollution, greenhouse gas emissions, and the loss of important plant nutrients. Initiating processes that improve soil quality and boost resource quality when crop residues are left on the soil surface and no tillage is used.

In order to fulfil the goals of sustainable agriculture production, Conservation agriculture has evolved as a new approach. It's a significant step in the direction of sustainable agriculture.

Therefore, there are major benefits to Conservation agriculture. Direct advantages to farmers include

- lower cultivation costs due to manpower,
- time, and farm power savings, and
- increased input usage efficiency.

More importantly, CA techniques stop the depletion of resources. By increasing nitrogen balance and availability, soil infiltration and retention, lowering water loss due to evaporation, and enhancing the quality and availability of ground and surface water, CA results in long-term gains in the effective use of water and nutrients.

3.2 Conservation Agriculture Definition and Goals:

Conservation agriculture is a management system that maintains a soil cover through surface retention of crop residues with no till/zero and reduced tillage. It is described as a concept for resource saving agricultural crop production which is based on enhancing the natural and biological processes above and below the ground. Conservation agriculture (CA), is not "business as usual," based on optimizing yields while utilizing the resources of the land and agro-ecosystem.

A balance of agricultural, economic, and environmental benefits is achieved by CA by optimizing yields and profitability. It argues that the social and economic benefits of both production and environmental preservation-including lower input and labor costs—are larger than those of production alone.

By using pesticides, fossil fuels, and other harmful substances, as well as by preserving the integrity of the environment and its services, farming communities may provide a wider population with better hygienic living conditions.

As per FAO definition CA is to:

- achieve acceptable profits
- high and sustained production levels, and
- conserve the environment.

It aims at reversing the process of degradation inherent to the conventional agricultural practices like intensive agriculture, burning/removal of crop residues.

Hence, it aims to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It can also be referred to as resource efficient or resource effective agriculture.

Table 3.1: Distinguishing Features of Conventional and Conservation Agriculture Systems

Sr. No	Parameters	Conventional Agriculture (Ct)	Conservation Agriculture (Ca)
1.	Practice	Disturbs the soil and leaves at a bare surface	Minimal soil disturbance and soil surface is permanently coverd
2.	Cropping system	Monocropping / less efficient rotations	Diversified farming / more efficient rotations
3.	Residue management	Burning or removal	Retention on the soil surface
4.	Erosion	Maximum wind and water erosion	Less erosion
5.	Soil health	Poor	Good
6.	Water infiltration	Infiltration will be lowest after soil pores clogged	Good infiltration
7.	Organic matter content	Low	High

Sr. No	Parameters	Conventional Agriculture (Ct)	Conservation Agriculture (Ca)
8.	Weeds	Control weeds and also produce more weed seeds to germinate	Weeds are problem only during early stages of adoption, later good control of weeds
9.	Timeliness	Operations can be delayed	Optimal timeliness
10.	Yield	Lower due to delayed operation	More yield when timely planting done

3.2.1 How Is Conservation Agriculture Different from Sustainable Intensification?

Sustainable intensification is a process to increase agriculture yields without adverse impacts on the environment, taking the whole ecosystem into consideration. It aims for the same goals as conservation agriculture.

Conservation agriculture practices lead to or enable sustainable intensification.

3.2.2 How Is Conservation Agriculture Differing from Organic Agriculture?

Conservation agriculture and organic farming both use crop rotation to maintain a balance between agriculture and resources and to protect the organic matter in the soil.

The main distinction between these two types of farming is that organic farmers use soil tillage, whereas conservation farmers use natural principles and do not till the soil.

Tillage is used by organic farmers to remove weeds without the use of inorganic fertilizers. Farmers who practice conservation agriculture use a permanent soil cover and plant seeds through it.

They may initially use inorganic fertilizers to control weeds, particularly in low fertility soils. Agrichemical use may be reduced or phased out gradually over time.

3.2.3 How Is Conservation Agriculture Differing from Climate-Smart Agriculture?

While conservation agriculture and climate-smart agriculture are similar, their goals are not. Conservation agriculture seeks to use natural processes to sustainably intensify smallholder farming systems while also having a positive impact on the environment. It enables farmers to adapt to and increase profits in the face of climate risks.

Climate-smart agriculture aims to adapt to and mitigate the effects of climate change by sequestering soil carbon and reducing greenhouse gas emissions, and finally to increase the productivity and profitability of farming systems to ensure farmers' livelihoods and food security in a changing climate. Conservation agriculture systems can be considered climate-smart because they meet the goals of climate-smart agriculture.

3.3 Principles of Conservation Agriculture:

Conservation agriculture practices used in many parts of the world are built on ecological principles making land use more sustainable. Adoption of Conservation Agriculture for enhancing Resource use efficiency (RUE) and crop productivity is the need of the hour as a powerful tool for management of natural resources and to achieve sustainability in agriculture.

Conservation agriculture basically follows 3 principles, which must be considered together for appropriate design, planning and implementation processes. These are:

3.3.1 Minimal Mechanical Soil Disturbance:

The biological activity of the soil creates very solid soil aggregates and holes of different sizes that enable the infiltration of air and water. This method, which is sometimes referred to as "biological tillage," is incompatible with mechanical tillage.

The biological health and life processes of the soil will be destroyed by mechanical soil disturbance. A minimum amount of soil disturbance promotes/maintains ideal levels of respiration gases in the rooting zone, moderate organic matter oxidation, porosity for water transport, retention, and release, and restricts re-exposure of weed seeds and their germination.

3.3.2 Permanent Organic Soil Cover:

It is imperative in conservation agriculture to protect the soil from harmful effects resulting from exposure to rain and sun; to provide constant food supply to the soil; micro and macro -organisms, together with the plant roots. Soil cover is attained with biomass obtained from crop residues and cover crops.

3.3.3 Diversified Crop Rotations:

Crop rotation is essential not just to provide a variety of "food" for soil microorganisms, but also to search through different soil levels for nutrients that have leached to deeper layers and can be "recycled" by the crops in rotation.

Rotation produces a variety of soil flora and fauna. By disruption of life cycles, biological nitrogen fixing, reduction of off-site pollution, and enhancement of biodiversity, the sequence and rotation of cropping with legumes contributes to the lowest rates of population build-up of pest species.

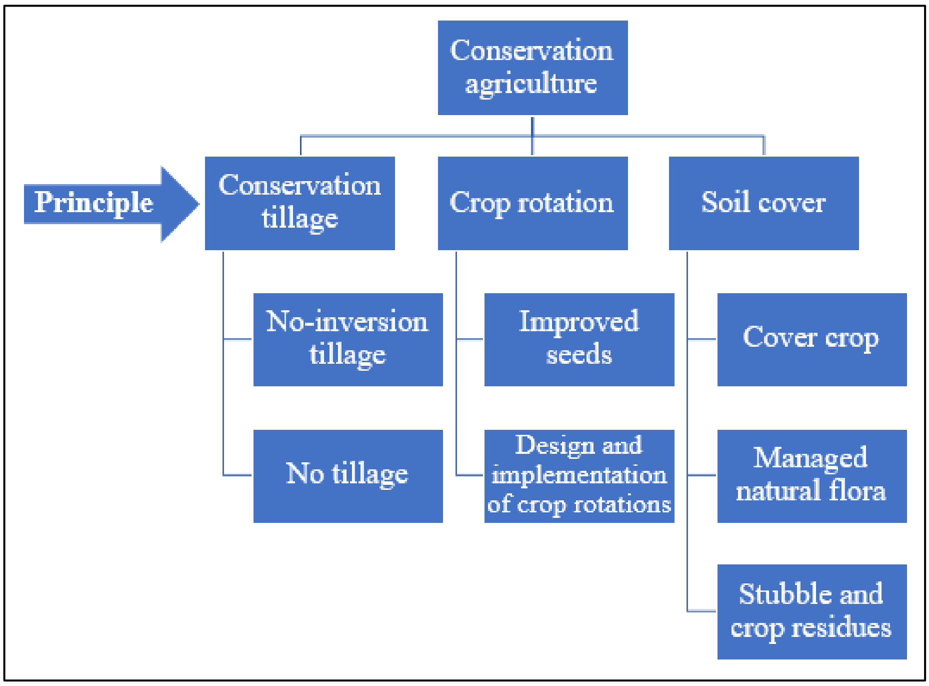

Figure 3.1: Principles of Conservation Agriculture.

3.4 History and Status of Conservation Agriculture in India and World:

The term "conservation agriculture" was coined in the 1990s, but the idea to minimize soil disturbance has its origins in the 1930s, during the Dust Bowl in the United States of America. CIMMYT began work with conservation agriculture in Latin America and South Asia in the 1990s and in Africa in the early 2000s. Today, these efforts have been scaled up and conservation agriculture principles have been incorporated into projects such as CSISA, FACASI, MAs Agro, SIMLESA, and SRFSI. Farmers worldwide are increasingly adopting conservation agriculture.

In the 2015/16 season, conservation agriculture was practiced on about 180 mega hectares of cropland globally, about 12.5% of the total global cropland — 69% more than in the 2008/2009 season. In approximately 125 million ha. of high-potential environments worldwide, CA is used. USA (26.5 M ha), Brazil (25.5 M ha), Argentina (25.5 M ha), Canada (13.5 M ha), and Australia are the top CA-practicing nations (17.0 M ha). The adoption of CA is still in its early stages in India. Over 1.5 million hectares have adopted zero tillage and CA over the past few years (Jat et al., 2012; www.fao.org/ag/ca/6c.html).

In the rice-wheat (RW) system of the Indo-Gangetic plains, zero-till (ZT) wheat is one of the main CA-based technologies being used (IGP). In other crops and cropping systems, the conventional agriculture based crop management systems are gradually undergoing a paradigm shift from intensive tillage to reduced/zero-tillage operations. In addition to ZT, other concept of CA needs to be infused in the system to further enhance and sustain the productivity as well as to tap new sources of growth in agricultural productivity.

The CA adoption also offers avenues for much needed diversification through crop intensification, relay cropping of sugarcane, pulses, vegetables etc. as intercrop with wheat and maize and to intensify and diversify the RW system. The CA based resource conservation technologies (RCTs) also help in integrating crop, livestock, land and water management research in both low-and high-potential environments. Spread of these technologies is taking place in the irrigated regions of the Indo-Gangetic plains where the rice-wheat cropping system dominates.

Zero-till seed-cum fertilizer drills for sowing wheat in rice-wheat systems have received the majority of attention in the development and promotion of conservation technologies. Additional interventions include alternatives to the rice-wheat system, raised bed planting techniques, land levelling assisted by laser technology, residue management techniques, etc. According to reports, the amount of wheat planted with the zero-till drill has been growing quickly (Sangar et al., 2005), and 25% to 30% of the wheat grown in rice-wheat-growing regions of the Indo-Gangetic plains of India is currently zero-tilled. The farmers in the northwest are also progressively implementing raised-bed farming and laser ground levelling.

3.4.1 Benefits of Conservation Agriculture:

Conservation farming seems to be the ideal solution for global problems. It improves crop productivity, the environment, and biodiversity. Farmers are increasingly using this farming method for its effectiveness:

- Improve soil structuring.
- Increasing soil's organic matter.
- Enhance soil infiltration.
- Improve soil nutrients.
- Protection against soil erosion.
- Decrease weed population.
- Organic crop protection saves biodiversity.
- Reduce farm finance.

A. Economic Benefits: The introduction of conservation agriculture has three important economic benefits:

- Save time and reduce labor cost.
- Reduce technical cost., fuel, machinery, etc.
- High efficiency lower input, high output.

B. Agronomic Benefits: The introduction of conservation farming leads to an increase in soil productivity:

- Increase soil organic matter.
- Increase conservation of soil water.
- Improve soil structure.
- Improve crop root anchoring.

C. Environmental Benefits:

Adaptation of conservation agriculture improves environment and biodiversity:

- Reduce soil erosion.
- Reduce infrastructure maintenance cost, roads, dams, power plants.
- Improve water quality.
- Filter atmosphere and improve air quality.
- Increase soil bio-diversity.
- Restore soil carbon content.

3.4.2 Prospects of Conservation Agriculture:

Now a day's different countries do so many things to meet the food and energy needs for coming decades which will have great impact on natural resources bases, global climate change and energy security for India and world. A shift to no-till conservation agriculture is perceived to be of much fundamental value in meeting these challenges.

Asian farmers/researchers will continue to need assistance to reorient their agriculture and practices for producing more with less cost through adoption of less vulnerable choices and pathways. Therefore, business as usual with conventional agriculture practices does not seem a sustainable option for sustainable gains in food-grain production, and hence CA-based crop management solutions adapted to local needs will have to play a critical role in most ecological and socio-economic settings of Asian Agriculture. The promotion of CA under Indian/Asian context has the following prospects:

- Reduction in cost of cultivation – it is the key factor contributing to rapid adoption of zero-till technology. Cost reduction is to save money in accounts of diesel, labor and input costs, especially herbicides.
- Reduction incidence of weeds – due to adoption of zero tillage it reduces weed incidence and it reduce herbicides.
- Saving in water and nutrients – It shows that significant fertilizer and water savings are made possible by zero-till planting, especially for crops that are laser levelled and planted in beds. These savings can range from 20% to 30%. No-till soils had higher soil water contents than conventionally tilled soils, which suggested that less water had evaporated during the earlier period. Also, they discovered that the soil water content under no-till was around 20% higher than under conventional tillage over the course of growing seasons.
- Increased yields were consistently higher in properly maintained zero-till planted crops than in traditionally prepared fields for identical planting dates. Due to concomitant effects like the prevention of soil degradation, improved soil fertility, improved soil moisture regime (due to increased rain water infiltration, water holding capacity, and reduced evaporation loss), and the advantages of crop rotation, CA has been reported to increase the yield level of crops. Nevertheless, during the early stages of adoption, there are no yield gains and potentially a yield decline.
- Environmental benefits – Crop residue burning, which produces significant amounts of greenhouse gases including CO2, CH4, and N2O, can be completely eliminated by

conservation agricultural practices like zero-till and surface managed crop residue systems. Burning crop leftovers causes a significant loss of plant nutrients that, with good management, might be recycled. Crop residue burning on a large scale is also a severe health risk.

- Crop diversification opportunities – Adopting Conservation Agriculture systems offers opportunities for crop diversification. Cropping sequences/rotations and agroforestry systems when adopted in appropriate spatial and temporal patterns can further enhance natural ecological processes.
- Resource improvement – No tillage when combined with surface management of crop residues begins the processes where by slow decomposition of residues results in soil structural improvement and increased recycling and availability of plant nutrients. Surface residues acting as mulch, moderate soil temperatures, reduce evaporation, and improve biological activity.

3.4.3 Constraints in Adoption of Conservation Agriculture:

Farmers in a country or region, where CA is not practiced, face a number of problems which make adoption difficult. These problems are of diverse nature, such as intellectual, social, biophysical and technical, financial, infrastructural and policy. Most farmers are facing, several of these problems, if not all, at the same time to the effect that only very few bold pioneer farmers adopt CA. Farmers are not in the position to start with a blank sheet and to weigh objectively the merits and disadvantages of CA against conventional tillage farming.

A. Intellectual Constraints to Adoption:

New technologies that are quickly adopted often have obvious advantages, resulting in rapid acceptance and enthusiasm. In many cases, this enthusiasm fades once the new technology is understood and the drawbacks become apparent. CA works in the opposite direction: it contradicts so much of what a farmer has learned and been told that the benefits of CA are not immediately apparent. However, once the gradual adoption process begins, CA's performance improves over time. The more experience producers have with CA, the more convinced and positive they are about it. The less practical experience people have with CA, the more critical and negative their attitude towards it. A study carried out with European and American no-till farmers and agricultural experts came to similar conclusions. It was found that the experts, mostly without practical experience in CA, anticipated many problems for its adoption.

In their opinion, the problems outweighed the benefits, resulting in an overall negative attitude. Farmers who were actually practicing CA and had experience with the system, on the other hand, had an overall positive perception, with the benefits clearly outweighing the problems (Tebrugge and Bohrnsen 2000). CA has two intellectual barriers to overcome: the first is that the CA concept and principles are counterintuitive and contradict the common tillage-based farming experience, which has worked for generations and has frequently created cultural values and rural traditions; the second is a lack of experiential knowledge about CA and the mechanism to acquire it. Soil tillage, and particularly the plough, has in most countries become part of the culture of crop production. Ploughing, cultivation and tillage are often synonyms for growing a crop.

Cropland is referred to as "arable" land, which is Latin for "plough able" land. The plough was part of the very early developments of agriculture and has the character of a brand symbol for what is 'correct'. People find it difficult to accept that the plough is suddenly dangerous and that crops can grow without tilling the land. Overcoming this "mental compaction" is frequently much more difficult than actually beginning no-till farming (Landers 2001). It's difficult to imagine a soil becoming softer and more structured without being tilled unless you've seen it happen. The second intellectual impediment to adoption is simply a lack of sufficient experiential knowledge about it and the means of acquiring it.

CA covers about 7% of agricultural land worldwide. Adoption is concentrated in a few countries, eventually exceeding 50%, while adoption in the rest of the world is less than 2%. This explains why most people have never seen a CA system in action. CA is rarely mentioned in the media because it is not yet represented in any labels or certification schemes and has no direct relevance to consumers. CA is also not included in university curricula, even at prestigious agricultural universities.

This explains why, despite having more than twice the adoption rate of organic farming, public awareness of CA is much lower. Even most agricultural professionals and many farmers have never heard of CA, or have only vague ideas about it. Permanent no-tillage farming and CA are frequently unfamiliar to farmers and thus do not appear on their radar. For actual CA adoption, the farmer would need to know not only about CA elements in general, but also how to implement CA elements under the specific conditions of an individual farm.

This knowledge is not typically available as an off-the-shelf technology package. Worse, CA is a complex and labor-intensive farming concept in which crop management must be planned ahead of time and is mostly proactive rather than reactive, as in traditional tillage-based systems. In tillage-based systems, soil compaction or uneven surfaces are corrected with tillage; in no-till systems, they must be avoided from the start. Weed and pest management in conventional tillage systems is frequently based on chemical or mechanical control as a response to the incidence, whereas in CA, the incidence of weeds and other pests is reduced through crop rotation planning.

This increased complexity necessitates the acquisition of experience and knowledge. This learning process and experiential knowledge has thus involved a lot of trial and error for early adopters until sufficient local experience and knowledge has been accumulated to make the adoption easier. However, farmers, not scientists, are best suited to develop solutions to these practical problems. Farmers' own adaptive "research and development" process typically produces more timely and applicable results than the so-called "Green Revolution" approach of leaving the development of a standard technology package "ready for adoption" to the scientific community.

B. Social Constraints to Adoption:

Farmers in developing countries are mostly conservative and risk opposition to this adoption. If any farmer doing different method of agriculture from others will therefore risk being excluded from the community.

This leads to social isolation and even to mocking, only very strong farmers can take a step forward. Even after seeing the success in individual farmer fields due to aversion created in their mind and due peer pressure other farmers not following. The pressure can be so bad that the community gets jealous of the success and instead of also adopting it, it leads to boycott including using 'black magic' and placing bad spells on the fields. For adoption of this process no need of any progressive farmer who can prove the success, but the farmers should socialize and integrated in the community. Other issues include traditional land tenure systems, in which no individual owns land, which makes it difficult for farmers to invest in long-term soil health and productivity improvement. Furthermore, communal grazing rights, which frequently include the right to graze on crop residues or cover crops after the harvest of the main crop, create conflicts that make the adoption of CA practices difficult.

These issues can be significant barriers to CA adoption, and conflicts arising, for example, from alternative uses of crop residues as mulch or animal feed cannot be resolved through orders or directives. Physical barriers, such as fences, may not be the best solution if they contradict the traditional social values of the respective cultures. Much more important in the process is that the entire community first understands the issues, as well as the changes and benefits associated with adopting CA, and then works together to find solutions.

C. Input Constraints:

Access to equipment, seeds, fertilizers, and herbicides is a major barrier to expanding CA in Africa. CA does not always necessitate more equipment than traditional agriculture, but some of the equipment is unique and not always available.

The most notable differences are found in land preparation and seeding. In silty or clayey soils, the soil surface is only penetrated in precisely targeted seeding lines or pits. Seeds are then deposited or inserted directly into the ground through the mulch or ground cover layer. Some conventional agriculture tools (e.g., certain weeding tools) can also be used for CA, while others can be modified for CA (e.g., hand hoes can be made narrower to dig CA planting basins). Equipment costs are relatively low for nonmechanized CA involving simple hand tools (if the requisite equipment is available at all). When using animal- or tractor-powered implements, costs skyrocket.

Access to (or affordability of) inorganic fertilizers, pesticides, and herbicides may also be a barrier to practising CA in the most productive way. However, one of the primary benefits of CA is that it can increase yields in situations where agrochemicals are unavailable or prohibitively expensive by encouraging biological processes and management practices that improve soil fertility, pest control, and weed control.

Nitrogen-fixing plants, which can include shrubs, annual herbaceous plants, or trees like *Faidherbia albida*, are an essential component of most CA systems. Intercropping with these species boosts yields, soil health, and soil chemical and biological properties while decreasing weed and pest problems. Despite these advantages, spontaneous adoption of cover crops for soil fertility enhancement is uncommon; instead, the plants must provide some direct benefit, such as human food or animal fodder.

D. Biophysical and Technical Constraints:

Although the concept of CA is universal, this does not imply that techniques and practises for every condition are readily available. Depending on the specific farming situation and agro-ecological conditions, the actual CA practise must be developed locally in most cases. Farmers in each location must discover and decide on crop rotations, cover crop selections, and crop-livestock integration issues. A wide range of issues arise, frequently involving weed management, residue management, equipment handling and settings, and planting parameters such as timing and depth, all of which must be discovered for the first time.

As a result, when CA is first introduced in a region, extension agents and advisors are unable to provide specific advice on practises and must instead develop these practises in collaboration with farmers. On the other hand, if properly applied, such an approach is much faster and more sustainable than the development of specific practises by scientists, because

it taps into the vast pool of experience and innovation potential of the farmer community. Some cover crops have been developed from weeds, and farmers have developed practises such as growing paddy rice or potatoes under no-till in CA without scientists even considering such innovations.

CA with higher levels of fertilizer than conventional maize production has the potential to raise yields, but cash constraints are a barrier to widespread fertilizer use (regardless of tillage method). Most farmers in Mozambique grow maize without fertilizer (Bias & Donovan, 2003). The benefits from fertilizer use depend on soil conditions. Fertilizer use in Africa is generally low because of both demand side and supply side factors. Demand is often weak because of "the low -levels and high variability of crop yields on the one hand and the high level of fertilizer prices relative to crop prices on the other."

Aside from financial or other constraints, another technical constraint is the simple lack of certain technologies or inputs. There are no cover crop seeds available in many countries where farmers begin with CA. The availability of equipment, particularly notill direct seeding equipment, is also frequently an issue. Most situations now have technologies available somewhere in the world. However, in some areas, farmers may be unaware of these technologies or may not have access to them. This is usually where external assistance, such as knowledge sharing, or even the introduction of specific technologies, such as direct seeding equipment, is required.

E. Financial Constraints:

Although CA is typically more profitable than conventional farming practises, there are still financial barriers to adoption, depending on the availability of capital to invest in this change of production system.

These constraints exist at all farm size levels, albeit to varying degrees and for various purposes. Converting a manufacturing system to CA is a long-term investment. In many cases, the change is motivated by the degradation of natural resources, particularly soil and water, as a result of previous tillage-based agriculture.

To begin with CA and successfully restore soil life and health, some initial investment in the land may be required, such as ripping existing compactions, correcting soil pH or extreme nutrient deficiencies, levelling and shaping the soil surface for the cropping system envisaged under CA. The capital for this type of investment is not available, particularly for small subsistence farmers.

Furthermore, the farmer requires new equipment, as most of the existing equipment is becoming obsolete and will most likely not find an attractive second -hand market. The larger the farmer, the more important this barrier, because a no-till seed drill, for example, is significantly more expensive than a conventional one.

This conflict between the potential improved profit margin on one hand and the very concrete and actual investment requirements on the other often leads to farmers deciding not to switch to CA, even if they are convinced of the benefits.

In general, CA is longer-term more profitable than traditional farming. Nevertheless, obtaining these long-term advantages could necessitate an upfront investment, which is frequently too costly or dangerous for small farmers to make on their own. Due to worries about household food security, vulnerable farmers are extremely risk conservative, and there is limited space for error.

However, while many farmers experience benefits in the first year of using CA, others take three to seven years to see a boost in yields or profitability. Farmers occasionally decide to stop using CA at this time, thus long-term adoption is more likely when CA offers large benefits in the first or second year. When CA is promoted along with sound agronomic procedures, improved seeds, and occasionally inorganic fertilisers, the likelihood of such an immediate benefit increases.

Credit facilities are one solution in these cases, but sometimes the availability of contractor services or technical advice on how to adapt and modify existing equipment as a low-cost intermediate solution to begin with can also be beneficial. Modification of existing equipment has, for example, provided an entry point for some farmers in Brazil and Kazakhstan to begin with CA and then, after benefiting from higher profitability, invest in proper equipment at a later stage. Homemade solutions for simple CA farm tools, particularly for small farmers, are an important component of CA adoption in Paraguay (Lange and Meza, 2004).

F. Infrastructural Constraints:

Conservation agriculture also necessitates some exogenous inputs in order to achieve high output levels. CA improves crop growth conditions and increases the efficiency of natural resources and input use, but it is not a 'perpetual motion' process that would allow crop intensification from endogenous resources. In order to increase production intensity, inputs should be available near the production area, processing units, and markets where produce is sold. Conservation agriculture produces better results than conventional agriculture even when no external inputs are used, but the difference is not significant.

Some inputs, such as fertilizer types, will differ only marginally from the requirements of conventional tillage-based farming. Herbicides, seeds for cover- and rotational crops, and especially equipment for direct seeding, planting, and residue management, on the other hand, are frequently completely different from those used in the past and must be introduced into markets. This necessitates not only a good input supply infrastructure, but also a proactive attitude on the part of the supply sector, such as dealers and manufacturers. It necessitates collaboration between the farming and input supply sectors, as well as some supportive policies.

G. Policy Constraints:

CA adoption can occur spontaneously, but it usually takes a long time to reach significant levels. Adequate policies can significantly shorten the adoption process, primarily by removing the previously mentioned constraints. This can be accomplished through information and training campaigns, appropriate legislation and regulatory frameworks, research and development, incentive and credit programmes, and other means. However, in most cases, policymakers are also unaware of CA, and many existing policies work against CA adoption. Commodity subsidies, which reduce farmers' incentives to use diversified crop rotations, mandatory prescription for soil tillage by law, or a lack of coordination between different government sectors are typical examples. In some cases, countries have legislation in place that supports CA as part of a sustainable agriculture programme.

If those countries have a programme to modernise and mechanise agriculture, the first items introduced under such a mechanization programme are usually tractors with ploughs or disc harrows. This not only sends the wrong signal, but it also works directly against the introduction and promotion of CA, while also passing up an opportunity to introduce tractors with no-till seeders instead of ploughs, assisting in overcoming this technological constraint. Even in countries where many farmers practice CA, policymakers frequently lack awareness of the practice, and in some cases, existing policies work against it.

Countries with their own agricultural machinery manufacturing sector frequently levy high import taxes on agricultural machinery to protect their own industry. This industry frequently lacks suitable CA equipment in the short term, but due to high import taxes, farmers who want to adopt CA are unable to import equipment from abroad. In other cases, the import tax on raw materials may be so high that local manufacturing of CA equipment becomes impossible.

To avoid such contradictory policies, policymakers and legislators must be made aware of CA and its ramifications. Where farmers do not farm their own land but rent land from others, there are additional issues with CA implementation: the accumulation of soil organic matter under CA is an investment in soil fertility and carbon stocks, which is currently not recognized by policymakers but is increasingly recognized by other farmers.

Farmers who still plough know that the mineralization of organic matter acts as a source of plant nutrients, allowing them to "mine" these lands with lower fertilizer costs. This allows them to pay a higher rent for CA land than the CA farmer can. Such cases can be found in both "developing" African and "developed" European countries.

To avoid this, some policy instruments are required to hold landowners responsible for maintaining soil fertility and carbon stock in the soil, which is difficult to achieve in the absence of agricultural carbon markets.

3.5 Conservation Agriculture's Challenges:

Challenges in conservation agriculture Conservation agriculture as an upcoming paradigm for raising crops will require an innovative system perspective to deal with diverse, flexible and context specific needs of technologies and their management.

Conservation agriculture R&D (Research and Development), thus will call for several innovative features to address the challenge.

A. Understanding the system – Unlike to conventional methods, conservation agriculture is far more difficult. The fundamental barrier to the adoption of CA systems has been site-specific expertise. Understanding the fundamental processes and component interactions that affect how well the system as a whole performs will be crucial to managing these systems effectively. For instance, crop leftovers that are kept on the surface operate as mulch, reducing the amount of water that evaporates from the soil and preserving a stable soil temperature regime. Crop leftovers can be a simple source of organic matter for decomposition, but they can also harbour pest populations that are undesirable or otherwise change the ecology of the system. No-tillage systems will influence depth of penetration and distribution of the root system which, in turn, will influence water and nutrient uptake and mineral cycling. Thus, the need is to recognize conservation agriculture as a system and develop management strategies.
B. Building a system and farming system perspective – A system perspective is built working in partnership with farmers. A core group of scientists, farmers, extension workers and other stakeholders working in partnership mode will therefore be critical in developing and promoting new technologies. This is somewhat different than in conventional agricultural R&D, the system is to set research priorities and allocate resources within a framework, and little attention is given to build relationships and seek linkages with partners working in complementary fields.
C. Technological challenges - While the basic principles that underpin conservation agriculture practises, such as no tillage and surface managed crop residues, are well understood, the key challenge is implementing these practises in a variety of farming situations. These difficulties are related to the development, standardisation, and adoption of farm machinery for seeding with minimal soil disturbance, as well as the development of crop harvesting and management systems.
D. Site specificity - Although adaptation strategies for conservation agriculture systems will be highly site specific, learning across sites will be a powerful way of understanding why certain technologies or practises are effective in one set of situations but not in another. This learning process will hasten the development of a knowledge base for sustainable resource management.
E. Long-term research perspective - Conservation agriculture practises, such as no-tillage and surface-maintained crop residues, result in resource improvement gradually, with benefits accruing over time. Indeed, benefits in terms of yield increase may not be realised in many cases during the early stages of evaluating the impact of conservation

agriculture practises. Understanding the dynamics of change and the interactions between physical, chemical, and biological processes is essential for developing better soil-water and nutrient management strategies (Abrol and Sangar, 2006). As a result, conservation agriculture research must have a longer time horizon.

3.6 Implications and Sustainability Uses:

Conservation agriculture entails a significant departure from traditional farming practises. Policy analysis is required to understand how CA technologies integrate with other technologies, as well as how policy instruments and institutional arrangements encourage or discourage CA (Raina et al., 2005). CA provides a means of halting and reversing the downward spiral of resource depletion by decreasing factor productivity, lowering cultivation costs, and making agriculture more resource-efficient, competitive, and sustainable.

While R&D efforts over the last decade have aided in increasing farmer acceptance of zero tillage for wheat in rice-wheat cropping systems, this has raised a number of institutional, technological, and policy issues that must be addressed if CA practises are to be adopted on a large scale in the region on a sustained basis.

A. CA technologies affect the plant growing microenvironment significantly. Changes in moisture regimes, root environment, the appearance of novel diseases, and a shift in the insect-pest situation are just a few examples. Plant types that are suitable for the new environment and meet specific mechanisation needs may differ. Complementary crop development programmes aimed at generating cultivars better suited to new systems are required. Farmers' participation in research appears promise for finding and producing crop types that are suited to a specific environment or place.
B. Support for the adaptation and validation of CA technologies in local environments: Adaptive research is necessary to match CA concepts and practises to local situations. This should be done in partnership with local communities and other stakeholders. Crop species, crop and cover crop selection and management, rotations, soil cover maintenance, and CA equipment should all be considered. In India, resource-poor and small-holder farmers lack economic access to new seeds, herbicides, and sowing machinery, among other things (Sharma et al., 2012). This necessitates a policy framework that makes crucial inputs readily available.
C. There is a need for generating a good resource database with agencies involved complementing each other’s work. Besides resources, systematic monitoring of the socio-economic, environmental and institutional changes should become an integral part of the major projects on CA.
D. Credit and subsidies: Another critical factor in the successful implementation of CA is the availability of financing to farmers to purchase equipment, machinery, and inputs at affordable interest rates from banks and credit agencies. At the same time, the government should provide a subsidy for farmers to purchase such equipment. For example, the Chinese government has recently undertaken a number of regulatory and economic measures to promote CA practises in the Yellow River Basin, including a subsidy on CA machinery and effective farmer training (Yan et al., 2009). This resulted in a significant increase in CA area. Presently, over 80% of the area under maize production in Shanxi, Shandong, and Henan provinces is dependent on no-till seeder.

E. Promote payments for environmental services (PES) and fines for faulty practices: Adopters of CA improve the environment through carbon sequestration, prevention of soil erosion or the encouragement of groundwater recharge. It provides ecosystem services, thus, farmers could be rewarded for such services, which have a great impact on the quality of life for all.
F. Scaling up conservation agriculture practises: Attempts to adapt CA concepts and technological components to the region's different agro-ecological, socio-economic, and farming systems began a few decades ago. More support from stakeholders, especially policymakers and decision-makers at the local, national, and regional levels, will facilitate CA expansion and let farmers to reap additional benefits from the technology. For more than a decade, substantial CA research has been undertaken in India, primarily at the Indian Agricultural Research Institute. Unfortunately, its reach among farmers is extremely restricted. There is a need to consider the challenges encountered during implementation and design a strategy that involves all parties involved. The majority of cases where reforms in favour of CA have happened have had limited success. According to FAO (2001), this is due in part to unfavorable policy conditions. One of the causes for the slow adoption of technology among farmers was the majority of farmers' previous inclination or mindset towards tillage (Hobbs and Govaerts, 2010).
G. CA allows for diverse cropping systems in various agro-ecoregions. Developing, upgrading, and standardizing equipment for planting, fertilizer placement, and harvesting while ensuring minimal soil disturbance in residue management for varied edaphic situations will be critical to CA's success. Bullock hauled equipment will be more useful for small landholders in various scenarios, such as in steep stretches. Ensuring quality and availability of equipment through appropriate incentives will be important. In these situations, the subsidy support from national or local government to firms for developing low cost machines will help in the promotion of CA technologies.

Conservation agriculture technologies are the future of sustainable agriculture. There are potential benefits of conservation agriculture across different agro-eco-regions and farmer’s groups.

The benefits range from nano-level (improving soil properties) to micro-level (saving inputs, reducing cost of production, increasing farm income), and macro-level by reducing poverty, improving food security, alleviating global warming.

There is a need for a global movement for promoting conservation agriculture. In India, the concept of conservation agriculture may be integrated with various government programs by sensitizing policy advisors, professionals and financial institutions.

The benefits of conservation agriculture need to be effectively communicated to all the stakeholders for its widespread adoption by the farming community. Failing that the sustainability of agriculture would be under threat and adversely affect natural resources and agricultural production. The most affected would be the under privileged and poor farmers in unfavorable and marginal areas. So it can be concluded that conservation agriculture is most need for Indian agricultural land for longer utilization and effective crop production

3.7 Conclusion:

Conservation agriculture represents a new paradigm for agricultural research and development that differs from the traditional one, which was primarily focused on meeting specific food grain production targets in India.

A paradigm shift has become necessary in light of widespread resource degradation issues that have accompanied previous strategies to boost production with little regard for resource integrity. Integrating productivity, resource conservation, soil quality, and environmental concerns is now critical to long-term productivity growth. In terms of knowledge base, developing and promoting CA systems will be extremely difficult.

The traditional approach to agricultural research and development in India has been replaced by a new approach that promotes conservation agriculture. It is becoming increasingly important to incorporate issues of productivity, resource conservation, soil quality, and the environment into continuous productivity increases.

It will be difficult to develop and promote CA systems without a solid knowledge base. Conservation agriculture provides a chance to prevent and reverse the downward spiral of resource degradation by lowering cultivation costs and increasing resource use efficiency, competitiveness, and sustainability in agriculture. The new mission must emphasize resource conservation while increasing output. Despite the obvious productivity, economic, environmental, and social benefits of CA, adoption does not occur on its own. Individual farmers have valid reasons not to implement CA in their specific farm situation.

The obstacles range in origin from intellectual, social, financial, biophysical and technical, infrastructural, to policy issues. Knowing the bottlenecks and problems allows for the development of strategies to overcome them. Crisis and emergency situations, which appear to be becoming more common in a climate change scenario, as well as political pressures for more sustainable use of natural resources and environmental protection on the one hand, and improving and eventually attaining food security on the other, provide opportunities to harness these pressures for supporting the adoption and spread of CA and assisting in overcoming existing adoption barriers.

As a result, the growing challenges confronting the world, ranging from the recent sudden global crisis caused by soaring food prices, high energy and input costs, rising environmental concerns, and climate change issues, provide policymakers with justification to implement supportive policies and institutional services, even including direct payments to farmers for environmental services from agricultural land use, which could be linked to the introduction of sustainable farming methods such as CA.

In this way the actual global challenges are providing at the same time opportunities to accelerate the adoption process of CA and to shorten the initial slow uptake phase. Conservation agriculture could decrease soil detachment and increase water infiltration that implies a decrease of water runoff; consequently, soil erosion would be reduced. Effects of conservation agriculture on reducing erosion were mainly caused by crop residues retained on the soil surface.

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