

Conservation Agriculture Policy –Perspective and Future Scope

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1. INTRODUCTION

Agriculture is an energy conversion process. It is both a producer and a consumer of energy. Agriculture provides food, feed and fibre. The introduction of high-yielding varieties of major crops like wheat, rice, etc. in India in mid-sixties paved the way for important technological changes and led to unprecedented rise in the crop yield and land productivity in many parts of the country.

Green revolution led to self-sufficiency in food grains with production reaching 203 million tons (Mt) in 1998-99 as against 50 Mt in 1950-51. This increase in production was achieved due to increased use of inputs such as fertilizer, irrigation water, diesel, plant protection chemicals, electricity, etc. which demand more human, animal and machinery energies.

Total commercial energy use in agriculture increased nearly five-fold with growth rate of 11.8 percent between 1980-81 to 1994-95, but the share of agriculture in total energy consumption in the country increased marginally from 2.3 to 5.3 percent during the same period. These gains in green revolution were accompanied by widespread problems of resource degradation and environmental pollution, which now pose a serious challenge to the continued ability to meet the demand of an increasing population and lifting people above the poverty line. Apart from this, the Green House Gas (GHG) emissions also accounted for enteric fermentation from livestock, manure management, rice cultivation, and burning of agriculture residues.

The fuel crisis in the 70s and the growing uncertainty in the supply of hydrocarbons and the concern on growing environmental pollution caused by inefficient use of energy were the main factors which led to increasing emphasis on energy efficiency and conservation the world over. With conventional energy sources depleting at a fast rate on account of increasing demand, energy has emerged as one of the most important considerations in design and management of agricultural operations in recent times. Increasing demand on energy from agricultural sources has resulted in large-scale deforestation, soil erosion and loss of fertility on one hand and in the manifold increase in the requirement of commercial energy in the farm sector on the other. The highly mechanized food system of the United States uses about 16.5 per cent of total national energy, about 80 per cent of which is provided by petroleum products in the form of fuel for engines, synthetic fertilizers, and agro-chemicals.

One of the most productive agricultural regions of the world is the Indo-Gangetic Plains (IGP) of the sub-continent. This is the home of the rice-wheat system that occupies 24 million ha of cultivated land in Asian subtropics. Nearly 1.8 billion people of South Asian

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countries of Bangladesh, India, Nepal and Pakistan depend on food and 60 per cent of them on gainful employment and livelihood on agriculture.

Rice-wheat systems are critical to South Asian food security. About 30 per cent of rice and 42 per cent of wheat in the region is grown in the IGP of India, Pakistan, Bangladesh and Nepal. The average area under rice-wheat systems in the sub-continent is about 13.5 m-ha (India 10.5 m-ha, Pakistan 1.6 m-ha, Bangladesh 0.8 m-ha and Nepal 0.6 m-ha). The rice-wheat system occupies another 10 m ha in China.

Rice-wheat cropping system is an important cropping system in India and contributes to 52 per cent of the country's total food production. Practicing rice-wheat systems for the past several decades have however fatigued the natural resources base resulting in declining factor productivity in many areas. The pressure on natural resources is immense: soils are less able to sustain crops as a result of continuous and intensive cropping and reduced organic matter levels. The development of salinity on irrigated land and depletion of ground water in areas irrigated by tubewells and water quality concerns have brought about heightened awareness of the need for the judicious use of water. Tillage costs are rising, which accentuates the already serious labour shortage during peak periods of land preparation and harvest. For these and other reasons, the sustainability of agricultural systems is in question. This has prompted the scientists to develop new technologies that are able to enhance and sustain cereal production without compromising the quality of natural resources.

A Consortium of South Asian National Agricultural Research Systems (Bangladesh, India, Nepal and Pakistan), international centres (CIMMYT, CIP, ICRISAT, IRRI and IWMI), and advanced research institutions (ARIs), non-governmental organizations (NGOs) and private enterprises and farmers' groups was formed to address the concern on rice-wheat systems. This consortium, known as the Rice-Wheat Consortium (RWC) for the Indo-Gangetic Plains (IGP) is convened by CIMMYT and is one of the eco-regional initiatives of the CGIAR. This brought together researchers, extension services, farmers and machinery manufacturers to interact and bring out technologies to sustain rice-wheat systems and the introduction and adoption of conservation tillage and conservation agriculture.

In India, the extensive cultivation of crops to obtain higher yields has resulted in intensive resource degradation problems. For example, there are the declining water tables in the high productivity northwest irrigated region which seriously constrain productivity and ecology. High level of fertilizer use and decreasing use efficiency are increasingly contributing to groundwater pollution and increased emission of green house gases (GHGs). High level of pesticides use in many areas has become a major health hazard. Thus, with the continuously deteriorating resources, widespread problem of water contamination and eroding ecological foundation, agriculture has become highly unsustainable and many farmers have committed suicide due to crop failure and debt. Hence, efforts have been made to conserve resources by practicing conservation agriculture (CA).

Tillage, interculture, irrigation, harvesting and threshing operations consume maximum energy. As tillage consumes maximum energy, hence, efforts were started world over in the 1970s to reduce energy use on the farm by efficiently applying different inputs and by reducing the number of tillage operations to bare minimum for seed bed preparation to get higher or equivalent yield. This led to the development of zero-till drills and gave rise to the concept of conservation tillage (CT).

CT is a practice that leaves crop residues on the surface which increases water infiltration and reduces soil erosion.

Zero till drills are specialized machines which can directly sow a crop in the standing stubbles of a previous crop without any land preparation. A good number of studies have been conducted to compare the effect of zero-till drills and conventional methods in India, Bangladesh, Pakistan and Nepal. Results of the studies showed that there was no difference in yield between zero drilled crops and conventionally sown crops. Use of these zero-till drills resulted in savings in fuel, time, labour and cost of operation.

CT studies resulted in the adoption of CA to reduce excessive use of inputs, such as seeds, fertilizers, chemicals, water and excessive tillage resulting in the degradation of land and environmental pollution.

CA refers to the system of raising crops without tilling the soil while retaining the crop residues on the soil surface. The aim of CA is to conserve, improve and make efficient use of natural resources, such as soil, water, fossil fuels through integrated management. It also aims to conserve the environment and helps in sustainable and enhanced agricultural production. It also helps in maintaining permanent or semi-permanent soil covers which act as a mulch. This mulch helps to protect the soil from sun, rain and wind and also act as a feed to soil biota. The soil microorganisms and soil fauna take over the tillage function and soil nutrient balancing. A good number of equipment such as rotavator, laser land leveller, zero-till drill, roto-drill, strip till drill, one pass equipment, happy seeders, sprinklers, straw cutter cum spreader, straw baler, straw combine have been developed and are being propagated for CA. Keeping in view the increased use of natural resources and environmental pollution, a large number of studies on CT and CA have been conducted worldwide and are discussed in the paper along with CA policies being followed and their implications.

2. CONSERVATION AGRICULTURE

In India, due to increased population, the demand for food production has increased and it has put pressure on land to get more output from the same field. This has resulted in over exploitation of natural resources, resulting in the water table having gone down in some places. In some places, water tables have gone up and the salts have leached above the soil surface. The excess application of chemicals have polluted the ground water and burning of farm residues to clear the fields for sowing in the next crop. This practice has resulted in environmental pollution and CHGs. Such practice has prompted the adoption of CA, a term resulting as an offshoot of CT studies for promoting use of zero till drills and reduced tillage.

Excessive tillage causes the soil to become denser and compacted, increases run off and soil erosion and reduces organic content due to burning of crop residues. It also leads to droughts becoming more severe and soil becoming less fertile and less responsive to fertilizer. To address to these concerns, it was necessary to achieve sustainable production systems when the basic principles of good farming practices are applied. The terminology adopted for such systems by FAO, ECAF and other organizations is CA. Many definitions of CA have been given as a result of many researches. Some of these definitions are stated below.

CA refers to the system of raising crops without tilling the soil while retaining the crop residues on the soil surface. Land preparation through precision land levelling and bed and furrow configuration for sowing crops further enables improved resource management.

CA aims to achieve sustainable and profitable agriculture and subsequently, at improved livelihoods of farmers through the application of three CA principles; minimal soil disturbance, permanent soil cover, and crop rotation.

CA aims to conserve, improve and make more efficient use of natural resources by practicing integrated management of available soil, water and biological resources combined with external inputs. It contributes to environmental conservation as well as to enhanced and sustained agricultural production. It can also be referred to as resource efficient/resource effective agriculture

CA can also be defined as a range of soil management practices that minimize effects on composition, structure and natural biodiversity and reduce erosion and degradation. Such practices may include precise land levelling by laser leveller to save water, direct sowing or drilling/no-tillage/reduced tillage/tillage for timely sowing, surface incorporation of crop residues and establishment of annual and perennial crops to add organic matter to the soil and avoid burning of straw, thus, pollution is reduced. This is also enhanced through the use of a straw combine followed by bailer to collect the straw lying in the field. The soil is thus protected from rainfall erosion and water runoff; the soil aggregates, organic matter and fertility level naturally increase; soil compaction is reduced and use of fossil fuels and GHG emissions are also reduced. Further, less contamination of surface water occurs, and water retention and storage is enhanced allowing for recharging of aquifers.

CA can be seen as a new way forward, for conserving resources and enhancing productivity to achieve goals of sustainable agriculture, which demands a strong knowledge base and a combination of institutional and technological innovation. It is being perceived by practitioners as a valid tool for sustainable land management. Hence, it is being promoted world over including IGP.

CA allows for the management of soil and water for agricultural production without excessively disturbing them. Presently, CA has assumed importance in view of the widespread degradation of natural resources leading to increased cost of production, unsustainable resource use, environmental pollution and health of ecosystems. Therefore, it is very important that CA practices are adopted in different agro-ecological regions without delay. Governments worldwide started giving incentives to the farmers to practice CA and some even formulated conservation policies. Various conservation tillage practices such as zero tillage, minimum tillage, reduced tillage, ridges and furrow method, broad bed and furrow and raised and sunken beds of different widths have been evaluated in different types of soils to reduce land preparation operations and to save energy.

CA has the potential to emerge as an effective strategy in response to the increasing concerns of serious and widespread natural resources degradation and environmental pollution, which accompanied the adoption and promotion of green revolution technologies since the early 1970s. The key challenge today is to adopt strategies that will address the twin concerns of maintaining and enhancing the integrity of natural resources and improved productivity; while improvement of natural resources takes a lead as it forms the very basis for long-term sustained productivity. CA practices in different agro-ecological regions, identifying the technological, socio-economic policy and institutional constraints, defining

agenda for research and development, and identifying institutional mechanisms for promoting the strengthened participation of a range of stakeholders as a means of seeking a way forward.

There should be strong linkages between resource degradation and poverty and that CA must be considered a route to sustainable development. Globally, CA systems are being adopted in over 80 million ha largely in rainfed areas. The countries where the system is being adopted and promoted extensively include US, Brazil, Mexico, New Zealand, Australia, Argentina, Canada, South Asia, China, etc. South Asian countries practice CA technologies in the irrigated Indo-Gangetic plains where rice-wheat cropping system dominates. CA systems have not yet taken roots in other major agro-ecological regions, like rainfed, semi-arid tropics, the arid regions or the mountainous agro-ecosystems in India. While the basic principles, which form the foundation of CA practices, i.e., no-tillage and surface managed residues are well understood, adoption of these practices under varying situations is the key challenge. Issues related to technology needs and inputs management addresses some of these basic issues for transition to CA.

The technological challenges related to development, standardization and adoption of farm machinery for seeding with minimum soil disturbance, developing crop harvesting and management systems with residues maintained on soil surface and developing and continuously improving site specific crop, soil and pest management strategies will optimize benefits from the new system.

Emphasis needs to be given to enhancing livelihood opportunities rather than increasing yields. CA marks an evolutionary change through a process of learning that offers the opportunity and a means to achieving policy goals. CA has to offer a way to address broader livelihood issues. The new institutional arrangements must be based on a good understanding of the features that distinguish the principles and practices of CA from the conventional research and development approach. Institutional mechanisms are required to ensure that CA is seen as a concept beyond agriculture. Institutionalizing the role of research, extension and farmers in such a way that the partnership among these stakeholders might be strengthened right from the beginning of the project, helps build up a sense of enabling ownership among them. CA must aim at broad livelihood strategies and move towards forming conservation villages with appropriate agribusiness strategies to increase employment in areas where it is adopted. However, caution must be taken to avoid blanket adoption of CA just every where. It should be site specific and need-based. CA is now considered a route to sustainable agriculture. Spread of CA, therefore will call for a greatly strengthened research and linked development efforts. CA requires a new way of thinking from all concerned, Along with this “new way of thinking agriculture”, there is already enough technical and agronomic evidence that could positively influence farmers contemplating the adoption of CA principles.

It is estimated that about 2 billion ha. in the world is affected by various forms of land degradation which include water erosion (1.1 billion), wind erosion (0.55 billion), chemical degradation (0.24 billion) and physical soil degradation (0.08 billion). According to latest estimates using global assessment of soil degradation, about 188 m. ha or 57 per cent of land is potentially exposed to various degradation forces, of which water erosion constitutes a major section of 148.9 m. ha or 45 per cent; and the remaining 38.9 m ha or 12 per cent suffer

from wind erosion; 13.8 m ha or 4.2 per cent for chemical degradation; 11.6 m ha or: 3.6 per cent for physical degradation.

The major factors responsible for large-scale degradation are deforestation, unsustainable fuel wood and fodder extraction, shifting cultivation, overgrazing, non adoption of adequate soil conservation measures, improper crop rotation, indiscriminate use of agrochemicals such as pesticides, improper planning and management of irrigation system and extraction of groundwater in excess of the recharged capacity.

Since land and water will be shrinking resources for agriculture, there is no option in the future except to produce more food and other agricultural commodities from less per capita arable land and irrigation water. In other words, the need for more food has to be met through higher yields, per unit of land, water, energy and time. Hence, there is need to evolve a scientifically-based land use system, a sound CA policy, and mission-oriented programme.

According to the National Agriculture Policy, India must achieve a growth rate of 3-4 per cent per annum in the agricultural sector, and food grain production of 400 m.t. by 2020.

The question is: how can this target and growth rate be achieved? This can only be achieved through mechanization, use of efficient machines and developing agronomic practices suited to agricultural machines and following CA.

2.1 Need for Adoption of CA and Mechanism for Accelerating Adoption

Due to intensive cropping, the quality of soil is on the decline. Current nutrient management practices result in inefficient use of nutrients applied through chemical fertilizers, resulting in increasing environmental problems, decline in the quality of groundwater due to either rising of salts in soil caused by water logging or to either leaching of salts into the soil, increasing emissions of GHGs, etc. Current cropping systems (rice-wheat) in IGP are also being carried out, resulting in the exploitation of groundwater resources, reinforcing current agricultural practices and policies which are contributing to the fast degradation of the resource base and the unsustainability of production systems. Hence, the important question is how to stop this degradation and make agriculture more sustainable. This can be done by adopting CA which will differ from soil type, to rainfall, climate and socio-economic situations. Hence, technologies have to be evolved keeping in mind the rural situation in a participating mode.

In “Green Revolution” era in India, efforts were made to enhance productivity of certain crops but the new challenge is the efficient resource use and conservation to ensure that earlier gains can be sustained and further enhanced to meet emerging challenges and needs. CA has emerged as a new way forward to achieve the goals of sustainable agriculture in response to resource conservation challenges. This will call for developing new strategies and promotion of new technologies to enhance production, productivity and formulation of long-term programmes.

Some of the doubts about CA are whether it can applied to small farms, disease problems due to residues left in the field, application only to grain crops or other crops and whether it is applicable to all type of soils and works in certain climates.

CA can be applied to all farm sizes, there are no disease problems and it will depend on the crop rotation system being followed. It can be used in a wide range of crops such as sugarcane, potatoes, pigeon pea, cotton, potato, fruits and vine. It can be practiced in all type of climates and soils. The only caution that needs to be taken is to control weeds.

Rice-wheat systems occupy 12 m. ha. and contribute more than 80 per cent of the total cereal production in the areas which are part of the rice-wheat consortium. The continuous production of rice-wheat has resulted in degradation of land, lowering of water table, contamination of water, environmental pollution of air due to burning of straw, excessive fuel usage to run the tractor and engines for performing various farm operations, thus threatening food security in the region and declining factor productivity in many areas. Satisfying the demand of growing population, preserving the agricultural natural resource base, and improving livelihoods are huge challenges.

For accelerating the adoption of these resource conservation technologies (RCT), there is need to expand stakeholders' participation, encourage farmers' testing, use modern knowledge management tools and provide suitable logistic support as adopted by the rice-wheat consortium which has been a success.

2.2 Advantages of CA

- Reduces labour, time and fuel costs
- Reduces overall cost of operation
- Reduced use of fossil fuel leads to less environmental pollution
- Reduces soil compaction due to less trafficability
- More yields in dry years
- Savings in water
- Less soil erosion
- Less environmental pollution, carbon sequestration (green house effect)
- Less leaching of chemicals and solid nutrients into ground water
- Less pollution of water
- Increased crop intensity
- Recharge of aquifers due to better infiltration

2.3 Disadvantages of CA

- Formation of hard pan below soil surface due to zero tillage and requires use of sub-soiler to break hard pan after 5-7 years
- Need to control weeds by using herbicides thus increasing cost
- Not suitable to all crop rotation systems
- May result in soil borne pests and pathogens in transition stage
- High cost of machinery such as laser land leveller, zero-till drill, strip till drill, raised bed planter, straw cutter cum incorporator, straw combine, straw baler, biomass digesters
- May also result in low yields

3. STUDIES ON CONSERVATION AGRICULTURE

3.1 Conservation Tillage/Reduce Tillage/ Minimum Tillage/ Zero Tillage Studies Conducted by Different Countries

Tillage is a mechanical manipulation of the soil to obtain favourable conditions for crop growth. Primary tillage is done to open the soil which is followed by secondary tillage to break the clods into small sizes followed by planking to get a levelled well-prepared seedbed.

Tillage is one of the operations responsible for 30 per cent of the total expenditures on crop production. Increased energy cost, increased soil erosion, environment pollution and rising cost of crop production and protection have led agricultural producers and scientists to adopt CT practices. Different equipment such as mould board plough, disc plough, rotavator, disc harrow, cultivator and leveller are used to obtain a well-pulverized seedbed. Tillage requires a large amount of energy (1600-MJ/ha for wheat and 2200-2600 MJ/ha for paddy). The energy used depends on the type of equipment, width and depth of operation, soil conditions such as moisture content, type of soil, crops grown, etc. To reduce energy use during tillage, different equipment like rotavator, zero till drill, strip till drill, happy seeders, etc. have been developed and are being used world over.

To reduce energy requirements during tillage operations, a number of studies have been conducted to determine the effects of reduced tillage on soil loss and yield. In a study conducted by Bateman and Bowers (1962) on Agricultural Engineering Experiment Field and at farmers' fields in Illinois, it was found that there was no difference in yield of corn between conventional tillage and minimum tillage fields. As can be seen in Table 1, minimum tillage gave higher yields than conventional tillage in 12 of the 70 comparisons, and lower yields in 13 of the comparisons. Both the decreases and the increases averaged 13 bushels an acre. According to conservative estimates, about half as much soil is lost with minimum tillage as with conventional tillage.

Table 1. Studies on Conventional and Minimum Tillage

Comparisons made	No. of comparisons ^a	Harvest population per acre		Yield, bushel per acre	
		Conventional tillage ^b	Minimum tillage ^c	Conventional tillage ^b	Minimum tillage ^c
RESEARCH RESULTS ON AGRICULTURAL ENGINEERING FIELD					
Total comparisons	70	14,500	14,000	95	93
Comparisons in which minimum tillage gave higher yields than conventional tillage	12	13,800	14,800	97	110*
Comparisons in which conventional tillage gave higher yields than min ^m tillage	13	13,900	12,300	90	77*
RESULTS OF DEMONSTRATION FIELDS					

Total comparisons	16	11,800	11,200	100	103
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Source: Bateman and Bowers (1962)

n Each comparison was based on average of three to six replications for each treatment.

b Soil was ploughed and disked one to three times before planting.

c. Soil was ploughed and planted with no major tillage operation between three operations. Methods included plough-planting; ploughing, with or without clod buster, then planting; and ploughing then planting in the tractor tracks.

*** The difference between minimum-tillage yield and conventional tillage yield is significant.**

The fuel crisis during the 1970s forced scientists to look for alternative sources of energy and its impact was also felt in agriculture. As tillage requires maximum energy, efforts were made to reduce tillage operations to bare minimum by following reduce tillage/ minimum tillage and zero tillage. This resulted in the development and introduction of zero till drills/direct drilling machines, which could sow the crop without tilling and in the standing stubbles of the previous crop. Hence, experiments were conducted world over to see the effect of reduced tillage and zero tillage. A number of specialized zero-till drills with floating-one, two and three disc openers were designed and introduced. At that time, the idea was to obtain comparable yield by reducing tillage operations to reduce fuel costs. As zero tillage involved sowing in fields of standing stubbles of previous crops, controlling of weeds using herbicides was deemed necessary.

Few herbicides companies abroad and in India promoted zero tillage for their own vested interests to sell their herbicides, e.g., -“Gramoxone”. Experiments on reduced tillage and zero tillage were also conducted in the U.K. The yields of zero tillage and conventional tillage fields were observed to be the same or comparable as given in Table 2. There was considerable reduction in fuel costs due to the use of zero tillage.

Table 2. Comparison of Conventional Tillage, Reduced Tillage and Zero Tillage in Wheat in U.K.

Hectares sown in 40 hr week	Treatments	Fuel consumed (litres)	Cost/ha (£/ha)	Man hr requirement per hectare
7.7	Conventional tillage (1 ploughing +3 disking)	6.66	46.50	5.2
10.8	Reduced cultivation (2 chisel plough + 2 disc)	3.88	37.50	3.7

	harrowing)			
40.0	Direct drilling (zero tillage + gramaxone)	1.15	25.00	1.0

Source: Anonymous. "The 'Cult' of Winter Cereals" ICI Publication

3.2 Conservation Tillage Studies Conducted in India and Other Countries

Rice-wheat crop rotation is the main rotation in South Asia, Nepal, Pakistan and Bangladesh. About 50 per cent of the land, i.e., 402 m.ha of land in these South Asian countries is devoted to agriculture. For these nations, intensively cultivated irrigated rice-wheat system in the IGP are of great significance for the countries' food security, fodder and food for the livestock and for hundreds of millions of rural and urban poor.

Agriculture policies in the 1960-1970s also focused on increased coverage of high-yielding varieties, use of external inputs, and provision of irrigation. The Green Revolution technologies have remained the cornerstone for a South Asian Strategy for food security, rural development, conservation of natural resources and poverty alleviation.

There is evidence that rice-wheat system have fatigued the natural resource base. During the last decades, high growth rates for food grain production (3 per cent for wheat and 2.3 per cent for rice) in these countries have kept pace with the population growth. However, the food security in these regions is under continuous threat due to increase in population. It is expected that these countries need to double their production by 2020 to meet the demand of the ever growing population from marginal quality land and water resources and also at the same time sustain environmental quality.

Anticipating a major upward shift in the energy demand and energy use pattern in the agriculture sector, the Indian Council of Agricultural Research (ICAR), New Delhi in 1971, initiated a multi-location project in the form of an All India Coordinated Research Project called "Energy Requirements in Intensive Agricultural Production" subsequently renamed and as "Energy Requirements in Agricultural Sector". The project envisaged to assess the energy use in various farm operations for different production sub-sectors of agriculture; locate critical components of use, and technique to improve system efficiency by reducing wasteful uses and assess future energy demand. Intensive studies were undertaken on various aspects of energy usage in production agriculture in different agro-climatic regions in order to capture the dynamic energy use patterns in the country and to identify energy conservation techniques. A large amount of data has been collected with respect to energy use pattern for major crops in different categories (small, medium and large farms). The results have provided a benchmark of spatial and temporal variations in the energy use patterns in Indian agriculture. The status of energy use efficiencies has been brought out along with possible ways to effect improvements. It has also generated a national perspective on research on energy use and management aspects in the country.

Efforts to promote zero tillage in India were started in the 1980s. The technology was promoted by Imperial Chemical Industries Limited of U.K. to promote the chemical herbicide,

“Gramoxone” to control weeds in zero tilled wheat. One of the basic requirements of zero tillage is that the weeds must be controlled. Late sowing of wheat results in a major problem in paddy-wheat cultivated areas, which implies a decreased yield of 1-1.5 per cent daily when planted after November. This happens due to the late harvesting of paddy especially the long duration basmati rice. Sowing of wheat with traditional method requires 7-8 days in field preparation which also delays sowing of wheat resulting in decrease in yield. Hence, for timely sowing of wheat, a conventional zero-till drill was developed by Shukla, Tandon and Verma (1981) at Punjab Agricultural University, Ludhaina. It consisted of conventional tractor drawn seed cum fertilizer drill with disc coulters attached in front of the fixed-type furrow openers. It was used for sowing wheat in fields where paddy had been sown earlier. The performance of the zero till drill was found to be satisfactory and comparable yields were obtained under conventional tillage. It also resulted in savings in time, labour and fuel costs. The results of the study are given in Table 3.

Table 3. Comparative Performance of No-Tillage and Conventional Tillage Systems for Growing Wheat after Paddy

Field No.	Plot No.	Treatment	Moisture content of soil in percentage	Average germination count/m	Wheat yield (Quintal/ha)
I	1	No-till	12.00	41.50	31.61
	2	1 disking + 2 cultivator +1 planking	12.50	39.00	30.12
II	3	No-till	14.00	43.10	34.58
	4.	1 disking + 2 cultivator +1 planking	14.00	41.30	34.58

From the above table, it can be seen that the germination count and wheat yield were higher in case of Field No.I. In Field No. II, there was no difference with respect to germination count and yield between no-till planted fields as compared to conventionally sown fields.

As the reversible furrow openers provided behind disc coulters of the no-till drill resulted in formation of clods, which allowed the seed to germinate but did not allow it to emerge above the surface. Hence, these reversible shovel furrow openers were replaced by boot type furrow openers. The modified drill was used for sowing wheat in fields where paddy had been grown earlier and in fallow land.

Table 4. Comparisons of Zero Tillage and Reduced Tillage for Sowing Wheat after Paddy and in Fallow Field.

Treatments	Average germination count per meter length/No. of tillers /plant	Average grain to straw ratio	Yield, Q/ha	Type of weeds
1.No tillage (paddy-wheat)	43.00/3.144	1:1.35	34.90	Lamb's quarter/Che nopodium album, Mexican prickly poppy (<i>Argemone mexicana</i>)
2.One disking (Paddy-wheat)	57.00/2.34	1:1.95	41.16	Lamb's quarter/Che nopodium album, Cynodondactylon
3.No-tillage (Fallow-wheat)	54.00/2.56	1:0.77	21.32	<i>Canobis sativa</i> , Chanopodium album

Source: Tandon and Powar (1985).

From the study conducted, it can be seen that there was not much difference in yield between zero till drilled fields and fields where one disking was done. The fallow-wheat rotation resulted in the lowest yield. In the zero till drilled plots, the incidence of weeds was less, mostly broad leaf weeds were observed. It has been recommended that after every five to six years of practicing zero tillage, deep ploughing needs to be carried out to break the hard pan formed below the soil surface by using chisel plough.

These furrow openers were later replaced by inverted "T- type" furrow openers in the 1990s. During the mid 90's, again zero till drill concept gained importance due to the sanctioning of 100 zero till drills by ICAR and about a dozen manufacturers started manufacturing these drills. Success was achieved in the State of Haryana in India due to the use of this zero till drills. This idea of zero-till was also promoted under a "National Agriculture Technology Project" of ICAR. Efforts were made by 30 centres located at

different ICAR institutes and state agriculture universities to promote zero till drills under the rice-wheat consortium (RWC). Under this project, efforts were also made to develop wheat varieties such as those with early sown short duration suitable for sowing with zero till drill.

The consortium for the IGP was formed to address the problem of rice-wheat systems. It is an alliance of the national agricultural research systems of the South Asian countries of Bangladesh, India, Nepal and Pakistan. In collaboration with several countries and agricultural research institutes, the RWC fosters sustainable productivity in rice-wheat farming systems. Under the RWC, efforts were also made to introduce zero-till drills and raised bed technology in India, Pakistan, Bangladesh and Nepal. The zero-tillage helped in early planting of wheat and thus helped in controlling *Phalaris minor*, a weed that has developed resistance to a common herbicide, "Isoprotoron" in North-West India. The wheat crop shades out this weed. Also, in no-tillage, since the soil is not disturbed as much as in conventional tillage, fewer weeds germinate. In India, zero till drills have been demonstrated in Punjab, Haryana, Uttar Pradesh and Bihar at farmers' fields and also in Pakistan and Nepal.

About 3 million ha has been covered under zero-tillage in India alone. Use of zero-till drill resulted in savings of INR 2000-3000/ ha, higher yields in many cases (1-2 q/ha), less lodging, no crop yellowing after first irrigation, less tractor use/wear of parts, better germination in salt affected soils, less need of herbicide, improved residue management and savings in time (30-40 per cent), labour and fuel (60 lit/ ha) and 30-50 per cent less incidence of *Phalaris minor* - all of which contribute to enhanced yield (1-3 q/ ha) and profits. Farmers reported fewer incidences of stem borers in direct drilled wheat. The concept of zero tillage has also picked up in other states such as Bihar and Bengal due to low yields of wheat. Zero-tilled drills, strip till drills, roto till drill, till planter, happy combo seeders have been developed for direct drilling of wheat after paddy. Some of these machines have also been introduced in Pakistan and Nepal. Sowing of wheat on raised bed has resulted in savings in water. Use of zero till resulted in savings in fuel (72 per cent), labour (76 per cent) and amount of agro-inputs as seen in Table 5.

Table 5. Comparison of Zero Till, Strip Till, Roto Till and Conventional Tilled Wheat.

Sr. No.	Parameters	Zero-till drilling	Strip till drilling	Roto till drilling	Conventional tillage sowing
1	Time required for sowing (h/ha)	2.98 (76.24)	4.05 (67.70)	5.85 (53.35)	12-54
2.	Fuel used (l/ha)	11.50 (72.93)	17.80 (58.10)	24.85 (41.50)	42.48
3	Operational energy (Mj/ha)	672.46 (70.06)	985.82 (56.11))	1364.24 (39.26)	2246.15
4	Cost of operation	690.12	998.46 (52.78)	1365.72 (35.41)	2114.50

	operation (Rs./ ha)	(67.36)	(52.78)	(35.41)	
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Source: S. K. Rautray (2003). Figure in brackets give percentage

CT as compared to conventional practice showed higher performance in terms of increased benefit cost ratio (3.7-15.4 per cent) and lower operational energy (5.1-26.1 per cent). The reduced tillage system lowered the cost of cultivation due to reduced energy requirement and yield returns were similar to the conventional practice as seen in Table 6. In zero tillage, the specific energy and operational energy were found to be the least (1.93 MJ/kg) as compared to other three treatments.

Table 6. Comparative Performance of Zero Till Drill, Strip Till Drill, Rota Till Drill and Conventional Tillage.

Sl.No.	Particulars*	Zero till drilled wheat	Strip till drilled wheat	Rota till drilled wheat	Conventional tillage seedling
1	Grain yield (t/ha)	3.71	3.66	3.70	3.80
2	Cost of product (Rs./ha)	9746	10328	11064	11825
3	Benefit cost ratio	2.47	2.30	2.17	2.09
4	Operational energy (Mj/ha)	7176	8604	9216	9708
5	Specific operational energy (MJ/kg)	1.93	2.35	2.49	2.55
6	Specific cost of production (Rs. /kg)	2.63	2.82	2.99	3.11

- Sale price of wheat Rs.6.50/ kg.
- Source: S. K. Rautray (2003)

The experience of zero tillage /direct drilling showed that there are many benefits in keeping the soil undisturbed for long periods as nature intended. It was found that due to zero tillage, the soil drainage improves with draught cracks - worm channels - old root systems and soil pores all linking together to help to remove rain water quickly and therefore avoiding the sponge effect created by normal cultivation. Researchers found that worm population are higher and that root systems are stronger and deeper in direct drilling system. Soil structure is also improved with the organic matter being retained near the surface. This helps to improve and build up a natural surface tilth which requires little preparation for cereal sowing in addition the crumb stability or increase in soil strength.

No tillage is being practiced in different European and Asian countries in about 46.533 m.ha area as given in Table 7.

Table 7. Area under Zero Tillage in Different Countries.

Sr. No	Name of country	Area under zero tillage
1	USA	19,347,000
2	Brazil	11,200,000
3	Argentina	7,270,000
4	Canada	4,080,000
5	Australia	1,000,000
6	Paraguay	790,000
7	India	3,000,000
8	Mexico	500,000
9	Bolivia	200,000
10	Chile	96,000
11	Uruguay	50,000
12.	Others	1,000,000
Total		46,533,000

Source : Rolf Derpsch (1999)

3.3. Conservation Practices in Paddy Cultivation

Paddy is sown in puddled soil and requires large amount of water and irrigation which need to be applied every alternate days under upland cultivation. Efforts were made to overcome the ill-effects of puddling on soil, structure in rice-culture, reducing drudgery of rice planting without yield decrease, and developing double no-till system to grow rice, wheat and other crops. In India, paddy (root washed seedlings) is raised in nursery and when the seedlings are 20-25 days old, these are uprooted and transplanted in well puddled field having standing water. Transplanting is done manually and requires large amount of labour. Hence, efforts were made to introduce mat type nursery raising technique and then transplanting using manual or automatic mat type paddy transplanters. The mat type nursery raising requires regular application of water and care during nursery raising. When seedlings are 20-25 days old, these are transplanted in the field by the transplanters. As nursery rising requires regular care and watering, this has not been adopted in India, except in southern part of India where it has been a success due to abundant water availability and good rain.

Hence, pre-germinated paddy seeders (4-6 rows) have been introduced and are also being used for direct sowing of paddy in puddled soil with only 1 cm standing water. Use of these have resulted in higher yields and reduced labour requirement as compared to transplanted crop.

Under the RWC, the direct seeding of rice using zero till drills on flat beds and furrow-irrigated raised bed system was tried and its performance compared with unpuddled wet seeding and transplanted rice in reduced till conditions. *Sesbania sisban* was grown along with rice in treatment combinations. Weeds were controlled through the use of 'Sofit', a post sowing, pre-germinated herbicide. The farmers liked inter-cropping of *Sesbania* for brown manuring in rice culture because of the following reasons: (i) no need of additional irrigation for raising *Sesbania sisban* crop in summer before rice when evaporative demands are close to 13 mm/ day; (ii) brown manuring keeps soil moist for longer period (less soil cracking) thereby eliminating the need to irrigate rice frequently; (iii) improves soil fertility; and (iv) helps control weeds (weed population is reduced 40-50 per cent).

3.3.1 Bed Planting Technology

This technology, called furrow irrigated raised bed system (FIRBS) was brought from CIMMYT in Mexico for trials in IGP for sowing wheat by the RWC. In this technology, the seedbed is prepared conventionally and raised beds and furrows are prepared using raised bed planter. The machine makes two beds of 70 cm width and can plant 2 to 3 rows in each bed. The farmers and scientists in India have found that the use of FIRBS results in 50 per cent savings in seeds, 30-40 per cent saving in water, and higher yields than conventional method; there is also reduction in lodging, facilitating mechanical weeding by tractor, offers opportunity for last irrigation at grain filling, avoids temporary water logging problems, allows subsurface basal and top dressing of fertilizer, thus reducing N losses and promotes rainwater conservation. This technology has been adopted in India and Pakistan.

In the village Desna in Haryana, rice was established on 125 ha of land by dibbling manually on the raised land. It was a late seed rice crop. There were no weeds when the crop was 67 days old. Farmers were of the opinion that bed planted crop needed less water, and crop condition could improve further if irrigated or if it rains. There is no soil cracking even though the crop was irrigated a week before.

In another experiment conducted in Karnal (Haryana), the results suggested that seed rate in direct-seeded rice should be kept at 20-25 kg/ ha for good results. Higher seed rate results in lodging, incidence of plant hoppers and deficiency of nitrogen. The bed planted rice in farmers field saved six irrigation as compared to conventionally tilled rice. Direct-seeded rice resulted in savings of US \$70–102/ ha as compared to puddle transplanted rice. The tillage induced saving were mainly through reduced cost of land preparation (77 per cent), irrigation water (15 per cent) and labour (8 per cent).

In the different states of India (Punjab, Haryana, U.P. and Uttranchal) rice was also direct seeded on the side of raised beds without puddling. The rice transplanted on raised beds yielded 10-15 per cent more grain and saved 14 per cent irrigation water as compared to conventionally tilled puddle transplanted rice. Direct seeded rice saved more than INR 6000/ha as compared with traditional rice culture.

3.4 RC through Surface Seeding in Water Logged Area

This is the simplest form of zero-tillage system and is sustainable for excessively moist conditions of poor textured, poorly drained soil commonly found in the low-lying areas of eastern IGP in Nepal, India and Bangladesh. In these areas, soils generally cannot be tilled for normal planting. In this method, wheat is broadcasted in the wet soil surface either before or after rice harvest. The seeds germinate and the roots follow the saturation fringe as the water recedes. As the soil is wet, no machine can go inside the field, so surface seeding is a very appropriate system for resource poor farmers as no equipment is needed. This system allows the farmer to take one more crop instead of keeping the field fallow and get 3-4 tons/ha of grain. It is also a very popular system in the Yangtze River valley of China.

The lowlands of Bihar, West Bengal and Bangladesh suffer frequent flooding during the Kharif season, which subsequently results in excessive soil moisture and water logging problems. The excessive soil moisture restricts entry of machines in the field. Hence, surface seeding of wheat by broadcasting method was attempted for timely crop establishment. It saves labour, fuel and tillage costs and also makes use of residual soil moisture and improves crop productivity through timely planting.

3.5 RC through Use of Laser Land Leveller

Land is levelled after seed bed preparation using either a wooden log tied behind bullocks or a planker attached behind a tractor. This method is crude and does not give a smooth levelled field. Unevenness in the soil surface adversely affects distribution of irrigation water and leads to poor crop stand and over irrigation. Precision in levelling can help eliminate this inefficiency and reduce water requirement through transmission losses and uniformity in moisture distribution to ensure uniform crop establishment and growth through the season.

The total water requirement for rice-wheat system is estimated to vary between 1382 mm to 1938 mm in the IGP, accounting to more than 80 per cent of the rice growing season. To reduce costs in irrigation, savings must be effected during the rice growing season. Rice is the major water user in the R-W system. Precision land levelling helps in the uniform application of water and better crop stands. Laser assisted precision land levelling saves irrigation water, nutrients and agro-chemicals. It also enhances environmental quality and

crop yields. The laser land leveller has been imported and is being used for land levelling. It also increases water application efficiency up to 50 per cent, cropping intensity by about 40 per cent, labour requirement by 35 per cent, and crop yields by 15 to 66 per cent (wheat 15 per cent, sugarcane 42 per cent, rice 61 per cent, and cotton 66 per cent).

In the state of Punjab, 100 laser land levellers and 60 in UP have been purchased by the farmers and are being used on custom hire basis. A farmer is able to recover the cost of the machine within two to three years. The total water use in wheat and rice in laser levelled field was reduced to 50 per cent and 32 per cent, respectively. In raised bed planted wheat, about 26 per cent water can be saved through laser land levelling.

When land levelling is combined with zero-tillage, bed planting and non-puddled rice culture, the plant stands are better, growth is more uniform and yields higher. In Pakistan's Punjab Province, average water saving with laser land levelling, zero tillage and bed planting over the traditional method was 715, 689, and 1329 m³/ha, respectively, for the year 1999-2000.

Keeping in view the all-year round shortage of irrigation water, receding water tables, uncertain rains and drought, greater emphasis on water management is needed in India and other countries of IGP. The laser land levellers need to be demonstrated at farmers' field. The Government of India is considering giving subsidy on laser land levellers. Under micro-management scheme of Department of Agriculture and Cooperation, a good number of laser land levellers have been sanctioned to different states for conducting frontline demonstrations.

It is estimated that the extension of laser-assisted precision land levelling system to two million hectares of area under rice wheat-system would save 1.5 million m³ of irrigation water and save diesel up to 200 million litres (equivalent to US \$ 1400 m) and improve crop yields amounting to US \$1500 million in three years and reduce GHG emissions equivalent to 500 million kg. It will also increase cultivated area by 3-6 per cent due to reduction of bunds and water channels in the field. In laser levelled fields, the performance of different crop establishment options such as zero tillage raised bed planting and surface seeding are known to improve significantly.

3.6 Residue Management and Reduction of Environmental Pollution through CA Practices

In most of the South Asian countries, the paddy straw is burned before sowing wheat. This contributes to soil degradation through loss of organic matter and soil erosion and also causes environmental pollution. Management of crop residues and plant into loose residues is a key issue not only to avoid burning and environmental pollution but addressing issues of organic matter decline and nutrient depletion/mining in IGP and promoting ground water recharge.

A strategy for incorporating the silica-rich rice residues seems inevitable in acidic soils of Eastern Gangetic Plains to address liming problems. Liming of these soils reportedly improved the yields of wheat and other upland crops. Incorporation of silica-rich rice residues into isoelectric soil manipulates the charge characteristics in a manner that improves the net negative charge, base saturation on the exchange complex and reduces fixation of applied phosphorus.

Hence, efforts have been made to develop machines to cut, spread and incorporate the paddy straw in the field to help in sowing wheat after harvesting paddy and avoid burning of the straw. A happy combo seeder in collaboration with Australia was developed for direct seeding of wheat in fields where paddy had been grown earlier. This machine cuts the paddy stubbles left in the field after combining and throws it at the rear of the machine. Efforts are on to use the cellulosic paddy biomass to obtain ethanol. About 1000 kg of biomass will approximately yield 1.0 litre of ethanol.

In wheat fields to obtain the wheat straw from the combine harvested fields, a straw combine (reaper) has been developed which helps in a recovery of 1000 kg of straw/ha and about 40-50 kg of grain/ha. This helps the farmer to recover the wheat straw which can be fed to cattle and also fetches additional income for the farmers.

Resource conservation studies are being carried out by different institutes of the ICAR and the state agricultural universities under the RWC in IGP. Efforts are being made to reduce the input use through efficient application and use of resource conservation technologies and equipment. CA does not, as per definition, include water management which is one of the most important components needing attention by the scientists worldwide. Growing of rice on raised bed is also being propagated to save water instead of growing paddy in standing water. Seeing the outcome of the use of laser land leveller in reducing water requirement by 30-50 per cent, the farmers in India are purchasing the machine by forming groups and using these under custom hire basis. Similarly, efforts are ongoing to develop good quality efficient machines for application with different inputs. The zero tillage concept has been adopted by few states and efforts are being made to demonstrate these in other states. The Government is also giving subsidy on the purchase of zero till drills and other resource conservation equipment for straw management and incorporation in the field.

4. CONSERVATION DEVELOPMENT IN THE WORLD AND MEMBER COUNTRIES- POLICY IMPLICATIONS OF CA

Due to the increasing pressure of population, efforts are on to produce more to feed the burgeoning population. This has led to increased use of natural resources such as water, seeds, chemicals, etc. to produce more for sustainable agriculture. This has also led to widespread problem of natural resource degradation and environmental pollution. CA is being practiced in about 80 m.ha mostly in South and North America and in rainfed areas. CA is being widely adopted in America, Australia, U.K., Argentina, Brazil and Canada. It is also being favoured by farmers of Latin America and South Asian countries. Many countries are promoting CA by giving incentives, such as easy credit loan/subsidy on purchase of machines, extension programmes, etc. Some countries enforced land retirement and taxes due to excessive soil erosion. Some countries have also been encouraging pasture conversion by providing free seedlings.

However, it has been felt that public policies which require tax payers to bear the burden would be effective in terms of cost per unit of controlled erosion but would become a fiscal problem, especially during an era of government budget deficits and rising debts. Hence, studies have remained inconclusive and site-specific results suggest that a universal approach is not possible. In some countries CA has found favour with the introduction of policy decisions. In Europe, France, and Spain, CA was adopted in about 1 m. ha area under annual crops. In Europe, the European Agriculture Federation (a regional lobby group), United National Associations in France, Germany, U.K., Spain, Portugal and Italy has been

founded. It is also being adopted in Southeast Asian countries such as Japan, Malaysia, Indonesia, Nepal and Bangladesh. The community-led initiative strongly supported by research and development organizations, rather than as a result of the usual research-extension system efforts is the reason for the widespread adoption of CA system in many countries.

Although a targeted policy approach may be more appropriate (i.e., say for example bringing 100 m ha under no tillage and 400 m. ha under watershed development) for the design of programmes directly promoting CA, there are some alternative policy presumptions that may be more universally applicable. Sometimes, the farmers can take pride in telling that they have obtained maximum yield due to adoption of no tillage and this may motivate others to follow suit. In India, in the State of Punjab, paddy-wheat is the main crop rotation system. Excessive use of ground water for paddy cultivation has resulted in lowering of groundwater. Hence, the government is motivating farmers to grow other crops aside from rice and is seen offering incentives. Both pride and peer pressure may be important forms of motivation in the adoption of CA. Government policies may be available to contribute to this front.

In Canada, Ontario's Environmental Farm Plan programme represents an innovative approach to environmental conservation on the farm through the voluntary participation of farmers to assess the environmental risks and raise environmental awareness on their farms. It is a farmer-driven process supported through government funds and technical advice. Compliance and interest among farmers is high especially relative to traditional government-led regulatory approaches.

In the absence of appropriate incentives, farmers are unlikely to get enthused with only "potential benefits" over long period in terms of resource base quality improvement. This would call for an examination of policy incentives which encourage certain crops and cropping systems, resource use practices, and consequent short- and long-term impact in terms of productivity and ecosystems health. Diversification to other crops along with effective procurement, infrastructure for providing services for resource conservation technologies at the local level and monitoring of resource base are the main policy and institutional requirements that need due attention.

4.1 Resource Conservation Technology of Rice-Wheat System in Pakistan

The Resource Conservation technology such as zero tillage, laser levelling and bed and furrow cultivation of wheat and mechanical transplanting of rice were demonstrated in various districts of Punjab, Province of Pakistan under the RWC. The zero tillage method of wheat cultivation was found to be the most economical and attractive option for farming followed by laser levelling and bed and furrow cultivation. Wheat sowing by conventional method proved to be economically less favourable. Mechanical transplanting of rice on sampled farms remained economically less feasible as compared to non-mechanical rice transplanting due to its higher transplanting cost.

4.2 Resource Conservation Technology in Nepal

Many on-station and on-farm experiments at Ranighat, Pparawanipur, and Bhairahawa in terai, lowland belt and at Naldung in the mid-hills near Katmandu have been conducted under the RWC. In these experiments, the performance of various crop establishment methods (bed planted, direct seeding with Chinese seed drill, drum seeded rice system for rice intensification; nutrient management strategies (N management with the help of leaf colour

chart); long-term integrated nutrient management; crop varieties; water management and weed management strategies were evaluated.

In Nepal, zero tillage has been introduced for sowing wheat after paddy by using Chinese power tiller operated zero till drills. The farmers have obtained higher yields using zero till technology. In some parts of Nepal, there is enough moisture in the field which restricts entry of man and machine; hence, surface seeding has been introduced. The wheat crop is broadcasted in the standing paddy crop ready for harvesting after draining the water from the fields. This helps in the timely germination of wheat and avoids delay in planting the crop. This method has been adopted in large areas of Nepal which has water logging problem.

The study highlighted the following concerns that need immediate attention such as, large runoff losses of surface soil which carry away a huge amount of organic carbon, phosphorus and potassium; imbalanced use of fertilizer; low productivity of rice and wheat in the terrain region; water logging; water and heat stress at physiological maturity of wheat; susceptibility of rice cultivars to blast and infestation due to higher dose of N; fertility management in mid-hill terraces; weed management in direct-seeded rice and zero-till sown wheat and low input use by the farmers.

4.3 Resource Conservation Technologies in Bangladesh

Bangladesh has diverse environments, which offer many opportunities for crop diversification, yet, it is faced with challenges and limitations. The challenge facing Bangladesh agriculture is to grow more food from the marginal and productive lands at lower production costs. Rice, jute, wheat and sugarcane are the main crops. The agricultural scenario has the complexity of small-scale farms. It is also faced with yearly problems of monsoon floods, changing water courses of tributaries and other physiographic changes within small distances. The traditional tank irrigation in irrigated area has gone down by more than 9 per cent over the past few decades. Most soils are deficient in N, P and sulphur.

Some of the key constraints leading to low productivity or even productivity stagnation in rice-wheat systems are: late transplanting and late-maturing photosensitive varieties of rice; low integrated use of organic and chemical fertilizers; multiple nutrient deficiencies; low use of external nutrient inputs by the farmers; inefficient management of irrigation and rainwater; continued rice cropping leading to greater incidence of insect and pests; soil acidity and non-availability of liming material; short-growing season for wheat and non-availability of agricultural farm implements. Under the RWC, studies on direct-seeded rice, and bed planted rice were carried out. The bed planted rice gave good yields. Zero tilled drilled wheat reduced weed infestation and enhanced water efficiency and ultimately gave higher yields.

5. CONSERVATION POLICIES AND PROGRAMMES

Many countries have launched CA programmes/ studies. CA case studies were carried out jointly by the African Conservation, Tillage Network, the French Agriculture Research Centre for International Development, the Swedish SIDA funded Regional Land Management Unit in ICRAF and FAO. The study throws light on controversial issues such as the challenges farmers face in keeping soil covered in gaining access to adequate equipment, in

controlling weeds and on the challenges projects and institutions face in implementing true participatory approaches to technology development.

5.1 Conservation and the Farm Bill: Agricultural Stewardship in America

The farmers and ranchers all across America are participating in programmes to restore wetlands, protect habitat, conserve resources and reduce runoff. A Farm Bill has been launched to implement conservation programmes which lay emphasis on conservation, clean water, improvement of grassland habitat and bio fuels. Land affected by erosion, rivers and streams harmed by farm-related pollution and wetlands and grasslands converted to agricultural fields are all being restored through incentives provided in the Farm Bill Conservation Programmes.

The Nation Resource Conservation Sources of US, the State Agencies Foundation and other organizations are offering resource Conservation Programmes in the State of Arkansas such as conservation reserve programme, conservation security programme, emergency conservation programme, emergency watershed protection programme, environmental quality incentive programme, farm and ranch lands protection programme, grassland reserve programme, wetland reserve programme, and wildlife habitat incentive programme. These programmes are described below in brief:

5.1.1 Conservation Security Program

The Conservation Security Programme (CSP) is one of the newest voluntary programmes offered by the U.S. Department of Agriculture Natural Resources Conservation Service. Under this programme, farmers and ranchers can receive income support for their efforts to maintain and enhance the quality of the soil, water, air and habitat on their operations. The Conservation Security Programme currently offers three tiers of enrolment based on the scope of resources addressed and the amount of farmland involved. Contracts are for five to ten years with an annual payment based on the duration of the contract. The best stewards can receive up to \$45,000 per year.

5.1.2 Conservation Reserve Program

The Conservation Reserve Programme (CRP) was established in 1985 to help farmers reduce soil erosion. It pays farmers to take croplands out of production and plant grasses year-round as cover to stabilize soils and improve wildlife habitat values. 'Continuous enrolment' allows farmers to sign up any time for assistance with planting grasses and trees along streams to reduce stream-bank erosion. Land owners receive rental payments and up to 50 percent cost-sharing.

5.1.3 Wetlands Reserve Programme

The Wetlands Reserve Programme (WRP) helps restore and protect wetlands on agricultural lands. WRP pays for conservation on enrolled lands and provides up to 100 percent funding for habitat restoration work. Approximately 1.8 million acres of wetlands have been restored till date.

5.1.4 Grassland Reserve Programme (GRP)

The Grassland Reserve Programme (GRP) helps landowners protect and restore grasslands, pasturelands, rangelands and other lands supporting shrubs. The programme funds up to 90 per cent of restoration cost and pays landowners for conservation easement or an annual rental agreement.

5.1.5 Farm and Ranchlands Protection Programme (FRPP)

The Farm and Ranchlands Protection Programme (FRPP) helps protect agricultural land from urban sprawl and other development. The land owners agree to a permanent conservation easement and receive a onetime, up-front payment equal to the fair market value of the development rights and continued use of the land for agricultural purposes. This permanent easement keeps the land from being developed.

5.1.6 Environmental Quality Incentive Programme (EQUIP)

The Environmental Quality Incentive Programme (EQUIP) assists farmers with technologies and practices to reduce air and water pollution, energy use and wildlife habitat impacts, while maintaining operations that are productive. EQUIP offers up to 75 per cent cost sharing for approved conservation measures.

5.2 California Wetlands Conservation Policy

A Wetland Conservation Policy has been launched by California with the goal of establishing policy framework and strategy that will ensure no overall net loss and achieve a long-term net gain in the quality and performance of wetlands acreage. The policy also promotes values in California in a manner that fosters creativity, stewardship and respect of private property; reduce procedural complexity in the administration of the State and Federal Wetland Conservation programme and encourage partnership to make landowner incentive programme and cooperative planning efforts the primary focus of wetland conservation and restoration.

To implement this policy and to achieve the objectives state-wise, policy initiatives have been taken such as wetland inventory, support for wetland planning, improved administration of existing regulatory programmes, strengthening landowner incentives to protect wetlands, support for mitigation banking, developing and expansion of other wetland programmes and integration of wetlands policy and planning with other environmental and land use processes. For successful implementation of the policies and programmes mentioned, regional projects have been developed to serve as pilots for implementing the policy. An interagency wetlands taskforce has been created to direct and coordinate administration and implementation of the policy.

Thus, various conservation programmes have been launched by the government of U.S. to provide financial and technical assistance to the farmers to conserve natural resources of the country.

The Government of India is being forced to continue policies to protect farmers' profitability, notwithstanding widespread and extensive resource degradation problems such

as declining water table in the high productivity northwest irrigated region which will seriously constrain productivity and ecology of the region. High levels of fertilizer use, decreasing resource use–efficiency and burning of plant residues are increasingly contributing to groundwater pollution and increased emission of green houses gases (GHGs). With continuously deteriorating resources, widespread problem of soil and water contamination and eroding ecological foundation, sustainability of agriculture is becoming highly questionable. Hence, there is need to develop conservation agriculture policy for sustainability.

In India, the government has launched the Watershed Development Programmes which ensure protection of land by conserving water and reduction of soil loss. Use of zero-till drills is being propagated and the government is giving subsidy on these drills. Front line demonstrations of these zero-till drills and other machines such as laser land leveller, raised bed planter, straw combine, and straw baler are being carried out by the State Department of Agriculture to promote CA. A RWC has also been formed by ICAR which is promoting CA technologies for rice-wheat systems but no CA policy has been formulated. The developing countries cannot afford to have policies like those of the U.S. where a large amount of incentives are being given to the farmers for practicing CA.

To promote CA among the farmers, the government needs to provide few incentives so that this technology is adopted instead of enforcing it on them. There should be free involvement of the farmers and the entrepreneurs in the CA programmes of the government instead of using the government machinery of extension for propagating the technologies. The following incentives have been provided by the government for adoption of CA by the farmers:

- 1) Minimum support price for growing other crops in place of paddy or crops using excessive water.
- 2) Subsidy on buying farm equipment such as rotavator, laser land leveller, zero till drill, straw combine, strip till drill, roto-till, raised bed planters, drip and sprinklers, straw combine, straw cutter cum spreader, straw baler etc.
- 3) Institutional financing at low interest rates for purchase of agricultural machines.
- 4) Increased tariff on electricity, removing free distribution of electricity.
- 5) Public private partnership to adopt RCTs and development of new equipment.
- 6) Consolidation of land to increase efficiency of farm implements.
- 7) Encouraging formation of cooperatives to take up CA practices.

6. CONSERVATION AGRICULTURE STRATEGIES ADOPTED IN INDIA

a) Conservation of Water through

- Paddy sown in unpuddled soils
- Paddy sown on side of ridges
- Less frequency of irrigation
- Introduction of laser land leveller – water savings of 25 per cent

b) Conservation Tillage Studies

- Development and demonstration of zero-till drill strip till drill, roto-till drill, till planting machine and raised bed planter.

c) Farm Residue Management through

- Stubble shaver
- Straw chopper cum incorporator, both aid in direct drilling
- Straw combine
- Straw baler
- For exhaust gas emissions, norms have been set up for tractors and other road vehicles.
- Fuel standards have been set up and have resulted in reduction in air pollution.
- Compressed natural gas use in buses trucks, auto and taxis in some metropolitan cities – resulted in reduction of air pollution.
- Introduction of biofuels and their mixing with fuel (5-10 per cent) is recommended – save foreign exchange and reduce GHGs

7. CONCLUSIONS

CA and productivity enhancing measures have become complementary. Earlier, the emphasis was to increase productivity by growing high-yielding varieties and increase use of inputs without any concern for the environment. A shift in concept has become necessary in view of the widespread problems of resource degradation, which accompanied the past strategies to enhance production with little concern for resource integrity. Hence, there is a need to integrate productivity by giving due attention to resource conservation technologies, quality and environment. A good number of equipment for conservation of agriculture such as laser land leveller, zero till drill, strip till drill, roto drill, till planting machine, raised bed plant, pre-germinated paddy seeders, Happy combo seeder, sprinklers, straw baler, straw combine, straw cutter cum incorporator have been developed in India and abroad. These need to be demonstrated and popularized by conducting front line demonstrations at farmers' field. The government should provide subsidy on purchase of these costly machines to cooperatives or self-help groups.

The Government of India has launched the rice-wheat consortium to promote CA through the use of generated equipment technologies. Practicing CA would help in utilizing the different inputs efficiently and effectively, reduce soil degradation, conservation of different resources, reducing cost of production and thereby help in enhancing productivity and production and reducing GHG emissions.

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