Sustaining Indian Agriculture

Conservation Agriculture - The Way Forward

For a country with the scale of population as India, agriculture's importance for needs of livelihood and food has been a subject of much discussion. 70 percent Indians depend on it as a means of livelihood, and all of us depend on it for our food needs. While agriculture has always been taken for granted, over recent years the discussion has shifted to the "crisis" being faced with "concerns" raised about the "reality" of the situation and what needs to done. We all know that these developments have been influenced by human actions and have not emerged as an overnight phenomenon. Thus, it is to be expected as with any deteriorating situation, the solution sought/professed may be equally strong, and many a times bordering on the impractical. It is in such a scenario that Conservation Agriculture (CA) is trying to find its feet within India. The world over, CA has gained ground due to the stated balance it has been able to achieve between needs of productivity and sustainability. With its basic approach directed at conserving resources and maintaining productivity, most would agree that it can offer a way forward to attain goals of sustainable agriculture.

Other influences adding to the challenges of agriculture in India are:

- The country's agriculture productivity curve has started to flatten while the population curve moves northwards.
- Climate change has now moved from the theoretical to an experiential level.
- The natural resource situation is assuming bothersome proportions.
- The industrial/service sector boom is also drawing people away from agriculture with migration playing havoc. India's leap in other sectors has further diluted share of agriculture in the national economy.
- Contribution of agriculture to GDP has also gone down and while such a reduction would be welcomed in any developed economy, India needs to attain a higher level of agriculture productivity, and open up non-farm job options for the rural youth to justify such a development.
- Policy decisions have placed the delivery of inputs in the hands of a few that encourages their existence, at times to the detriment of poor farmers.
- The government too with all good intentions can bring in measures that have an impact beyond comprehension of planners such as National Rural Employment Guarantee Scheme contributing to shortage of agriculture labour in Punjab and Haryana that function as the country's food bowl. This will of course lead to bringing about mechanization in agriculture, now driven from needs of compulsion and not just economic gain.

Yet hope is not lost. India's agriculture sector has an impressive record of taking the country out of serious situations every time a demand is made on it. This time though, the approach will have to be different with inbuilt "sustainability" woven through environmental, social, and economic perspectives. Thus, as before, when need was met through a favourable interplay of infrastructure, technology, extension and policy support backed by a strong political will; the same factors will need to be applied, though in a different manifestation.

1. Background: Evolution of Indian Agricultural Research System

India's agricultural research system has come a long way over the past six decades and is now on the threshold of change looking to the demand being made on it. In fifties research started to be organized on the basis of commodities and academic disciplines within separate sections of national and state research organizations. Sixties and seventies saw a beginning of All India Coordinated Research Projects with maize in 1957. The concept was then expanded to include all major field crops, fruit crops and even disciplines like plant protection, soil science, water management and agricultural engineering with establishment of several State Agricultural Universities (SAUs). During the eighties, many of the commodity coordinated project headquarters were upgraded to Directorates, National Research Centres or Institutes to provide scientific leadership for strengthening disciplinary research. NRM related institutes (Soil Science, Water Management) were established with coordinated project headquarters and co-ordinators forming part of the institute. Agricultural Universities were strengthened by establishing zonal research centres, each located in a distinct agro climatic zone (defined as a region with relatively homogeneous agricultural conditions) with a view to adapt broader research findings and technologies to local conditions and to foster closer links between research and extension.

Nineties saw increasing awareness and recognition of the problems of resource degradation in achieving sustainable improvements in productivity and the need for balancing commodity research with increased research efforts on NRM forming the focus. Recognizing that 'Green Revolution' technologies were showing signs of fatigue and that they had only limited impact on rainfed agriculture CGIAR responded to the challenge posed to the long term sustainability of agriculture by elaborating an 'Eco-regional Approach to Research in CGIAR' (TAC/CGIAR 1991). The approach had inherent advantages in organizing research on physical and biological aspects of conserving and managing natural resources including biodiversity along agro-ecological zones. Eco-regional approaches provide a sound basis for the much needed integration and functional linkages amongst stakeholders, both vertically (local-regional-national-global) and lateral (including public and private), therefore in minimizing the rampant duplication in research currently present in the system.

Effective linkages between research and extension are particularity critical in not only effective dissemination of knowledge but also providing a mechanism that allow continuous up-gradation of technologies and knowledge base, that is fundamental to sustained agriculture. Accelerated adoption of technologies calls for favourable policy regimes at different scales. Eco-regional approaches offer a way to mainstream policy research within the agricultural research system and provide a sound basis for such interventions. New technologies that call for integrating concerns of enhanced productivity and minimizing resource degradation particularly call for a dynamic and differential policy regime to take into account regional variations.

Following this, eight global 'Eco-regional Programs' were identified in the 90s. Particularly relevant to India was the program 'Rice-Wheat Consortium for Indo-Gangetic Plains (RWC)' involving four national agricultural research systems of the region (India, Bangladesh, Nepal and Pakistan). The need for adopting eco-regional approaches to research conceptualized and implemented at international level was

highlighted with Rice-Wheat Consortium for Indo-Gangetic Plains that was a CGIAR sponsored and facilitated, and NARS-led initiative implemented in the region. This was commissioned in 1994 and was reviewed in 1999 (Henzell *et al* 1999) and again in 2003 (Seth *et al* 2003). The main objective of this consortium was to sustain the productivity of the intensively cultivated rice-wheat cropping system. These reviews have important lessons for India's agricultural research system. An important conclusion of these reviews is that *'The principles underlying the eco-regional approach are valid and of continuing high priority for pursuing the sustainable improvements of agricultural productivity'*.

This eco-regional approach to research in ICAR was facilitated by the World Bank that also supported the National Agricultural Research Project (NARP) (1978-1996) launched by ICAR with a view to initiating and promoting agricultural research in the context of agro-climatic zones in the country. The objective was to set up or upgrade 'Zonal Research Stations' in each of the agro climatic zones for generating location specific, need based research targeted for specific agro-ecological situations. The focus was on analyzing and understanding agro-ecological conditions and cropping patterns to contribute to developing an agenda directly targeted to solve local problems based on natural resources, farming systems, production constraints and prevalent socio-economic conditions. Under the project, approximately 125 agro climatic zones were identified with the state as a unit and zonal research stations set up.

This was followed up by National Agricultural Technology Project (NATP) again supported by World Bank that was conceived and implemented aiming at reforms in technology generation and refinement process to resolve problems of agricultural productivity and natural resource management. This was done by focusing on eco-regional problems and to introduce new models of technology dissemination institutionalizing research-extension linkages at the grassroots. The NATP implemented between 1998 and 2005 constituted a major effort aimed at technology refinement and dissemination by institutionalizing research-extension linkages. The setting up of Krishi Vigyan Kendra's (KVKs) in each of the districts during the 9th and 10th plan periods has contributed significantly in meeting critical needs of enhancing accessibility to agricultural knowledge.

At the beginning of the current decade amplified concerns over declining resource use efficiency reflected in stagnating productivity and profitability on one hand and concerns of promising research findings not reaching farmers due to inadequacies in research design, results or deficiencies of linkages with the delivery system on the other. This led to conceptualization and implementation of National Agricultural Innovation Project (NAIP) in 2006 that was particularly relevant to the environmentally and socio-economically weak areas prompting a revisit to agricultural research priorities and strategies. The ongoing National Agricultural Innovation Project (2006-2012) is a major effort aimed at broadening the goals of research to address the larger livelihood issues, particularly of those living in disadvantaged regions and in strengthening the basic research component so essential to enhance system preparedness to respond to newer emerging challenges. Among the more specific objectives of the NAIP is to *enhance the system's capacity of catalyzing a change that will permit system based approaches to address problems in a production to consumption system mode, including efforts at value addition, improve livelihood security in the disadvantaged regions and to build capacity*

to undertake basic and strategic research to meet technology needs in the immediate and predictable future.

Past developments and new challenges provide a unique opportunity to induct accelerated changes aimed at bringing much needed system wide changes to respond to the multitude of challenges.

2. Challenges Facing the Sector

Slowdown in agricultural growth has wider, long term and serious ramifications that can seriously impact food and nutritional security, widening economic disparities between the regions (e.g. irrigated and rainfed), furthering the rural urban divide, undermining the poverty alleviation goals and increased vulnerability to world commodity price volatility following trade liberalization. These concerns have led to serious deliberations at various levels to understand the causes for slowdown with a view to arrive at strategies aimed at revival of the sector.

The main driver of long run growth was technological augmentation of yields of principal food grains crops resulting in nearly four-fold increase in food grains production from 51 million tones in 1950-51 to 217 million tones in 2006-07. Similar gains were achieved in production levels of oilseeds, sugarcane and cotton. As would be expected in any development scenario, contribution of agriculture sector to GDP has declined over a period of time from almost 50 percent at the time of independence to about 18 percent at present. While this would be acceptable as a fair indicator of any fast developing country, in India's case it can be worrying given the lack of corresponding reduction in population involved with the activity, many of whom are dependent on the produce from the land.

Even the family's operating land holding has gone down with 70 percent accounting below 1 ha in 2003 compared to 56 percent in 1982. These overall developments and recent productivity trends have been a cause of serious worry to the country's planners towards maintaining a comfortable food security position. In India roughly two-thirds of its 1.1 billion people still depend on agriculture for a living. However, the agricultural sector is projected to register a mere 2.6 percent growth in the year 2007-2008 against the overall GDP growth rate of 8.7 percent.

A matter of concern is that the per capita increase in GDP of the agricultural worker in 2006-07 was only 75 percent higher than in 1950 in real terms compared to a four fold increase in overall agricultural productivity. This is also attributed to the failure to reduce the dependence of the rural workforce on agriculture significantly, by creating non-farm opportunities to absorb surplus labour from rural areas, and equipping them to access such opportunities (Planning Commission, 2008).

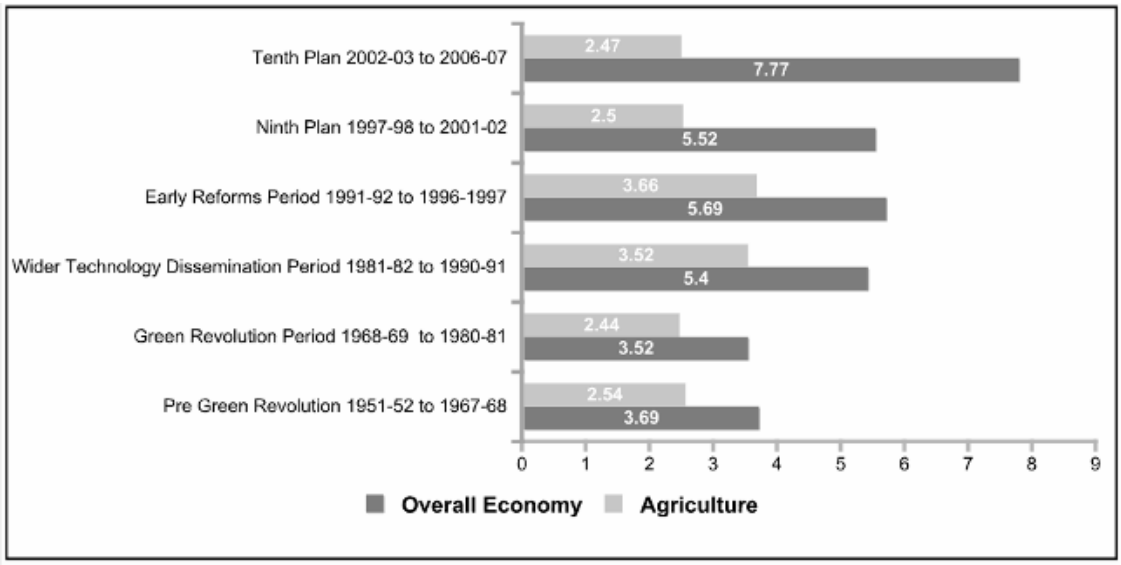
Slower Agricultural Growth

There appears a general consensus that the dynamism in agriculture sector observed during the green revolution has faded, raising serious concerns. Growth in agricultural GDP decelerated from over 3.5 percent per annum during 1981-82 and 1996-97 to only around 2 percent during 1997-98 and 2004-05. Deceleration in growth was most marked in rainfed areas where the poorest live, constituting more than 65% of India's agricultural area and offering livelihood to 70% of India's farmers. This was noticed across almost all states and sub-sectors including horticulture, livestock and fisheries where high growth was expected as a given.

Consequently growth in agricultural GDP was well below the target of 4 percent set for both ninth (1997-98 to 2001-02) and tenth (2002-03 to 2006-07) plan periods. In fact the 10th plan growth averaged even less than the 9th plan, but for some upturn in the growth in the last year of the plan period largely attributable to favourable weather conditions.

These trends coupled with a steep rise in prices of most agricultural commodities in recent months and the recent trends of diversion of area under food crops for bio-fuels in many countries implies a need for a stronger response based on better understanding of problems afflicting the sectors' productivity growth.

Figure 1: Average overall and agriculture GDP % growth rates.



Source: Planning Commission, 2008

Over the past couple of years a number of studies have been undertaken and several deliberations initiated through various forums to understand and pinpoint the reasons for slowing growth with a view to strategize and put in place an action plan to reverse the processes that have contributed to the sector's declining performance. These efforts are reflected in the Eleventh Five Year Plan (2007-2012) document.

Lack of Eco-regional Approach

The Planning Commission's 11th five year plan Working Group on Agro-Climatic Zonal Planning underlined that the concept of setting up Zonal Research Stations was an excellent thought, but unfortunately the concept was not translated to bring about the desired shift in planning and funding of agricultural research to achieve desired objectives. This was largely on account of its inability to bring a change in the mindset that needed to accompany efforts. One reason advanced was that while the primary objective of setting up zonal research station was 'technology generation' relevant to local situations, these came to be used more as a 'transfer' route of technology generated on university campuses, very often resulting in promotion of misdirected technologies. These inadequacies also contributed to neglect of much needed emphasis on rainfed farming situations and needs of poor and smallholder farmers, also ignoring issues concerning gender and the environment that are significant cross cutting issues. The working group reiterated that these needed to be revitalized by providing necessary funds with the focus directed at prevalent farming systems of the respective regions. These are also the reasons why a relevantly pursued eco-regional approach used by the Rice-Wheat Consortium for Indo Gangetic Plains has not been able to influence the Indian Agriculture system on both counts, technological and institutional.

Neglect of Rainfed Agriculture

An important avenue for achieving increased production goals is to enhance the productivity of rainfed agriculture areas that accounts for nearly 60 percent of the net cultivated area of the country. These are areas where productivity growth observed during 1985-1996 has decelerated more than in irrigated regions (Planning Commission 2008). These are also the areas where vast majority of the poor live, and livelihood efforts exercised to alleviate poverty are intimately linked to our ability to make an impact on agriculture. Rainfed agriculture is practiced under a wide range of soil and climatic conditions. Rainfall regimes, amount and distribution, and soil characteristics are key determinants of rainfed cropping potential and these vary widely in rainfed regions. In the absence of widespread adoption of cost effective moisture retention and conservation technologies, the soils suffer from rapid rainwater run off and erosion reducing their productive capacity and agronomic potential. *Realizing this potential essentially hinges on our ability to reverse processes of degradation – processes that will contribute to institutionalize water conservation, reduced runoff and erosion. Thus resource conservation issues represent an essential prerequisite to achieve enhanced productivity. In the past there has been little R&D effort that recognizes resource conservation to be a precondition to sustained productivity increase.* Given the wide range of soil, climate and socio-economic situations, it is obvious that these technologies have to evolve and be adopted considering local situations and in a participatory manner.

Over past two decades, the Govt. of India has devoted considerable attention and resource in programs such as watershed development in rainfed areas. The main focus of these programs has been to generate water resource by run-off collection and harvesting by concentrating on water storage structures and reuse. Scant emphasis has been placed on the more fundamental way to enhance and sustain productivity of affected areas through development and widespread adoption of technologies that improve *in situ* conservation of rainwater. This will help improve the capacity of soil to absorb and retain water, and reduce erosion. This trend is likely to continue with Planning Commission (2008) estimating a requirement of approximately Rs. 36,000 crore over the 11th Plan Period.

Notwithstanding the often emphasized benefits from these programs, there are serious questions and compelling reasons (Dinesh Kumar *et al* 2008) to review the basic tenets that call for much greater emphasis on '*in-situ'* conservation of rainwater *vis-a-vis* 'water harvesting' for irrigation that has been the case thus far. There appears a need for a serious effort to shift the balance of effort from the current emphasis on 'water harvesting' to '*in-situ'* conservation in area programs aimed at improving the productivity of our rainfed area.

Challenge of Climate Change

The threat of global climate change has serious implications for India faced with the challenge of sustaining rapid economic growth. With its economy closely tied to its natural resource base, climate sensitive sectors such as agriculture, water and forestry are particularly vulnerable and may face a major threat because of projected changes in climate with accompanying adverse implications affecting livelihoods of its people. Recognizing these challenges, the Government of India (2007) has set out on a National

Action Plan on Climate Change (NAPCC) that addresses critical concerns of the country through a directional shift in its development pathway. The National Action Plan on Climate Change has identified measures that address climate change related objectives of adaptation and mitigation while achieving development goals.

To implement the NAPCC the document has proposed setting up eight national missions that will operate through appropriate institutional mechanisms to ensure effective delivery of objectives. The Plan hinges on development and use of new technologies, building public private partnerships, and civil society action. The focus of the mission will be on better understanding aspects of climate change, adaptation and mitigation, energy efficiency, and natural resource conservation. *National Mission on Sustainable Agriculture is one of the eight missions which form a core of National Action Plan aimed at long term and integrated strategies for achieving key goals in the context of climate change.* These efforts and initiatives will reinforce current programs that may need a change in direction, enhancement of scope and effectiveness and accelerated implementation of time bound plans.

3. Current Efforts to Revitalize Indian Agriculture System

Despite various efforts described in the introductory section to revitalize the Indian agriculture system recently, several efforts have been taken up at the national and international level. Earlier the National Agricultural Policy (MoA, 2001) reiterated the need *for regionally differentiated approaches to agricultural development* where the central government would increasingly assume a role of advocacy, articulation, and facilitation to assist the states in achieving outlined objectives of accelerated agricultural development.

Recognizing the seriousness of problems facing the agriculture sector, the 53rd Meeting of the National Development Council (NDC, 2007) of all Chief Ministers under the chairmanship of the Prime Minister deliberated exclusively on ways to put in place a strategy to revitalize the sector. The main highlight of the deliberations was that India's technology generation and dissemination system had hit a point of fatigue and needed to be revitalized to be able to respond to newer challenges faced by the system. A more significant message of the deliberation pointed to a clear recognition that the problems facing agriculture called for localized solutions that took into account local resource endowments, potentials, as well as constraints to be at the core of any agricultural revamp strategy for the country. As a result of these conclusions, it was decided that the states develop their own plans building on district level plans which would take into account base line levels of production, constraints in achieving enhanced productivity, and put in place credible strategies and programs for achieving targeted goals. *These vital decisions have direct and serious implications for India's agricultural research and education system if it has to effectively respond to the challenges facing the sector.*

Concerns Recognized by Planning Commission

Essentially there appears to be a broad agreement that continued decline in performance of the sector over past years can be attributed to a combination of factors that include *a slow down in public investments in the sector including areas of infrastructure (irrigation development, electricity etc), access to agricultural services (credit, markets, insurance, extension), and the trend of increased budgetary subsidies (on fertilizers, power, irrigation water, etc) that have increased from 3 percent of agriculture GDP in 1976-80 to about 7 percent in 2001-03. During the same period public investment in agriculture declined from 3.4 percent of agricultural GDP to less than 2 percent as stated above (Figure 1).*

Increasing level of subsidies has not only prevented investments for productive purposes (irrigation development and development of rainfed areas being worthy mentions) but have actually contributed to widespread problems of resource degradation adversely affecting the sustainability of production systems. *The Eleventh Plan strategy group recognized this as by far the most critical factor limiting sector growth related to 'technology fatigue'* that reflected on the state of the National Agricultural Research System and where it stood in the post-green revolution phase. *The Plan document recognizes that agricultural research was under-funded but stressed that lack of resources was not the only problem. The system lacked a clear strategy that could assign definitive responsibilities, prioritize research agenda rationally, and recognize that more holistic approaches were the need for technology development and delivery.*

While recognizing the need to substantially increase investments in the sector, the 11th Plan strategy emphasized the need to revive the National Agricultural Research System to make it more effective and responsive to the new challenges facing the sector. Other concerns raised include:

- The need to mainstream impact assessment work routinely in all major projects to ensure adequate resources and attention to development of resource groups with capacity to undertake such studies. Work to assess farm level impact should include analysis of potential constraints, technical as well as socio-economic, to adoption of promoted technologies.
- Particular attention needs to be paid to human resource development for systems based research efforts.

These and other lessons need to be elaborated, deliberated, and internalized towards evolving more efficient and effective systemic response to emerging challenges facing the sector.

As a result of these concerns, 11th Five Year Plan (2007-2012) document recognized that the main source of yield growth in this plan could come about only by adopting region specific plans based on specific regional constraints and would require much stronger linkages between research, extension and farmers. Table below provides an example of specific constraints that greatly limited agricultural growth in respective regions (Table 1) as recognized by the Planning Commission.

Table 1: Region specific factors that can be attributed to low productivity

Agro-climatic region	States/parts of states	Region-specific constraints
Western Himalaya Region	J&K,HP, Uttarakhand	Severe soil erosion, degradation due to heavy rainfall/floods and deforestation, poor road, poor input delivery, inadequate communication infrastructure and marketing
Eastern Himalayan Region	Assam, NE States, Sikkim	Aluminium toxicity and soil acidity, soil erosion and floods, shifting cultivation, non-availability of electricity, poor road, poor input delivery system and communication infrastructure
Lower and Middle Gangetic Plains Region	West Bengal, Bihar, Eastern UP	Flood/water logging, improper drainage, salinity/alkalinity, arsenic contamination, non-availability of electricity, high population growth, poor road and communication infrastructures
Upper and Trans-Gangetic Plains Region	Western UP, Punjab, Haryana	Groundwater depletion, decreasing total factor productivity, micronutrient deficiencies, inadequate-availability of electricity, and high population density
Eastern Plateau and Hills Region	Orissa, Jharkhand, Chhattisgarh	Moisture stress, drought, soil acidity, iron toxicity, non-availability of electricity, high population growth, poor road, poor input delivery and communication infrastructure

The 11th Plan document further emphasizes the pressing need to pursue accelerated agricultural growth that must not be at the cost of sustainability of our natural resource base that is limited and compounded by widespread degradation of soil and exploitation of groundwater. *Action on the environmental front cannot wait especially in the face of*

looming adverse impacts of climate change resulting from global warming. Increasing subsidies on fertilizers, per se, have further contributed to natural resource degradation.

Thus far, research has focused on increasing the yield potential through more intensive use of water and chemical inputs. Far too little attention has been given to long term environmental impact or on methods or practices of efficient use of inputs for sustained agriculture. These features have been talked about but efforts to correct these have been inadequate and have not made much of a difference. *There is thus a need for a major paradigm shift to transform the present commodity centric research to increasingly adopt systems-based approaches in finding solutions to problems.* This would be best accomplished by bringing about convergence between R&D agencies within a region (agro-climatic) to bring region specificity to the process of technology generation and adoption, laying the groundwork for a seamless continuum between research, development, and needs of stakeholders.

A shift to eco-regional approach to research for development has important consequences in terms of research prioritization at local, regional and national levels and the role and responsibilities of research system partners, within their respective system and with each other. State agricultural universities with a direct responsibility to address development needs of the state are therefore the main stakeholders for locally and regionally relevant research, and for generating quality resource. On the other hand, central (ICAR) institutions have to increasingly assume a greater role in undertaking more strategic and basic research aimed at strengthening knowledge base for addressing increasingly complex problems of national and global dimension. A better understanding of roles and responsibilities of key stakeholders would also allow better and more focused funding to address needs of both situations, the short and long term perspective.

It is increasingly recognized (Planning Commission 2001, World Bank 2007) that knowledge presents the most attractive opportunity for lifting vast majority of Indians out of poverty by enhancing overall productivity and per capita income. Knowledge economy as it has come to be termed is an economy that creates, disseminates and uses knowledge to enhance growth and development. Building effective knowledge economy calls for both enhancing our knowledge resource and creating an environment in which the knowledge can be distributed, accessed and internalised effectively. This will require that we adopt more comprehensive approaches to agriculture that aim at bringing about improvement in our existing knowledge systems and in creating avenues for generating and disseminating new forms of knowledge and the role of the National Knowledge Commission (NKC) in achieving such goals.

Consultations on Agriculture organized as part of NKC's efforts in 2007 involved practitioners, writer-activists, government officials, experts and researchers. Through workshop this group deliberated on current nature of agricultural research and extension, reasons for its rapid deterioration, irrelevance in a changing scenario, and measures that may be adopted to ameliorate the situation. Its purpose was to identify areas of intervention and these findings have great relevance to revitalizing the Indian agriculture system.

National Mission for Sustainable Agriculture (2007) formed under the National Action Plan on Climate Change (NAPCC) will focus on areas critical to agriculture in adapting to climate change. Some of the priority actions include:

- Development and promotion of improved technologies to conserve soil and water, development of stress resistant crop varieties (using biotechnology tools)
- Enabling farmers for adoption of relevant technologies, developing and promoting improved management strategies for improved use-efficiency of inputs and reduced greenhouse gas emissions
- Strengthening information sharing and dissemination mechanisms amongst farming communities
- Strengthening of database and sharing/access mechanisms at different levels on land use, soil and water resources, resource degradation, socio-economic features and agro climatic variables.

NAPCC recognizes and lays stress on the need to enhance the quality and quantum of human resource that is a prerequisite to resolve increasingly complex issues that are emerging on account of climate change.

With such policy documents in place, there is an urgent need to mainstream these and other concerns into the institutional framework that governs India's agricultural research and education system.

Global Efforts That Have a Bearing on to National Concerns

Besides national efforts, India has also a stake in global efforts to revitalize agriculture in a sustainable manner. International Assessment of Agriculture Science and Technology for Development IAASTD, Report (2008) has serious learning to offer for India. The report released earlier this year strongly emphasized better targeted and increased investments in agricultural knowledge, science and technology that would explicitly take multi-functionality of agriculture into account while adopting innovative institutional arrangements to bear upon the challenges facing the sector and could contribute effectively to achieve sustainable agriculture development. To achieve it, the report strongly states that "BUSINESS AS USUAL IS NOT AN OPTION" and thus a need to look at the way forward. The report is an outcome of 3 years of co-operative effort involving governments, representatives of civil society and private sector and large number of scientists. It has much to offer by way of chartering a future course of action by the national and international agricultural research systems.

Amongst its key findings is *the need to counter negative consequences on environmental sustainability associated with past emphasis on singular efforts to increase yield and productivity.* These consequences being gradual in nature were not foreseen earlier, but have today adversely impacting livelihood and food security needs of a large section of the population, more so in developing countries. According to the study, *agriculture contributes about 60 percent of anthropogenic emissions of CH_4 and about 50 percent of N_2O, and inappropriate use of fertilizers and pesticides has led to serious problems of groundwater pollution, eutrophication and loss of biodiversity.* Loss of soil fertility, soil

erosion and breakdown in agro-ecological functions are the other major factors responsible for poor crop yields and land degradation.

Future research for development efforts must recognize the multifunctional role of agriculture including ecosystem functions that mitigate environmental impacts while maintaining and increasing productivity. Formal, traditional and community based agriculture knowledge need to be tapped by the science and technology system to respond to worsening quality of water, degraded soils and landscape, loss of biodiversity and ecosystem functions while addressing agricultural strategies. It goes without saying that such efforts should help limit emissions of greenhouse gases and adapt to aspects of climate change and increased variability.

The report stresses the essentiality of innovative institutional arrangements for the successful design and adoption of ecologically and socially sustainable systems. Achieving sustainability goals would demand creating space for diverse voices (farmers, NGOs) and perspectives (private, public) and involving social scientists in policy and practice of agricultural knowledge, science and technology. More and better targeted investments in agricultural knowledge science and technology system can help advance development and sustainability goals explicitly taking into account multi-functionality of agriculture as practiced by both, the public and private sectors.

Technology for development must now go well beyond raising yields to save water, energy, risk, yet work to improve on product quality, environment, and tailor pursuits to needs of gender mainstreaming. These concerns and challenges are also flagged in the recent World Development Report – Agriculture for Development, 2008 (The World Bank, 2008). The report observes that rapidly changing institutional setting for technological innovation is opening the space for a wider range of actors to come on board the process of innovation including farmers, private sector and civil society organizations. Linking technological process with institutions and markets to engage this diverse set of actors will be at the heart of future productivity growth. *These changes imply that while setting the research agenda, innovation and technology needs to be less driven from a supply perspective, but more from demanded needs, i.e., needs of farmers, consumers, as well as interests outside agriculture. Innovation for new agriculture would need to rest on tenets of feedback, learning and collective action among a much broader set of actors.*

The greatest impact on productivity will be achieved by increasingly adopting ecological approaches that combine improved varieties with other variables, management technologies, crop-livestock integration and mechanical technologies to exploit their synergetic effects. The report observes that research for development efforts continue to be grossly under-funded in most developing countries, not withstanding the past experience that has shown close links between agricultural productivity increase to investments in agricultural R&D. These investments and institutional innovations will be even more important in the future with growing resource scarcity, rapidly changing markets, and greater uncertainty.

Making R&D more responsive to farmers and the market will call for building partnership with farmers' organizations aimed at enhancing demand for innovation by bringing farmers' voice into decision making. Collective action will help identify

constraints, pool indigenous knowledge and aggregate technological demand. These partnerships will help scale up adaptive research, test, disseminate and facilitate access to inputs, markets and finance for new technologies.

These and other conclusions of the report have direct relevance to the challenges facing Indian agriculture and to develop and pursue strategies to meet challenges ahead.

Harnessing innovation towards sustainable and inclusive growth is an area where India is underperforming relative to its potential and in comparison with countries such as China, Korea or other developed economies (World Bank 2007). Knowledge creation and absorption efforts most relevant to needs of the poor have to be at the core of innovation and this is where agricultural research and education have a critical role to play. According to the report, if India is to unleash its innovative potential it needs to develop a strategy that promotes innovative organizational forms enabling new means of interaction, encourages stronger competition amongst enterprises, enables better networking among scientists and researchers, builds market relevant skills by investing in training, both in-service and educational curricula, enables better diffusion and absorption of existing technologies, increasingly develops and adopts internationally recognized quality certification services, taps talent of the Indian diaspora, and ensures that innovation systems and processes percolate down to grassroots.

Similarly Global Forum for Agricultural Research (GFAR, 2006) emphasized that agricultural research for development needs to urgently reorient itself to become more pro-poor to be able to contribute to satisfy the needs of small producers and the rural poor. *The change required to be addressed is not only of technology but that of processes too that generate it, and also within systems in place for agricultural research and the institutions that foster them. The paradigm needs to shift from increased production and productivity alone to how to enable enter agricultural system to respond to markets, creating sustainable livelihoods in rural areas and conserving natural resources. For agricultural innovation to contribute to alleviation of poverty there is urgent need to mobilize, share and exchange agricultural knowledge, information, experience and skills globally and nationally.*

Achieving this shift calls for strengthening all the stakeholder constituencies so that they can, through an inclusive process, contribute to agricultural research and innovation to meet the new challenges. Enabling and building partnerships to respond to specific issues and enabling sharing and exchange of knowledge, skills and resources that contribute to agricultural research and innovation globally, regionally, nationally and at local levels will provide the much needed preparedness to meet challenges facing the agricultural research and education system.

The recent meeting of GFAR on 'A Comprehensive Movement for Conservation Agriculture' held in Rome on July 21, 2008 provided a neutral platform for agriculture for research and development stakeholders to foster innovative multi-stakeholder partnerships to address key agendas in agricultural research for development. The meeting recognized that CA was one of the few options available for sustainable increases in agricultural productivity and that its adoption and adaptation required active innovation systems comprising multiple stakeholders from public, private and farmer groups that in turn required current knowledge of CA research results and performance in

different agro ecosystems around the world. To facilitate this, GFAR'S Global Partnership Platform for Resource Conserving Agriculture (GPP-CA) also aimed at empowering those involved in national agricultural research and innovation systems with better knowledge and skills related to CA research, adoption, adaptation and impact.

At an organizational level, Food and Agriculture Organization (FAO) has been spearheading and catalyzing a movement to focus on and promote the cause of CA globally. A recently organized technical workshop (2008) in the backdrop of rising global concerns over:

- World's ability to ensure continuing food security
- Evidence of the vast scale at which scarce available land is degrading
- Long term sustainability of technologies on which agricultural intensification is now based
- Rising cost of energy and its impact on food production
- Growing scarcity of water available for agriculture
- Need for reducing GHG emissions

The consensus of the workshop (attended by 96 stakeholders from 40 countries representing a wide spectrum of stakeholders) was that these outcomes will be achieved through adoption and implementation of CA principles and practices. *The participants agreed that ample evidence now exists of successes of CA under diverse agro-ecological conditions to justify a major investment of human and financial resource in catalyzing a shift whenever and wherever conditions permit it from tillage based production systems to those based on minimal soil disturbance, organic residue retention and crop rotations and combinations.* Such a shift will lead to large and demonstrable savings in machinery and energy use and in carbon emissions, a rise in soil organic matter content and biotic activity, less erosion, increased crop water availability and thus resilience to drought, improved recharge of aquifers and reduced impact of apparent increased volatility in weather associated with climate change. It will also cut production costs, lead to more reliable harvests and reduce risks especially for small land holders.

The workshop came up with a framework on actions that would help to empower farmers to engage in management methods centred on CA principles enabling land to be farmed in a more intensive, productive and sustainable manner. The framework calls for goals, priority action, and simultaneous attention to strategic issues in respect of key elements, such as science and technology development, scaling up of CA and creating supportive policies.

Sustainability of agriculture together with environmental and socio-economic concerns is undoubtedly one of the most relevant global and national issues. Agriculture should guarantee not only economic and social viability but also food security and safety while conserving and even improving local, national and global basic resources and the environment. This is one of the major post green-revolution challenges world-wide and certainly in India where the adverse impact on conventional agricultural practices of farm productivity and sustainability as well as of basic natural resources and environmental

processes is being increasingly recognized, documented, with growing awareness of the need to change these practices.

The state of agriculture in India seeks some warranted changes as reflected through emphasis of agriculture policy, NDC, and 11th five year plan which all support sustainable agriculture (discussed earlier). These are now well supported by IAASTD that calls for a fundamental change in the way we do farming to better address soaring food prices, hunger, social inequities and environmental disasters. The key message points to small farmers and agro-ecological approaches forming the way forward to avert the current food crisis. Such an approach would meet needs of local communities with more and better food being produced, without destroying rural livelihoods or natural resource.

With increasing scarcity of land and water, productivity gains will be the main source of growth in agriculture, and the primary means to satisfy increased demand for food and agriculture products globally. With globalization and new supply-chains emerging, farmers and countries need to continuously innovate to stay competitive. Climate change will call for greater adaptation and all regions, particularly risk prone rainfed systems need sustainable technologies that increase productivity, stability and resilience of the production system. From the above effort there indeed emerges the need to identify issues and action points that can point to revitalizing Indian Agriculture to face national and global challenges.

4. The Way Forward – Issues and Needed Actions

The task of bringing in a paradigm change in India's agricultural research system is by no means going to be a straight forward task. Fortunately, the system has been constantly evolving in response to emerging challenges and is well placed for an accelerated evolution, consistent with new challenges facing the system. While these efforts no doubt have contributed to greater preparedness, what has been missing is a concerted and a consistent effort by the system to mainstream/institutionalise many of the innovations/processes that would enable sustained improvement in the system *What is required is a shared vision amongst key stakeholders defining where we wish to reach and what initiatives we need to take.* Some of the initiatives taken in the past and more recently have provided points through which strong leveraging could be developed contributing to building an accelerated process for achieving new goal horizons. This calls for broadening and deepening of the knowledge base to solve increasingly complex problems. *What is needed now are interventions that contribute to achieving short term goals while enhancing preparedness to solve futuristic problems in ways that are efficient and effective.*

Agricultural Research System Needs to be Revitalized

The 11th Plan document (Planning Commission 2008) observes that it is necessary to take a comprehensive view of funding India's agricultural research system and make systemic changes during the course of 11th Plan. Thus far, research has tended to focus largely on increasing the yield potential by intensifying use of water and chemical inputs and far too little attention has been given to the long-term environmental impact on methods and practices for efficient use of inputs. These corrections need to be made if sustainable agriculture is to be pursued. These features are well known, but efforts to correct these have not been adequate and at any rate have not made much of a difference. The document recognizes that agricultural research is under-funded and that lack of resources was not the only problem, with available resources not being optimally utilised because of lack of a clearly defined strategy that:

- Permitted rational prioritization of research agenda
- Assigned definite responsibilities among partners
- Recognized that research mode was not always best suited for technology development and delivery
- Needed to bring together cohesion of efforts among various stakeholders

The document identified the major constraints facing the system. These include:

- Dominance of commodity based focus in R&D that lacks holistic approach involving the matrix of resource endowments, farm enterprises and prevailing socio-economic conditions
- Strict compartmentalisation within the research system and between R&D and extension agencies
- Lack of large scale validation and refinement of promoted technologies/practices and feedback mechanisms

- Under-stressed strategic and basic research component aimed at well defined researchable issues pointing at medium to long term effort to solve imminent problems by involving relevant disciplinary teams and institutions.

From a Crop Focused to Eco-region Specific Approaches

The Plan document emphasized the need for a major paradigm shift needed to transform the present commodity centric research to one that is systems based. Since farm level problems and required solutions are specific to an agro climatic unit, what is needed is convergence between R&D agencies within individual agro-climatic units so as to bring region-specificity in technology generation and related extension strategies, including highlighting policy imperatives. Such an approach will also help in establishing the much needed research-extension-policy continuum involving all stakeholders.

While the crop-centric focus of R&D strategies in the past have contributed to large productivity gains, particularly in more favourable environments, the need now is to enhance productivity across the agro-ecological regions by focusing on a wider array of crops and sectors, such as horticulture, livestock productivity, fisheries; and integrating them. These and increasing concerns of widespread problems of resource degradation across regions call for a shift from crop specific to eco-region specific strategies to agricultural research for development.

Benefits of Eco-Regional Approach: Eco-regional approach has several advantages over the crop-specific approach that we have adopted thus far:

1. It allows building a farming systems perspective in research and for this reason the likelihood of acceptance of technologies by stakeholders is much better.
2. The approach allows building a systems perspective to R&D that provides a sound basis for linkages both horizontally and vertically. In this manner, it can contribute to building enhanced partnership between the scientific community with important stakeholders, farmers on one hand and development community on the other.
3. The approach can also contribute to building a basis for developing greater complimentarily of efforts of scientists working in the state agricultural universities and those at ICAR institutes.
4. It will also enable research prioritization and better targeting of research agenda at the local, regional and national levels. Importantly, the approach permits research for development strategies which integrate the concerns of enhanced productivity while addressing issue of maintaining and improving the natural resource base quality.
5. The approach contributes to ‘problem solving mode of research and a way to increasingly address policy related issues at different levels, local, regional, national.
6. Most importantly, the approach will contribute to developing a ‘demand led’ research agenda and building a clear linkage between the adaptive, strategic and basic research components for sustained gains from investments.

Operationalising Eco-regional Approach: The concept of eco-regional planning for research and development will evolve with time and ICAR and its institutes will have a focal role in guiding the evolution while addressing emerging research and development agenda. Operationalising the eco-regional approach to research for development will call for initiatives both at the state and central level. Agriculture being a state subject, the onus for operationalising the approach at the state will be that of state agricultural universities that are key institutions to back up knowledge for agricultural development. At the central level, Indian Council of Agricultural Research (ICAR), the apex research and coordinating agency will have a critical role in conceptualizing an eco-regional framework that is flexible, open to evolution and one that aligns national agenda and state priorities, while facilitating the process of change in the system of which it is an integral part. Agricultural universities and ICAR will also have a major role in entering into a new relationship respectively with the state and central development departments that will be more organic in nature.

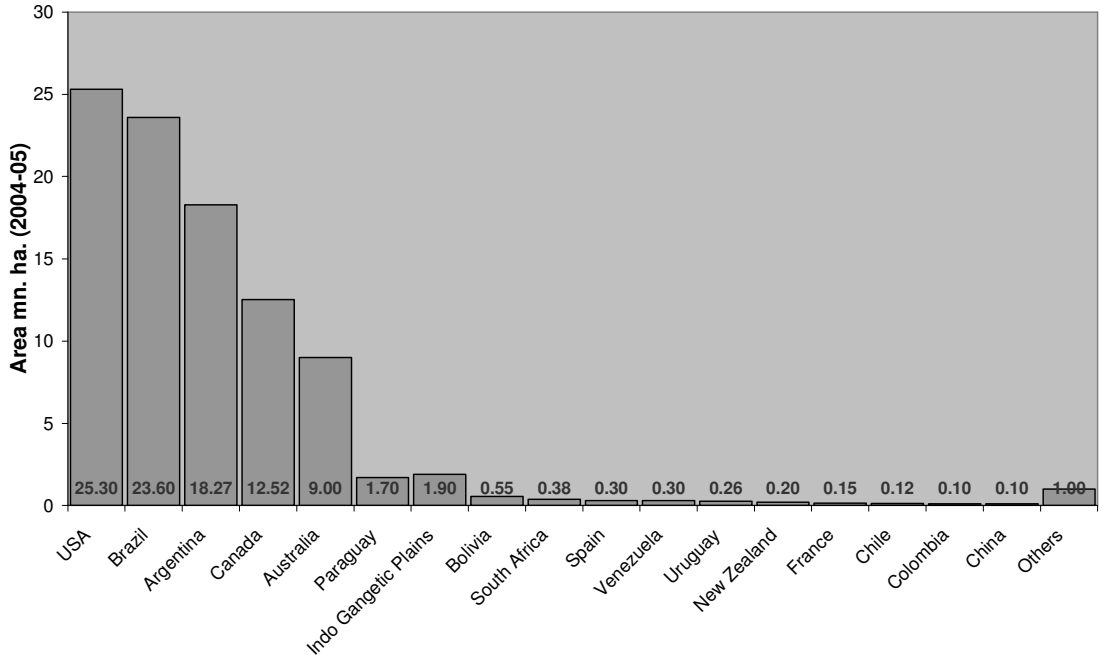
While organizing region specific research and linking to development programs for each of these regions is the task of state agricultural universities, ICAR Institutes have the critical role to view and approach the problem from a national perspective, facilitate linkages and coordination within universities and ICAR institutes having a related mandate and be able to synthesize issues across the regions. Thus efforts to operationalise eco-regional approach calls not only for conceptual clarity shared by major stakeholders but also backed by an ability and resolve to achieve what has been accepted as being the way forward.

Eco-regional approach to research for development constitutes a major paradigm shift from the way agricultural research and development have been visualized and approached in the past. This has wide implications for India's agricultural research system - the way it is structured and it functions. An implication critical to the success for the approach is the scientific capacity to analyze, understand and find solution to systems based problems. Successful evolution of eco-regional approach is fundamental to facing the challenge of sustainable agricultural growth and development and will call for a new vision that is widely shared amongst the key stakeholders. Mechanisms will also need to be positioned to monitor, guide and leverage step-wise change while learning and making corrections as we move forward to meet the overall goal of sustainable agriculture.

5. Conservation Agriculture as an Emerging Global Strategy

The present day agriculture crisis facing the world has raised questions on the merits of conventional agriculture. We have reached a point where we must seek new directions by way of strategies, policies and actions that must be adopted to move forward. Alternative practices, technologies and approaches such as inclusion of green manure crops, organic manures, management of crop residues, reduced/zero tillage, conservation tillage/mulch based approaches, resource conservation technologies (RCTs) have emerged as adaptive strategies to emerging challenges of nature and environment. *Amongst various technological alternatives Conservation Agriculture (CA) based farming systems appear to have the potential to be applied on a large scale and to contribute significantly to achieving goals of sustainable agriculture* (KASSA, 2006, FAO, 2008, Reganold and Higgins 2008). This is felt since the CA approach can cohesively address issues such as productivity, economics and environment to bring systemic change to revitalize agriculture in India.

Figure 2: Area under conservation Agriculture: some major countries (2004-05)



Source: Derpsch (2007)

Areas adopting CA practices are expanding in various countries (Figure 2) because of benefits they generate in terms of yield, sustainability of land use, and incomes as a result of the initiative shown by farmers and organizations involved. It is estimated that now almost 100 million ha of arable crops worldwide are grown without tillage. Except for a few countries (USA, Australia, Latin American countries of Argentina, Brazil, Paraguay and to some extent Europe) *these approaches to sustainable farming have not been mainstreamed in agricultural development programs in the absence of adequate scientific/technological support and suitable policy and institutional backing in most countries* and the total area under CA is still very small relative to areas farmed conventionally, using tillage. Several global initiatives in recent years have focused on

the need of participatory adaptation and large scale adoption of CA to suit diversity of local conditions and constraints to meet pressing food needs.

Considering the need to promote world-wide adaptation of the principles and locally adapted practices of CA, First World Congress on Conservation Agriculture organized in Madrid, Spain 2001, brought together international organizations, farmers' associations, scientific institutions, private sector, non-government and other organizations from more than 70 countries emphasized that *CA has to be considered a theme that cuts across various disciplines, organizations and ministries.* The Congress concluded with an action plan and called upon stakeholders (national and international) to develop and work in partnership, and commit themselves to design, plan and implement action to meet needs of days ahead.

The subsequent Congresses held in Brazil in 2003 and Kenya in 2005 endorsed the conclusions and declarations of earlier Congresses, monitored advances made in the period since the previous conference in terms of technological, institutional and policy imperatives in adoption and spread of CA practices in different agro-ecological and farming system situations. These Congresses strongly reiterated that CA comprising the universal principles of the need for the minimum soil disturbance by adopting direct seeding/planting (zero-tillage), maintaining a permanent cover on the soil surface and multi cropping systems/rotations is the principle road to sustainable agriculture and capable of addressing problems of hunger and environmental crisis while improving quality of life.

The next World Congress on Conservation Agriculture will be organized in New Delhi, India in the forthcoming year in February 2009. It is in this context that a National Consultation is being organized on Dec 11, 2008 to serve as a platform for internal deliberation, discussion, and identification of issues/actions needed to make CA as a basis for directional change in agricultural research for development. This will be done through the involvement of all the stakeholders to help develop a national action agenda.

The need to look to efforts to mainstream CA within the national agricultural research system is coming from many directions with initiatives at the global level offering pointers. With continuously deteriorating resources, widespread problems of soil and water contamination and eroding ecological foundation, sustainability of agricultural activity is becoming highly questionable. CA has emerged as an alternative for a safe and healthy natural resource management system as well as a means to improved agricultural and rural livelihoods. *It is being increasingly recognized and viewed as an entry point for agricultural research and development system to contribute to the much needed paradigm shift from conventional agricultural practices to the evolution of a sustainable agricultural production system based on resource conservation.* This assumes great relevance given the need to sustain productivity in the face of increasing environmental and climate change mediated challenges.

Progress of Conservation Agriculture in India

Over the past 2-3 decades the concept of Conservation Agriculture (CA) has emerged as a way for transition to sustainability of intensive agricultural production systems. CA permits efficient use of scarce resources and management for agricultural production while protecting the resources from processes that contribute to degradation. *CA that*

refers to the system of raising crops without tiling the soil while maintaining crop residues on the soil surface with appropriate crop combinations has emerged as a way for transition to the sustainability of conventionally managed intensive production systems. In India, and other countries of the region efforts to develop and spread CA practices have been made through combined efforts of several State, National level institutions and CGIAR institutions. Efforts to adapt and promote elements of CA have been underway for over a decade but it is only in the past few years that new technologies have started finding acceptance by the farmers. It is estimated that these technologies are being adopted in over one million hectares chiefly in the Indo-Gangetic plains and it is important to draw lessons to thus benefit other regions of the country.

Initial efforts to promote adaptation and adoption of resource conservation technologies in the contemporary sense owes its origin largely to the work of Rice-Wheat Consortium for Indo-Gangetic Plains (RWC), an eco-regional collaborative initiative of CGIAR that commenced efforts in mid nineties. The collaborative initiative involved several international centres (CIMMYT, IRRI, ICRISAT), the national agricultural research systems of four countries of the region (Bangladesh, India, Nepal and Pakistan) and other advanced scientific centres. The initiative was a response to the increasingly expressed concern with regard to sustainability of the intensive rice-wheat cropping system that occupied some 10.5 million ha in the four countries of the region and where sustainability was critical to the food security of the region.

Due to wide variations in biophysical and socio-economic situations across the Indo-Gangetic Plains (IGP), the problems facing farmers varies a great deal across the plains. While in north-west plains (Punjab, Haryana, Western UP) farmers obtain high yields of both rice and wheat crop and farms are mechanized; in the eastern plains, yields are low as is the level of mechanization. While enhancing cropping system productivity constitutes a major challenge in the eastern plains, the north-west region is facing increasing environmental problems arising from excessive use of chemicals, declining water tables, declining soil fertility etc. The practice of zero-tillage has been developed and been adopted by farmers for seeding wheat in the rice-wheat cropping system. The main driving force for the evolution of zero-till seeding of wheat in the system is the long turn around period (3 to 5 weeks) required for tillage operations following the harvest of rice crop that results in delayed planting of wheat, when timely planting of wheat is critical to enhancing wheat/cropping system productivity. The technology that was in the testing phase in late nineties started picking up from year 2000 onwards and in the recent context (2006-07) an estimated 1.5 million ha was planted adopting the technology. *The major driving force for adoption by farmers was reduction in cultivation cost on account of fuel and machinery costs, saved on account of tilling not being carried out.*

Not withstanding the initial success in the adoption of zero tillage for wheat and the associated benefits, there are a number of questions which call for serious deliberations with regard to future strategies to promote conservation agriculture that is being accepted as a way forward to achieve sustainability goals. As such, although zero tillage has been adopted over a significant area for growing wheat there are serious questions on how these initial successes will be sustained and future strategies built upon. Several constraints are already showing up. While the practice has picked up rapidly in the high productivity north-west region where this was initially tested, the spread has been slow in

the eastern region due to a variety of reasons, most importantly, strong variations in respect of socio-economic and edaphic situations and the need for adaptive research backing to be able to find answers to questions which are raised by the farmers. In reality CA's ability to address problems makes it more needed to address needs of rainfed areas, thus bringing into productive use lands that have given up/are giving up on agriculture. While the world over CA has been implemented in rainfed areas, it has yet to show its presence and relevance in these areas in India.

Even in the north-west region there is evidence that farmers who have used zero-till for seeding wheat for 3 to 4 years have a tendency to revert to ploughing the land occasionally or adopting what is being referred to as 'reduced tillage' which implies reduced number of ploughings followed by seeding using the 'no-till' seeding machine. This has largely been on account of a limited pursuit of the elements of the CA component, thus making efforts not complete in a manner of speaking.

Relevance of CA Principles

These basic principles can be applied equally to irrigated and rainfed systems and can be tailored for a variety of field and horticultural crops, though much effort as has been pursued within the Indian context has largely been restricted to the irrigated and better endowed regions. The basic premise is based on accumulated learning which led to the conclusion that combination of intensive soil working (tillage) together with continued dependence on chemical fertilizers as the main and often sole source of nutrients, and low level of biomass restitution to the soil results in progressive degradation of fertility and the physical state of the soil. This is a consequence of both, mechanical damage to the soil (through compaction and structural break down), and decline in soil organic matter content and biodiversity especially when crop residues are not retained. The result is progressively unfavourable physical, chemical and biological (flora and fauna, eg. earthworms) environment in the soil that are vital for processes that contribute to functioning of soil as an effective medium for plant growth. Tillage induced soil degradation also leads to increasing proneness of soils to crust formation and reduced capacity of soils to absorb and retain water needed during drier spells. Reduced infiltration capacity also causes greater runoff, increased risks of soil erosion and catchments degradation.

Reduction in the inherent productive capacity of the soil is often marked by heavier application of chemical fertilizer at ever increasing cost. *In short, the agricultural practices that we have developed and promoted in the past are proving increasingly unsustainable and pointing to the need for emergence of alternate practices that are embodied in the 'Conservation Agriculture' theme.*

Conservation Agriculture approach has the potential to contribute to achieving goals of food security by:

- Reversing the processes contributing to soil degradation
- Reducing use of agrochemicals and environmental pollution
- Improving food quality
- Conserving and enhancing the quality of natural resource and biodiversity
- Increasing farmers' net income and competitiveness
- Sequestering carbon from the atmosphere

Considering leaving crop residue on the field is a practice integral to CA, machines need to be developed to seed the crop in the presence of residues left on the soil. Adaptive work has been done in this regard and machineries are available in the regions through shared or custom hire basis, yet farmers continue to burn the crop residues before planting. There is ample evidence that unless the practice of zero-tillage is adopted in an uninterrupted manner, and supported by continued maintenance of crop residues on soil surface over the years, the much desired benefit by way of improvements in soil quality etc. will not come about. Thus it needs to be appreciated that zero-tillage is but one component of the conservation agriculture approach and when adopted in isolation and over a period of time, is unlikely to contribute to resource improvement.

*It needs to be further realized that adoption and wider adaptation of CA practices calls for a departure from our past approach where technology generation and promotion were viewed as two distinct steps of a linear process. This is in sharp contrast to the real need where farmers and scientists should work hand in hand to define and resolve technology refinement issues that call for adaptive research and is best undertaken in field farming situations***.** It is also clear that research efforts aimed at refining and adapting CA practices under specific farming situations calls for scientists from different disciplinary backgrounds to work as a team to test, refine, adapt, evaluate technologies and define appropriate policy regimes to promote CA working in close cooperation with other stakeholders. *In conclusion it is apparent that to pursue CA efforts effectively, such efforts will need to be linked to a changed thinking in the manner in which we organise our efforts to develop and transmit technologies.*

Transition to Conservation Agriculture

In recent past, several academicians and policymakers have addressed the need for transformation in conventional agricultural R&D. The transition has mostly affected some isolated elements and has not taken a comprehensive CA approach. This too has been achieved with resistance despite all the benefits of production and productivity and cost savings that have been documented and analyzed. The need at this point of time is to understand CA efforts in the Indian context and explore new institutional arrangements to enable CA in India. To arrive at the way forward discussions as proposed to be conducted through the process of National Consultation will help identify institutional changes and approaches to mainstream CA. To make the effort purposeful, it will be important to facilitate the needed transition by building on the current expertise of key stakeholders as indicated in the table on the following page:

Table 2: Stakeholders role and requirement for transition to CA

Research System (ICAR institutes, SAUs)	**Farmers**	**Extension Systems**	**Private Sector**
○ Strengthen socio-economic research: monitoring, evaluation, policy ○ Strengthen Farm Machinery research /development ○ Work in multidisciplinary teams with the farmers ○ Strengthen adaptive research through participatory approaches ○ Build and work in partnership with a range of stakeholders, private, public ○ Build strong backing of disciplinary/ interdisciplinary research ○ Understand longer term implications of new approaches ○ Strengthen information sharing ○ Undertake intensive HRD programs ○ Strengthen funding substantially	○ Viewed as reservoir of indigenous location specific knowledge ○ Enabled to organise themselves into groups and be able to articulate their experience and knowledge needs ○ Must be viewed and enabled as partners in defining research agenda, and developing and promoting new technologies and farming practices	○ Greatly strengthened capacity in resource management and monitoring ○ Enhanced understanding of CA principles ○ Greater exposure to similar situations/ ecologies adopting CA approaches ○ Greater ability to organize farmer groups, articulate issues of gender ○ Better equipped with farm machinery issues ○ Role should not be one of being just a 'mid-wife' but one who are active partners in conceiving science agenda, adapting new technologies , influencing policy and promoting technologies.	○ Viewed as important stakeholders in accelerated development and advancement of technologies ○ As effective agents of change/ extension of technologies ○ Encouraged to be partners in R for D efforts

Annexure

Discussion Points for National Consultation

Being more than just a farming practice, CA embraces a holistic concept of agriculture and is best implemented at watershed level in order to capture all potential benefits. Outlining a road map towards the goal there is a need to address key issues as below:

- Institutionalizing the role of research, extension and farmers in a manner that partnership among these stakeholders is strengthened through all stages to build a sense of ownership among them. This would need farmer participatory research approaches to develop, adapt and extend CA practices with full support of scientific community.
- Developing and spreading awareness of virtues of CA to society, highlighting benefits of resource conservation, environment, climate change mitigations, economics. Exchange and sharing of information nationally and internationally would also be important.
- Promoting integrated crop-livestock CA systems and other means of minimizing conflict of demands on crop residues through better understanding of farming systems.
- CA has to be linked with appropriate agribusiness strategies to increase employment in areas where it is adopted. At the same time looking to needs of mechanisation, a system of affordable custom hire must be encouraged for improved availability on an affordable basis. Adaptation of such mechanisation to needs of women, small farmers, and those in hill regions would also have to be understood.
- Helping evolve a more relevant research and extension system more in tune with changing needs of today's farmers. HR evaluation within the agricultural research system should consider qualitative and not just quantitative parameters of a professional's performance to ensure their professional growth.
- Strengthening of social science research to identify barriers, assess impact, and highlight policy issues for wider adoption need to be taken up. CA adoption will thus call for greatly strengthened monitoring and evaluation practices along with policy support in favour of "green" practices.
- Supporting policy development for bringing about a paradigm shift necessary to improve adoption of CA practices by farmers, technicians, educationists and policy makers. This will require a correction of policy imbalance promoting non eco-friendly technologies.
- Need for new funding arrangements and public-private partnership mechanisms encouraging scientists, farmers and the business community to work for mutual gain, within a more responsible framework of agriculture pursuit.

- Generating an extensive resource database with agencies working in unison to address the cause of sustainable agriculture. Besides resources, an understanding would need to be developed relating to the role of socio-economic, environmental and institutional factors in relation to CA.
- Emphasizing CA as a strategy to address needs of international conventions such as Convention to Combat Desertification (CCD), Convention for Biological Diversity (CBD), and as a strategy for mitigating global warming and promoting carbon sequestration.

These are some of the measures that need to be articulated in the national context and appropriate steps taken to address them through deliberations at the proposed National Consultation.