GOVERNMENT OF ANDHRA PRADESH
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FICCI

international conference-cum-exhibition on

Food 360°

Agribusiness and Food Processing

Seeding Success through Innovation and Technology

NOVEMBER 5-6, 2012
HOTEL TAJ KRISHNA, HYDERABAD

KNOWLEDGE PAPER

KNOWLEDGE PARTNER

ICRISAT
Science with a human face

Seeding Success through Innovation & Technology

Role of Innovations in Transforming Indian Agriculture

ICRISAT & FICCI

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Message from the Conference General Chair

FICCI Andhra Pradesh State Council is organizing the 2nd edition of FOOD 360: International Conference on Agribusiness and Food Processing on November 5-6, 2012.

The second edition of FOOD 360 is of particular significance as it is focused on Innovation and Technology. I firmly believe that innovation and technology in Agriculture and Food sector will drive the future of our country and world at large.

The key challenge is to encourage and enhance agricultural innovations. Presently, there is a need to understand and examine the process of innovation in Agri and food processing sector. We believe that marketing plays a phenomenal role than production. It increasingly drives agriculture and food processing development. Hence, we need to adopt changing approach for support and encouragement to agricultural innovation.

The conference will try to look into additional insights and types of innovations that can be derived from an innovation and technology perspective that can influence the present and future generations and use of Innovation, Information and Technology for agricultural development in India.

In this background, I am happy that FICCI has taken a lead in organizing this conference in Andhra Pradesh again in the year 2012. I am sure the participants will be benefited out of the Conference deliberations and Exhibitions.

We hope this report will encourage a greater participation by Indian & International companies in the Agri and food processing sectors.

We hope this report will be useful and look forward to your inputs and feedback.

J A Chowdary
Conference General Chair - FOOD 360
Co-Chair, FICCI AP State Council
& Executive Chairman - Talent Sprint

Message from the Programme Chairman

The agriculture, agribusiness and food processing sectors covered under the label 'Food 360' are probably the most vital sectors to India, given their role in providing livelihood opportunities to more than half the population and food & nutrition security to the entire nation.

While tremendous progress has been achieved across all these sectors from the days of 'ship to mouth' existence to becoming a leading 'agri products exporter', further potential is immense. There are also new challenges such as dwindling bio-diversity and declining natural resources, while the pressure on growing more food is ever-increasing.

The key to realizing this potential, by overcoming the challenges posed, lies in leveraging technology and innovation. For the desired outcomes to occur in a complex system like agriculture and food, it is not enough for such innovation to take place in islands of excellence. The innovation has to be synchronized across the whole ecosystem.

For synchronized innovation to occur, a shared vision among all the stakeholders is critical, supported by a conducive policy environment.

I am sanguine that this report specially prepared by ICRISAT for the second edition of FICCI Food 360, together with the Conference and Exhibition, will play a catalytic role in evolving such a shared vision and in turn laying a strong foundation to build a vibrant innovation ecosystem for the benefit of consumers, producers and the industry.

S. Sivakumar
Programme Chair, FICCI FOOD 360 &
Group Head - Agri & IT Businesses, ITC Limited

ICRISAT Science with a human face
International Crops Research Institute for the Semi-Arid Tropics

Office of the Director General

Message

The International Crops Research Institute for the Semi-arid Tropics (ICRISAT) has been involved with FICCI, Andhra Pradesh Chapter, since the Inaugural session of Food 360° as Knowledge Partner. We are happy to continue with this association in the present edition of Food 360°- a two day International seminar on Agribusiness and Food Processing with the theme: "Seeding Success through Innovation and Technology".

Recently ICRISAT celebrated its 40th Anniversary marked by exploration of opportunities for inclusive and sustainable development to finally surmount the twin challenges of global hunger and poverty in the dryland tropics. During the Anniversary celebrations we took the opportunity to reflect on our strategy, priorities and progress. We sought the expertise of leading stakeholders through a science symposium focused on the question *"How can smallholder farming feed the world and promote economic growth?"* We chose this question because it relates closely to our institutional strategy of '*Inclusive Market Oriented Development' (IMOD)*.

These discussions brought forth the need for policies and institutions supportive of smallholder agriculture, getting more from less land, enhancing the income levels of female farmers in order to improve child nutrition and health, providing access to financial assistance to help more smallholders adopt value chain innovations, providing farmers with access to information about weather, soil diagnostics, water, improved technologies. In this manner we will promote "resilient development" in order to make the smallholder agriculture increasingly productive, linked to commercial markets, sustainably implemented, and resilient to shocks, especially climate change. This also leads us to understand that the agricultural research-for-development community must become more effective in scaling-up innovations for wider impact, and must learn faster in a world in which knowledge is advancing at an ever-accelerating pace.

ICRISAT believes that this edition of Food 360° with the theme *"Seeding Success through Innovation and Technology"* addresses the important issues mentioned above and explore, deliberate and bring forth ways and means to promote agribusiness and food processing especially benefitting the small holder farmers and entrepreneurs, thus enabling IMOD.

We appreciate this initiative and thank FICCI for involving our Institute as a Knowledge Partner to produce this study. I am sure that the conference and this report shall provide all the stakeholders with an understanding of the important prerequisites, mechanisms and technologies required to establish an adaptive agricultural innovation system, one that will seed success through innovation and technology, and ultimately benefit the small holder farmers and the millions who depend on the sector.

With that, I wish you all much success in this activity and more power to FICCI!

William D. Dar
Director General

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1. Background

Agriculture remains the most important sector for India, vital for ensuring its food and nutritional security. From an economic perspective, the sector provides livelihood means to over 58 percent of the nation's population, while contributing 14 percent to the Gross Domestic Product (GDP) by providing bulk of the wage goods required by non-agriculture sectors, and most of the raw materials for the industries. The Green Revolution and the transformation it brought about to this sector helped in easing poverty, and proved that agricultural development has a direct role in improving the livelihood of the people and the society.

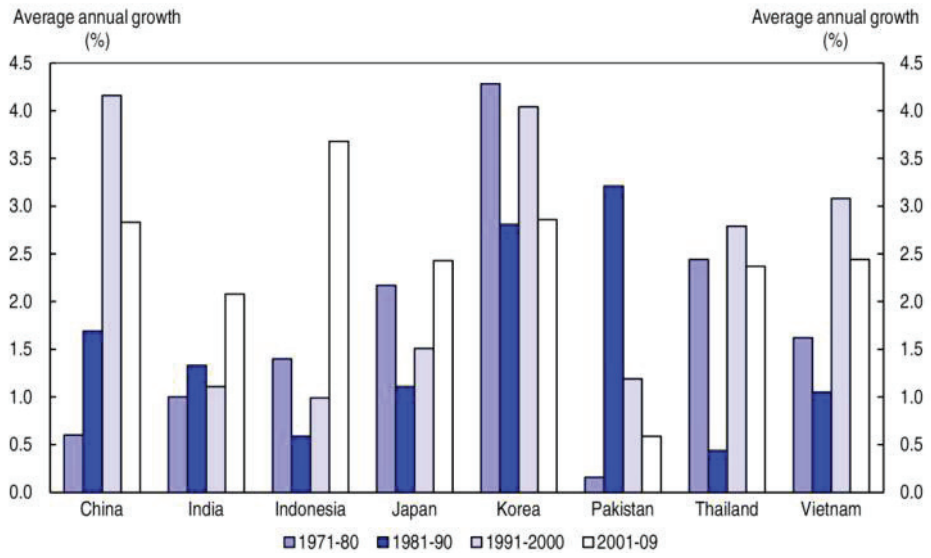
However, despite its importance, various indicators from the sector show that all is not well. Across the world, the challenges facing the sector are immense: declining natural resources, smaller landholdings and lesser area for cultivation, erratic monsoons, climate change crisis, energy crisis, loss of biodiversity, weak extension machinery, rising input costs, inadequate storage infrastructure, high post-harvest losses, and lack of access to markets. There is also an urgent need to promote the competitiveness of this sector and gearing up our agricultural systems including technological aspects so as to meet the pressures of consumer demand and international markets.

Food grains production in India touched an all-time high of 257.44 million tonnes in 2011-12, but inadequate storage infrastructure means that much of it is left to rot at a time when India holds the dubious distinction of having one of the highest prevalence (over 50 percent) of under nutrition in the world[1]. This is also happening at a time when the cost of the basket of essential food items has increased by 30 percent to as high as 200 percent (e.g., the recent onion crisis) leading to food shortage crisis. In India, people spend more than twice the proportion of their income on food than UK residents who spend an equivalent of £10 for a liter of milk and £6 for a kilo of rice[2]. Productivity is declining within the sector - unevenly across the country due to structural anomalies in land availability, population spread, off-farm employment opportunities, weak research & development (R&D) domain, and lack of access to modern agro technologies.

There is a widening gap in terms of the growth amongst the three sectors of the economy, with the GDP of agricultural sector declining from the highs of 40 percent to less than 15 percent currently. While this can be explained by a fast growing and structurally changing economy, it also shows that the growth in this sector has been much slower owing to the modest growth in the total factor productivity (TFP), and in particular weak labour productivity[3] (**Figure 1**). The Global Hunger Index (GHI) for India is classified as alarming and has remained stagnant over the period of 1995-97 to 2008-10 at a time when the gross national income (GNI) per capita almost doubled[4]. China in the same period has been successful in bringing down its score to low category. While other African countries are also facing an alarming situation, the GHI score does shed light on the fact that even with economic growth, inaccessibility to quality food produce is prevalent across all sections of the population. This could be a reason for the low productivity levels.

[1] Indian National Science Academy (2009), 'Nutrition security for India–Issues and way forward'.
[2] Oxfam (2011). 'Growing a better future'.
[3] OECD 'Better Policies' Series (2012). 'India: Sustaining high and inclusive growth'.
[4] IFPRI (2012)

Figure 1. Agricultural TFP growth



Source: Fuglie, KO (2012) in OECD[5]

Considering that the labour force engaged by the sector is high, such inequality in terms of wealth creation and distribution will adversely impact the societal fabric of the country. There is already a lack of interest among the rural youth in engaging with agriculture as a livelihood option, where most are migrating to the cities in search of a better standard of living. A recent survey of the National Sample Survey Organisation (NSSO) shows that 45 percent of the farmers, if given the chance, would not continue farming.

Declining productivity, smaller landholdings, and escalating input prices puts a premium on the produce that goes out from the farm gate. Reduction in marketable surplus (MS) will, therefore reduce the returns to the farmer that cascades into reduced purchasing power, lesser demands for finished and processed products, which in turn affects the production and outputs of other sectors of the economy, and finally slowing down the economic growth. Farmers are now shifting to crops that are considered high value, including spices, plantation crops and exotic vegetables to overcome the situations. However, without adequate infrastructure and improved technological advancements, this endeavour mostly forces the farmers into agrarian debt.

The technology diffusion mechanism for the agricultural sector in the country is through the National Agricultural Research Systems (NARS) of the Indian Council of Agricultural Research (ICAR). The technology system has not been able to make any new breakthrough in agriculture since the Green Revolution[6]. According to a Planning Commission review, low productivity since the 1990s has been linked to weak support systems of non-responsive agricultural research, broken-down extension mechanisms, and inadequate seed production, distribution and regulation. India currently invests only 0.4 percent of its agricultural GDP in R&D. While it is 0.7 percent in other developing countries, China invests close to 1 percent, and Brazil invests 1.8 percent when compared to 2-3 percent in the developed countries. This show that the Government has been under-investing in the sector which can offer high social returns besides

[5] OECD 'Better Policies' Series (2012). 'India: Sustaining high and inclusive growth'.
[6] Ministry of Finance (2011). 'Economic Survey Report 2010-11'.

offering scope for diverting incremental outlays to priority areas in research. The involvement of the private sector research in agriculture has concentrated on few crops and emerging areas of biotechnology and seed industry where the profit levels are high. However, the current system benefits only a handful of large farmers.

With the opening of the economy in 1991 and advent of globalization and the Information & Communication Technology (ICT) revolution, India is no longer insulated from the shocks occurring in the world economy. The integration of the domestic and international markets led to an influx of agri-commodities into our market that led to lowering of prices. At the same time, the cost of cultivation remained high and the Government had to shield the farmers from this imparity through high subsidies, thereby rendering the sector non-competitive. Even though IT has transformed the economy of the country, it has so far not helped in improving the agricultural landscape and removing the information asymmetry and lack of price discovery in the sector. Due to the volatilities in the external markets, uncertainties in cultivation increased and misleading price signals on specific crops was also noticed leading to adoption of economically unviable and ecologically unsuitable cropping patterns (**Box 1**). The uncertainties extended to the sub-sectors also.

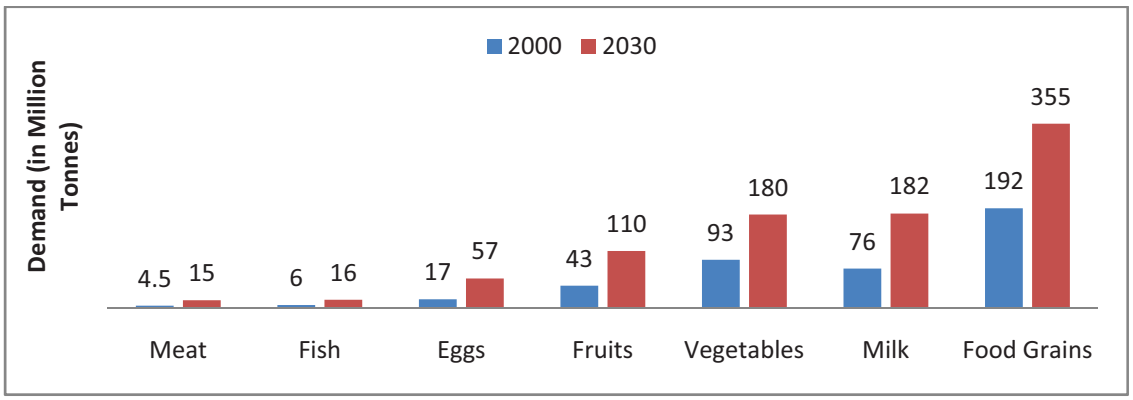
Box 1. Volatility in pricing and market information

The rapid adoption of vanilla crop in upland Kerala was due to the increasing prices for vanilla at a time when prices of all the other major crops grown in the region were falling. The domestic price of vanilla which in 1995-96 was Rs.2,000 per kg touched Rs.8,000 per kg in 2001-02. During 2002-04, the domestic price shot up to Rs.15,000 per kg, due to a fall in production of processed vanilla owing to a cyclone in Madagascar. Once the production resumed and increased in Madagascar by June 2004, the vanilla prices fell sharply to Rs.1,618 per kg in January 2005. Many farmers, who had replaced their coffee plantations with vanilla, were left helpless as a switch-back to coffee would have involved another gestation period of at least 3 years.

Source: ASSOCHAM (2011)

At the same time, there are multitudes of opportunities that can spur the growth of the sector and improve the livelihood of millions and the many stakeholders that depend on it. There is an increasing demand for food and processed commodities due to growing population and rising per capita income. Chand (2009) estimates an annual growth in per capita income by over seven percent and population growth of 1.2 percent. There are projections that demand for food grains would increase to 345 million tonnes in 2030 (**Figure 2**). Hence in the next 20 years, production of food grains needs to increase at the rate of 5.5 million tonnes annually. The rise of the middle class income of the country has also increased the demand for high-value processed food products. There is diversification in the food consumption basket with the consumption expenditure on cereals accounting to only 15 percent of the total amount of money spend on food and food products, which still accounts for nearly half of the expenditure by an average household. In fact, the demand for high-value commodities (such as horticulture, dairy, livestock and fish) is increasing faster than food grains and its demand is expected to increase by more than 100 percent by 2030. The domestic food market is expected to grow by up to 40 percent of its current market size by 2015.

Figure 2. Projected food production demand at 2030 vis-a-vis 2000



Source: ICAR Vision 2030

Advancements in the ICT sphere has brought in a new dimension to generation and sharing of knowledge while making far markets within reach of the producer. This *global village* concept means that nations have to remain competitive in all sectors in a globalizing market. The social and economic landscape of the sector is undergoing many changes in this era, where new roles have been defined for the state, private and civil society. The future growth models should take full advantage of the potential of ICT in improving access to knowledge and facilitate quicker trickledown effect amongst the actors, making an impact on the development of the sector.

The way forward, therefore, will be on how to improve the productivity of the sector while ensuring that the growth is inclusive and sustainable. Agricultural development plays an important role in fostering development in the rest of the economy through various linkages between it and other sectors. For very poor households, agricultural development is not only a defense against hunger but can also raise their incomes by nearly four times more effectively than the growth in any other sector. Research done by IFPRI in many countries, and recently in Africa shows that investments in R&D have the highest impact on agricultural growth per million rupee invested. A review of literature reveals that every dollar of additional value added in agriculture generates another 30-80 cents in second round income gains in other part of the economy, showing that agriculture is indeed the motor for economic growth.

Indian agriculture needs to shift towards a more market-oriented system rather than the traditional subsistence mode. Modern agriculture involves multiple actors in the development process, and the focus is shifting from plain agricultural production to development of value chains within the sector, thereby enabling multiple models in the same chain. It has also led to the farmers becoming entrepreneurs, and small-scale agribusiness ventures gaining momentum; but many tend to fail since support systems are not accessible and system not fully tuned to their needs.

The advancements made through the Green Revolution showed that with the right mix of the political will, bureaucracy, scientific minds and farmers, productivity from the sector can be improved. It also showed that reduction of poverty can also be achieved through agriculture. The future course of agricultural growth will have to happen within the constraints faced by the sector, and needs a mechanism that brings together the public and private players to advance new agro-technologies and reach out to the farmers. Innovative partnerships and ways to address the diverse needs of the actors in the domain have to be designed.

Given these existing conditions, agricultural development demands and depends on innovation and innovation systems. If farmers, public and private ventures, and even nations are to cope, compete and sustain in the midst of the global economic changes, innovation is crucial. Innovation is widely recognized as a major source of improved productivity, competitiveness, and economic growth throughout advanced and emerging economies. Innovation also plays an important role in creating jobs, generating income, alleviating poverty, driving social development and allows for a dynamic interaction among the many diverse actors involved in the entire agricultural value chain. The innovation systems concept is attractive not only because it offers a holistic explanation of how knowledge is produced, diffused, and used, but because it emphasizes the actors and processes that have become increasingly important in agricultural development.

1.1 Need for an Agricultural Innovation System

Change is the underlying theme of this century, and it applies to all sectors. Agricultural development plans are no longer concerned with food production. These plans now give far more attention to diversification into new crops, products, and markets and to adding value to serve new markets better (Bhargouti et al. 2004). Modern agriculture is operating within an ecosystem that is always in a constant state of flux in terms of production, trade and consumption behaviours; dominated by market forces; private sector playing a vital role in dissemination of knowledge, information and technology with ICT being the pivotal driving force; and agricultural development taking place in an increasingly globalised domain. These changes are being driven by rapid urbanization and by increased integration of many developing countries into global markets for agricultural products and services. Adding more complexity to the scenario, agriculture is increasingly moving away from production-oriented mode and getting integrated into a value chain mode which has many actors and entities in its forward and backward linkages.

Urban markets often cause supply chains to grow longer; in turn, shelf-life, handling requirements, and other market requirements assume greater importance for agricultural products. Before reaching the end consumer, the produce may pass through the hands of several agents and more value may be added in the food processing stage than in production. New bulk or niche markets may appear. Agricultural production is increasingly based on a wider range of inputs that must be combined and used judiciously within an ecosystem of climate change, and limited natural resources to arrive at sustainable production systems. The issues surrounding agriculture (as elaborated earlier) like poverty, labour and water productivity, post-harvest management etc. can all be addressed through the growth of the value chain. Each of the links in the *production-to-consumption* systems thus provides scope for income generation, growth of the individual and economy and opens up new opportunities for further innovations to happen. For innovation to occur in the agricultural sector, the interactions amongst the actors needs to be facilitated and has to draw upon the most appropriate available knowledge and partners (**Box 2**).

Box 2. Examples of agricultural innovation and innovation process

The cases shown here, highlights the importance of taking collective action, having the benefit of facilitation and coordination by intermediaries, building a strong skill base, and creating an enabling environment. The actors' (either market, private, public sector) ability to improve their interactions and strengthen their links to one another proved crucial to their success. Policies, R&D and other incentives were also key.

- *Cassava-processing innovation system, Ghana:* Research-led development and promotion of new cassava products with a private sector coalition.
- *Cut flower innovation system, Colombia:* Continuous innovation in response to changing markets, using licensed foreign technology and coordinated by an industry association.
- *Medicinal plants innovation system, India:* Mobilization of traditional and scientific knowledge for rural communities, coordinated by a foundation.
- *Golden rice innovation system, global:* Complex partnership of multinational companies, international agricultural research organizations, universities, and development foundations; complex but creative institutional arrangements over ownership; innovation targeted to poor (nutrient-deficient) users.
- *Potato, Peru.* Facilitation by an international research center of the development of new indigenous potato products with a coalition of researchers, smallholders, and multiple private actors (including supermarkets, traders, and restaurants).

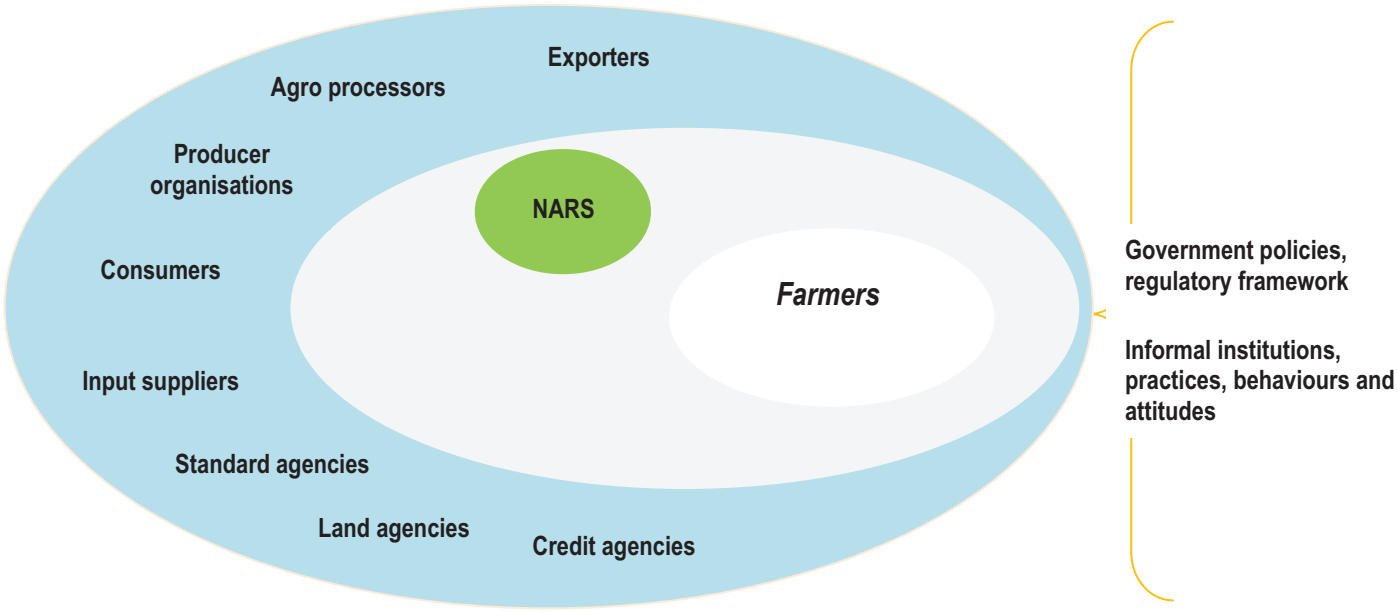
Source: The World Bank (2012)

It also depends on a platform that allows for collective action, trust, coordination and exchange of information amongst the players, incentives and resources available to join alliances, partnerships and businesses and finally allow for an inclusive growth approach that provides for growth of farmer-entrepreneurs and enables them to use such innovations. This market-led agricultural development relies more strongly on the private sector and on the interaction of agriculture with other sectors and disciplines. Since the new markets for agricultural products and services change continuously, agricultural development will have to depend upon a process of continuous, incremental innovation. The scope of innovation includes, not only technology and production, but organizations (in the sense of attitudes, practices, and new ways of working), management, and marketing changes. Ways of producing and using knowledge must also adapt and change. The innovation systems concept emphasizes adaptive tendencies as a central element of innovation capacity.

Converting the results from R&D domain to the farms requires an ecosystem of enterprises working in conjunction: entrepreneurs, researchers, finance providers, business enterprises and policy-makers. Modern agriculture needs an interactive, dynamic, flexible innovation ecosystem.

The Agricultural Innovation System (AIS) is a platform that looks at addressing this current need that can engage with all the players (**Figure 3**). The AIS concept extends beyond the creation of knowledge and accepts the totality and interaction of the many actors involved in innovation, by encompassing the factors affecting demand for use of knowledge in novel and useful ways, making it more productive and self-evolving.

Figure 3. Agricultural Innovation System (AIS)



Source: The World Bank (2012); modified

AIS allows for a new business environment that enhances the interaction of individuals and organizations possessing different types of knowledge within a particular social, political, policy, economic, and institutional context. It brings actors together in their desire to introduce or create novelty or innovation into the value chain, allowing it to respond in a dynamic way to an array of market, policy, and other signals. The perspective provides a way of planning, in order to create and apply new knowledge required for the development, adaptation, and future profitability of all the actors in the value chain and sustainability of the sector.

Table 1 highlights key features of the AIS and also compares it with other previous agricultural development approaches like the NARS and the Agricultural Knowledge and Information Systems (AKIS). It can be seen that, across various parameters, AIS allows for a more holistic approach that allows for a greater degree of integration with the agricultural production systems and value chains, while strengthening the role of the actors in the system. The capacity for innovation also underscores:

- Actors in the innovation system and their respective roles
- Attitude and practices of these actors in the value chain
- Pattern of interaction amongst the actors
- Enabling environment for generation of innovations and knowledge that can used by the farmers.

Table 1. Key features of various Innovation System frameworks

Feature	NARS	AKIS	AIS
Purpose	Planning capacity for agricultural research, technology development and technology transfer	Strengthening communication and knowledge delivery services to people in the rural sector	Strengthening the capacity to innovate throughout the agricultural production and marketing system
Actors	National agricultural research organizations, agricultural universities or faculties of agriculture, extension services and farmers	National agricultural research organization, agricultural universities or faculties of agriculture, extension services farmers, NGOs, and entrepreneurs in rural areas	Potentially all actors in the public and private sectors involved in the creation, diffusion,, adaption, and use of all types of knowledge relevant to agricultural production and marketing.
Outcome	Technology invention and technology transfer	Technology adoption and innovation in agricultural production	Combinations of technical and institutional innovations throughout the production, marketing, policy research, and enterprise domains.
Organizing principle	Using science to create inventions	Accessing agricultural knowledge	New uses of knowledge for social and economic change
Mechanism for innovation	Transfer of technology	Interactive learning	Interactive learning
Degree of market integration	NIL	Low	High
Role of policy	Resource allocation, priority setting	Enabling framework	Integrated component and enabling framework
Nature of capacity strengthening	Infrastructure and human resource development	Strengthening communication between actors in rural areas	Strengthening interactions between actors; institutional developments and change to support interaction, learning and innovation; creating an enabling environment.

Source: The World Bank (2006)

The following sections highlight how AIS can be developed that allows for an innovation ecosystem, and how the changes induced by the market forces can be structured and suited to benefit the farmers and millions that depend on the sector. A section is also devoted to understanding the key drivers, technologies and processes that shall foster innovation in agriculture and food processing sector.

2. Fostering Innovations in Indian Agriculture

Given the changing context of the agricultural sector-from a traditional, subsistence mode to market-oriented, value chain approach, it is imperative to keep innovation as the engine that allows the sector to operate in most efficient, yet inclusive and sustainable manner. The role of agricultural science and technology assumes a greater importance in addressing the challenges facing the sector, with added emphasis on the inclusiveness of the rural poor in the development process. The paradigm shift that is already being felt in the sector needs to ensure the participation of all the actors in the sector to ensure that the innovation capacity to generate demand-driven interventions is sustainable.

Innovations do not happen in vacuum, but occur more due to the interaction at various levels and players. As discussed earlier, AIS approach allows multiple stages of interaction between many actors in the agricultural value chain. This inherent interactive nature of the system helps in creating and applying the new knowledge, along with institutional innovations that will further the growth that nurtures new ideas and techniques that can lead towards prosperity of the sector, utilising the resources in the most optimum manner. This interactive nature, however needs to be enabled and nurtured, given the number of actors and their pattern of activity, practices etc; ability to form formal and informal partnerships to achieve economies of scale and better utilisation of resources; and the ability of the system to respond to emerging market opportunities and incentives.

Although, there are many areas to be covered while creating an innovation ecosystem, the focus of this section will be limited to how innovations can reach out to the market and the bottom of the pyramid through small and medium entrepreneurial ventures; how the vast agri research and education network under the ICAR can be leveraged upon for bringing in institution and technological innovations; the role of markets, modern food value chains, and how smallholder farmers who make up the majority of the Indian agricultural sector can be linked to it and derive the benefits from the technological advancements to attain better income; and how policies and Intellectual Property Rights (IPR) play a crucial role in maintaining and advancing the innovation levels within the sector. In each, the role of the private, public, and civil society will also be looked at.

2.1 Agribusiness, Business Incubators & Innovations

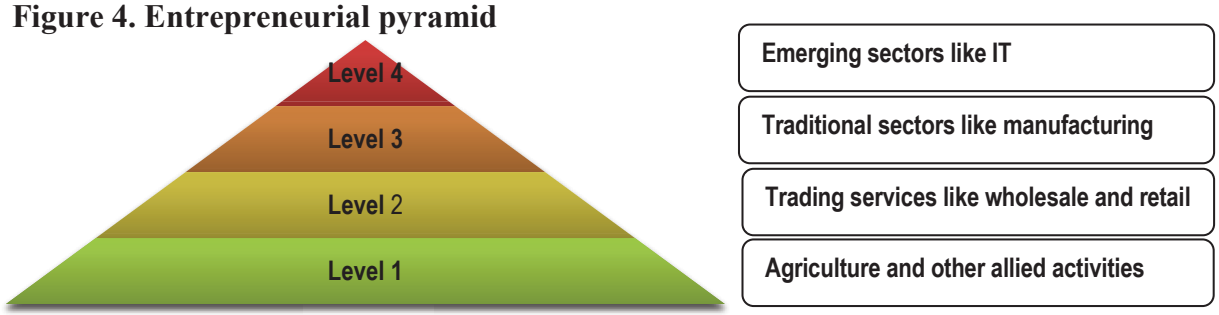
Entrepreneurship employs "*the gale of creative destruction*" (Schumpeter, 1942) that will replace in whole or in part, inferior innovations across the market space and industries while creating new business models at the same time. Globally, entrepreneurs and Small & Medium Enterprises (SMEs) have helped in the development of many of the economies. The dynamism generated through innovations and new combinations of existing means of production leads to changes in status quo.

Using local resources including manpower, entrepreneurs engage in ventures that address the needs of the local economy, and later at a bigger market scale. This fosters conditions that will result in increasing employment opportunities (predominantly for skilled labour), creation of more wealth and savings (crucial for the population at the bottom of the pyramid), application of new technology, and changes in lifestyle. An entrepreneurial venture generates employment and income into the local economy; this economic cycle and the generation of demand and supply from

the local economy outward leads to more value creation and ventures and thus acts as a catalyst bringing in structural changes and supporting the growth of the economy and national competitiveness[7]. Formal SMEs contribute up to 45 percent of employment and up to 33 percent of the GDP in developing economies; these numbers become significantly higher once the contributions from the informal sector SMEs are also added[8].

The entrepreneurship pyramid in India (in terms of sectors and numbers of people engaged) is made up of four levels[9] (**Figure 4**). Levels 2 and 3 of the pyramid comprise the traditional areas of entrepreneurship. Level 4, on the other hand, is an emerging/ modern sector of entrepreneurship with high growth rates. In future, we may expect a broadening of Levels 3 and 4 with the activities from Levels 1 and 2 migrating to the other levels due to better livelihood opportunities.

Figure 4. Entrepreneurial pyramid



Source: Entrepreneurship in India, A study by National Knowledge Commission, GoI

It should be noted here that activities in Level 1 are considered more subsistence rather than business-like unlike other three levels. It is, thus clear that to retain and remain competitive in the globalised era, Indian agriculture will need to have an ecosystem that promotes entrepreneurship amongst farmers that fosters an innovation climate in the sector.

Given the potential of entrepreneurship to make an impact on the agricultural sector and the rural economy, it is one of the better solutions to meet the many challenges of the sector. Agribusiness will also enable a climate of innovations in the sector that can help in not only refining the agro-technologies from the research stations but also evaluating new local technologies that are generated at any point in the value chain, which can then be scaled up. There are several avenues in the agricultural and allied sectors for agribusiness start-ups and private sectors to operate like seed business, farm ventures like contract farming, organic farming, bio-parks, processing sectors, agro-biotechnology, supply chain management etc.

Modern agriculture and its market demand-driven approach offers plenty of scope for agribusiness ventures to be setup at any point on the long food value chain. However, there are many ventures that are also being marginalised in the long run through lack of access to resources and the market. Given that agribusiness ventures are played out in a live and at times unpredictable environment involving natural and artificial entities, it faces the following challenges.

[7] 2010 Global Report, Global Entrepreneurship Monitor. Retrieved on June 2, 2011 from http://www.gemconsortium.org/download/1315900429045/GEMpercent20GLOBALpercent20REPORTpercent202010rev.pdf
[8] IFC, 2010
[9] National Knowledge Commission, Government of India (2008). 'Entrepreneurship in India'.

Challenges to entrepreneurship in agriculture

- **Motivation:** Agribusiness is a challenging field with considerable risks and varying returns, which might take many years to be realised. The difficulty in accessing credit for agribusiness ventures in the initial stages, government clearances, regulatory issues etc. can be major deterrents for a newcomer. This is further exacerbated by poor management skills, lack of access to raw materials and inadequate scientific knowledge. It is very important that the motivation of the entrepreneur is nurtured and strengthened in these negative circumstances.
- **Knowledge:** The entrepreneur should be able to access relevant information regarding the nature of the business and its social and financial benefits. Apart from the scientific and technical details, the entrepreneur should also be equipped with knowledge of financial management, people management and should be aware of the government policies, regulatory issues that can have a bearing on the start-up venture. Networking also plays a vital role in ensuring the viability of the firm and in getting entry into the market.
- **Skills:** It may not be possible for entrepreneurs to have all the skills required by their respective enterprise; however, they need to possess certain generic skills required for any entrepreneur, including self-motivation, self confidence, work ethics, time management, administrative skills, and knowledge of sales, marketing, and finance, and other skills specific to their own venture. Currently, the avenues available for an Indian entrepreneur to acquire skills through adequate training and/ or hand holding support in agri-business ventures are very limited.
- **Market/Business development:** In today's competitive scenario, marketing and selling one's product is not an easy task. The challenges involve finding a suitable market, developing the marketing channels, and reaching the end consumers. Be it an existing or a developing market, these are formidable challenges faced by any entrepreneur. These issues are all the more compounded in case of an agri-business venture, as there is limited support to new entrepreneurs in terms of availability of information about markets, prices, networking etc.
- **Regulatory issues & Business environment:** The Indian regulatory scenario poses several difficulties for entrepreneurs. For example, entry into the domain of contract farming is restricted by the State Agricultural Produce Markets Regulation (APMR) legislation. Similarly, restrictions on marketing, futures trading, export and import of various items has the potential to constrain innovative agribusiness ventures. Business facilitation environment within the country is yet another challenge. Access to relevant information and quality infrastructure is lacking and this leads to additional costs for the entrepreneur. **Table 2** highlights the extent to which entrepreneurship development gets discouraged in the country vis-a-vis other developing and developed countries. Such an environment reduces the capacity for innovation.

Table 2. Doing Business Report

Parameters	India	Singapore	USA	Korea	South Africa	Spain	Argentina
Ease of doing business*	133	1	4	19	34	62	118
Starting a business*	169	4	8	53	67	146	138
Number of procedures for starting a business	13	3	6	8	6	10	15
Time taken for starting a business (days)	30	3	6	14	22	47	27

** Rank from 181 countries*
Source: The World Bank (2010); modified

The ease of doing business clearly outlines the predicament faced by entrepreneurs in the country. The table also shows how many procedures have to be completed and the time it takes for an entrepreneur to just start a venture in India.

- **Finance & Risk mitigation:** The development of agribusiness and agro-industries will require a substantial infusion of fixed investment and working capital. Early stage start-ups generally find it difficult to get access to finance and it is all the more difficult in agribusiness ventures, as potential investors look for high returns on their investment. Public sector banks look for adequate collateral and credit worthiness of the entrepreneur before funding and are generally risk averse. The risk mitigation mechanism is also not well developed in the sector, thereby leaving agripreneurs and farmers in a difficult position.

It is in this context that the role of the business incubator becomes relevant in meeting the challenges indicated above and help in nurturing and promoting entrepreneurship, thus developing an ecosystem that is conducive for technology development and innovations in the sector.

Business Incubators

Start-up companies are particularly vulnerable in their early stages of growth since the business environment is generally risk averse and there is not much option for testing one's idea due to lack of funds, technical support, networks and infrastructure. Studies show that worldwide, while 66 percent of new start-ups survive after two years of starting, it reduces to 44 percent after four years. OECD study shows that over 70 percent of start-ups wind-up their operations by the seventh year of their operation.

Business Incubators like the Agri-Business Incubation (ABI) program at ICRISAT (**Box 3**) provide an attractive framework to entrepreneurs (referred to as incubatee/client) for dealing with the difficulties faced during start-up stage. Business Incubators help in creating the links that connects the SMEs with public and private sector, facilitates in bringing together diverse partners required to develop and deploy new agro-technologies, and help in attaining sustainability and scalability for the start-up ventures. Business Incubators occupy the space between mechanisms such as business development services, technology parks and other business development platforms. With a core focus on emerging enterprises, incubators provide the much-needed backup to small and new firms by providing numerous business support services and they are useful in fostering technological innovation and industrial renewal[10]. They can be viewed as a mechanism:

- to support regional development through job creation,
- for new high tech venture creation, technological entrepreneurship, commercialization, and transfer of technology,
- to deal with market failures relating to knowledge and other inputs of innovative process.

Box 3. Incubating Success

The **Agri-Business Incubation (ABI) Program at ICRISAT** was started in 2003, as joint venture between ICRISAT and DST, GoI. ABI program offers agripreneurs with scientific and technical backstopping with state-of-the art infrastructural facilities.

Apart from the regular services, ABI also provides specialized incubation services like funding innovations and softlanding for foreign agribusiness firms who wish to setup base in India. ABI works on five thematic areas including Seed business ventures, Bio-fuels ventures, Farming ventures, Agri-biotechnology ventures and Innovative ventures.

So far, ABI has incubated 165 agribusiness ventures, helped in commercializing 62 agro-technologies, benefited more than 40000 famers and facilitated business development worth $17.3 million, and generated $6 million for ICRISAT.

ABI has won many accolades, chief among are the Best National Technology Business Incubator award by the Government of India (2005), and Best Business Incubator by the Asia Pacific of AABI (2007).

In general, with incubation support, the closure rate has come down to 15–20 percent among incubator tenants. Currently, there are over 3500 business incubators across the world. Most of these relate with the ICT and ITES sectors. In fact, there only 60 odd agricultural sectors-oriented incubators in the world; India is the only country that has the most number of agribusiness incubators (11). Depending on the environment, different types of incubators can be designed ranging from: Mixed portfolio incubators, Sector-oriented incubators and Technology oriented incubators.

Incubators have evolved over the years since the inception of the first incubator in 1957. However, in general, business incubators provide the following support (single window approach) for a start-up:

- Scientific and technical backstopping
- Technology transfer from University and Research Institutes
- Business plan preparation and marketing consultancy
- Infrastructural facilities like office space, conference rooms, communications

[10] *info*Dev (2009). 'Mixed use incubator handbook.'

- R&D lab space
- Mentoring assistance
- Access to funding agencies, angel investors, venture capitalists, crowd-sourcing etc
- Training to incubatee-SME management, skill set development
- Promotional support through exhibitions, conventions, workshops etc
- Operational costs reduction
- Networking with Industry, Research bodies, Commerce chambers, Government
- Assisting in getting clearances with Government regulatory bodies and Licensing bodies
- IPR management

To further elaborate, a successful case study is provided in **Box 4**.

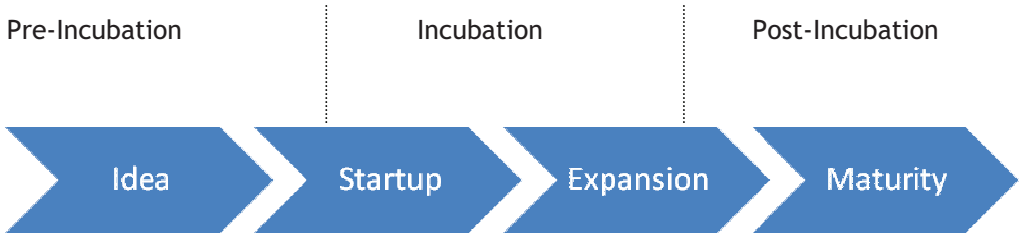
Box 4. Nurturing entrepreneurship

Mr Sultan Singh is a progressive fish farmer-cum-entrepreneur from Bhutana village of Karnal in Haryana. An incubatee of the business incubator of the Central Institute of Fisheries Technology (CIFT), Cochin, he was instrumental in setting up *Sultan Singh's Fish Seed Farm* and *Sultan Singh's Food Court*. In 2011, with the support of the incubator, he setup India's first inland fish Processing Unit for the production of value added products from fish in Bhutana, with technical collaboration from the Fish Processing and Quality Assurance & Management division of CIFT. The unit, with a processing capacity of one tonne of fish per day, was designed in such a way that even the waste from the processing could be converted into fish feed, thereby setting a fine example of zero waste agriculture.

The incubator also imparted training in the production of fish based value added products like fish nuggets, burger, fingers etc which are marketed under the brand name *Fish Bite*. The incubator is currently engaged in providing further marketing assistance by establishing retail kiosks at Delhi, Punjab, Haryana and Maharashtra. The unit, also acting as a training centre for progressive farmers and scientists, is expected to improve the economic status of hundreds of families engaged in fish farming in the village ponds and other entrepreneurs in the region.

Source: NIABI Nexus (2012)

The stages in business incubation support mirror that of the agri start-up and can be described as given below[11]:



- Pre-incubation stage can be offered for helping individuals who have an innovative idea. These incubators are usually attached to Universities and Research Institutes and have easy access to scientific and technical support. The risk factor will be high at this stage and can be mitigated by the incubator.
- Incubation stage is where the idea transforms into a plan and operationalized. Incubators can help in refining the plan, provide resources and even invest in the company, thereby financially supporting the start-up. This is the stage where incubation happens. The stage

[11] *info*Dev (2009). 'Mixed use incubator handbook.'

will help the incubatee in moving to a more mature stage in the business cycle and usually is for a period of five years.

- Post-incubation stage can be utilized by those agribusiness ventures that are looking for specific support facility. This will also help the incubator in supporting their other incubatees and programs. The risk factor is very low at this stage.

A key feature of the incubator domain is networking. Although, considered a soft skill, networking is vital to gaining access to the competitive market and getting necessary support from private, public and civil sector. By virtue of its extensive linkages, incubators have easy access and symbiotic relation with the players in the chosen sector. Business incubator networks are spread across the world. Some of the prominent incubator networks are National Business Incubator Association (NBIA), UK Business Incubator (UKBI), Asian Association of Business Incubators (AABI), Asia Pacific Incubator Network (APIN) and *info*Dev (The World Bank).

Through these networks, the SMEs can even access global market. India also has its own domestic agribusiness network (**Box 5**), which provides an opportunity for agribusiness entrepreneurs in connecting with other incubatees, research bodies and industries that will help in its success.

Box 5. Networking with Incubators

The Network of Indian Agri-Business Incubators (NIABI), setup in 2009, is a network consisting of ten agribusiness incubators spread across State Agricultural Universities and Central Research Institutes under NARS and coordinated by ABI-ICRISAT. The Network, setup to promote agribusiness in the country through technology commercialization and other business incubation services, works on a co-business incubation mode between the incubators. NIABI has commercialized 52 agro technologies, with revenue generation of Rs.9 crore, so far.

Using co-business incubation mode, technology transfer and scientific support can be made within the network that is spread across the country. It can also be used for linking with potential customers that can lead to commercialization of the venture.

By nurturing rural enterprises, incubators help in generating benefits to the society and its parent institutes through technology commercialization and royalty. Incubators (and in turn its clients) also get incentives from the Government of India (**Box 6**).

Box 6. Incentives to support Incubators & its clients

- Incubators and its SME clients are exempt from service tax and corporate tax.
- Foreign equity ownership of incubated SMEs can be as high as 100 percent.
- Select incubators have been provided with Seed Funds for supporting its SMEs (Rs.1 crore per fund).

Source: DST, GoI

The benefits of business incubation range from direct financial benefits in terms of tax revenues to the society from the employment each SME generates to significant improvements in SME sustainability, through which new technologies, services and business models can be tested and later scaled up. Incubators also help in creating an entrepreneurial and innovation hub around a sector, like agriculture or fisheries for example. The incubator also offers the platform for research bodies and public and private sector to come together and share their innovations, knowledge and ideas.

Studies show that for every US$ of public investment in an incubator, the return has been US$ 30 in local tax revenue; 84 percent of incubator graduates stay in the community where they were incubated (thus keeping the economic cycle running) and 87 percent of the graduated firms remain in business[12]. With a large population, especially in the rural sector, these figures clearly highlight the potential of incubators in nurturing an ecosystem of entrepreneurship that will help in generating more innovations into the agricultural sector in the country and the local economy, leading to an improved livelihood.

2.2 Leveraging NARS for Fostering Innovations & Agribusiness

With over 90 ICAR institutes and 45 agricultural universities spread across the country, this is one of the largest National Agricultural Research Systems (NARS) in the world. The Indian NARS follows a three-tier structure which is geared towards developing partnerships for research. At the center are the organizations under the ICAR, an autonomous organization under the Department of Agricultural Research and Education (DARE), Ministry of Agriculture, Government of India. At the state level, there are State Agricultural Universities (SAUs), while Zonal Research Stations, under the SAUs are present at the zonal level covering the districts. Apart from these, Krishi Vigyan Kendras (KVKs) are also present at the district levels for dissemination of technologies.

The ICAR is the apex body for coordinating, guiding and managing research and education in agriculture including horticulture, fisheries and animal sciences in the entire country. ICAR also has one of the largest countrywide networks of research institutions for the advancement of agricultural and allied sectors through technology development and commercialization[13]:

- All India Coordinated Research Projects: 61
- Network Projects: 17
- ICAR Institutes: 49
- State Agricultural Universities: 46
- Central Universities: 5
- National Research Centres: 17
- National Bureaux: 6
- Project Directorates: 25
- Krishi Vigyan Kendras: 589

ICAR played a pioneering role in ushering Green Revolution and subsequent developments in the sector through its research and technology development that has enabled the country to increase the production in agriculture and allied sectors making a visible impact on the national food and nutritional security. With changing times, it has been able to adapt its R&D activities to meet the challenges of technology commercialization in the globalization era. ICAR has a dedicated IPR management cell for monitoring IP commercialization through its numerous institutes; the number of IPR applications has increased to more than 1300 from 47 institutes over the past decade showing that newer technologies are being developed and are in the pipeline. Over the past three years (2008-11), ICAR has been able to generate revenue worth `

[12] The World Bank (2012). 'Agricultural Innovation Systems: An Investment Sourcebook,.'
[13] Retrieved on September 13, 2011 from http://www.icar.org.in/aboutus.htm

Rs.586 lakhs through commercialization of IP protected technologies and Rs.666 lakhs through non-IP protected technologies.

However, failure in extension machinery has weakened the technology delivery mechanism leading to a breakdown in connecting research to the farmers. This has been partly due to the reduced fund outlay for extension services from the central and state pool. The productivity gains will be possible only if agricultural research systems are mobilized to develop improved agricultural technologies and if extension systems are strengthened to assure dissemination of the improved technologies and techniques to both male and female farmers.

Understanding the complexity of the problem facing the sector, the ICAR has taken a few initiatives to address technology fatigue and revive the agricultural sector in the country. Engagement with the private sector has been more marked with a realization that the private sector will be able to provide the scale and support, which is missing. Again, the need for staying relevant in a market driven agricultural sector and ability to use opportunities that result from changes has allowed the NARS to look at multiple engagements with other public and private R&D units. This has started to see some results and positive impact in the way R&D is being done in the institutes.

- *ICAR Vision 2030*[14]: ICAR has outlined in its role in shaping the future of the Indian agricultural research for growth, development and equity through a roadmap, *Vision 2030*. In the document, it is now realized that agriculture sector would have to face several challenges and threats, along with the opportunities that are emanating from both supply and demand perspectives. An effective agricultural invention-and-innovation continuum would play a crucial role in addressing a number of supply-side obstructions and in harnessing numerous demand-side opportunities. The preconditions for making agriculture sector more remunerative and sustainable would be to evolve effective mechanisms for technology delivery and to enhance capacity of all stakeholders in the invention-innovation continuum. While realizing that it alone will not be able to solve the problems of the agricultural sector, ICAR is open to partner with various government agencies, farmer organizations, private agencies, Civil Society Organizations etc. through a well-defined Intellectual Property Rights (IPR) domain that aims at commercializing the technologies in its vast trove.
- As part of the ICAR guidelines on Intellectual Property (IP) management and technology transfer/commercialization, ICAR had setup Institute Technology Management Units (ITMUs) in 95 ICAR institutes, Zonal Technology Management Centres (ZTMCs) in five ICAR institutes for management of IP activities at zonal level and all of which is coordinated by the Agro-Technology Management Centre (ATMC). This decentralized three-tier IP management mechanism had the individual institutes of ICAR empowered and enabled to enter into licensing contracts or commercial agreements for the commercial transfer of ICAR technologies to the interested parties. The ZTMCs formed the middle tier for facilitating business and strengthening public-private partnerships. ATMC facilitated the techno-legal and policy matters/concerns that may arise on case-to-case basis in the course of developing win-win relationships and also catalyzes public-private relationships at the central level.

[14], ICAR (2011). ' ICAR Vision 2030'. Retrieved from http://www.icar.org.in/en/node/2574 on February 24, 2011

- Another initiative by ICAR in the 11th Five Year Plan period was the Intellectual Property Management and Transfer/Commercialization of Agricultural Technology Scheme. The objectives of the scheme were:
  - ► To set in place an institutional mechanism to protect/manage IP generated within the system.
  - ► To implement the incentive system for scientists incorporated in the ICAR guidelines for IP management and technology transfer/commercialization and to encourage greater capacity and rapid innovativeness in the system.
  - ► To maximize technology transfer by ICAR institutes, and to generate income/resources through commercialization of IP.

- The above two initiatives were further bolstered with the initiation of the Network of Indian Agri-Business Incubators (NIABI), a project of the National Agricultural Innovation Project (NAIP) whereby 10 Business Planning & Development units (BPDs) were setup in five SAUs and five ZTMCs. The BPDs essentially were agribusiness incubators setup to promote agribusiness in the country through technology commercialization and other business incubation facilities. The Network covers all sectors of agriculture and has so far commercialized 52 agro-technologies and generated revenue worth Rs. 9 crore (**Box 7**).

  The incubators, mentored by ABI-ICRISAT have shown that technologies can be disseminated through this platform while also supporting entrepreneurship in the sector. Again, as can be seen from **Box 7**, the platform offers an effective mechanism for engaging with the private sector players. There are already plans to scale up the number of incubators to 100 in the 12th Five Year Plan.
- AGRINDIA is a registered company fully owned by the Government of India through DARE, Ministry of Agriculture. It focuses on integrating proficiencies in agriculture sciences with management, such as market intelligence, pricing and valuation issues, to nurture demand-driven research and would undertake the following major activities:
  - ► Protection and management of intellectual properties generated in the system and its commercialization/ distribution for public benefit.

Box 7. NIABI: Gateway to agribusiness & technology commercialization

NIABI has been able to successfully nurture 73 entrepreneurs through technology commercialisation and supporting innovations and promoting agribusiness in the country. Some of them are:

- ✓ Non-exclusive license agreement for the production and marketing of wheat varieties was agreed by CCSHAU with various seed companies which will ensure that the seeds will reach out to more number of farmers.
- ✓ Trichoderma based formulation as pesticide was commercialized by IARI to M/s Sai Bio Organics, Punjab.
- ✓ IVRI commercialized Peste des Petits Ruminants (PPR) and Goat pox vaccines to Hester Biosciences, Ahmedabad for Rs 34 lakhs and royalty fee of 3.5 percent.
- ✓ Chitosan technology, transferred to Matsyafed, Kerala by CIFT, is now under commercial production and branded as Chitone.
- ✓ SMS operated irrigation technology, an innovation by M/s Emral Tune Line Auto Tech India, was incubated by TNAU and through the incubator linkages has been able to scale up its venture and sales touch Rs 20 lakhs per year.
- ✓ Leading private veterinary product companies like Pedigree, INTAS have tied up with IVRI for technology transfer worth Rs 10 lakhs each.

Source: NIABI Nexus (2011)

- Production, marketing and popularization of ICAR's products, processes and technologies in agriculture and allied sectors.
- Providing skill services for ICAR, such as consultancies, contract research, contract service, customized capacity building, technical support for turnkey project etc.
- Setting up research and development farms and assist in setting up production units outside India.
- Public-Private Partnerships (PPP) in research, education and other capacity building in agriculture and allied sectors.

Plans are also afoot for setting up an entrepreneurship project for building an ecosystem that nurtures entrepreneurship development, conducting translational research for technology commercialization, management of technologies for commercialization and developing research for breakthrough technologies for accelerated growth and higher economic impact.

While the NARS-led initiatives in nurturing innovations and entrepreneurship are finally seeing results in transforming the sector, other agricultural R&D institutes have already initiated their mechanisms of engaging with players in the value chain so as to harness the potential of innovation. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) was the first amongst the 15 institutes under the Consultative Group on International Agricultural Research (CGIAR) to develop a platform for engaging with entrepreneurs and private sector. Realising the potential of the other players in the agricultural value chain to achieve scalability and reaching out to the farmers and families in the last mile, ICRISAT developed the Agribusiness & Innovation Platform (AIP) that engages with innovators, entrepreneurs and private sector players. AIP also allows a channel for disseminating the technologies developed by ICRISAT. It was also a prime example of how effective partnerships can be forged between the Government, R&D institutes to nurture entrepreneurship and innovations in the sector (**Box 8**). Given the advancements in biotechnology, ICRISAT also took the unique initiative of setting up the Platform for Translational Research on Transgenic Crops (PTTC) with the support of Department of Biotechnology, Government of India. The PTTC with its state-of-the-art facility will facilitate the translational / advancement of potential transgenic technologies into usable products to achieve the ultimate goal of using crop biotechnology in a socially responsible way for addressing the food security crisis & agricultural needs. These initiatives have helped ICRISAT to relook at its strategies and newer effective ways to achieving its mission and goals (**Figure 6**. Pg 25), helping it stay relevant to the changing economic environment.

Box 8. Platform for technology transfer and nurturing innovations

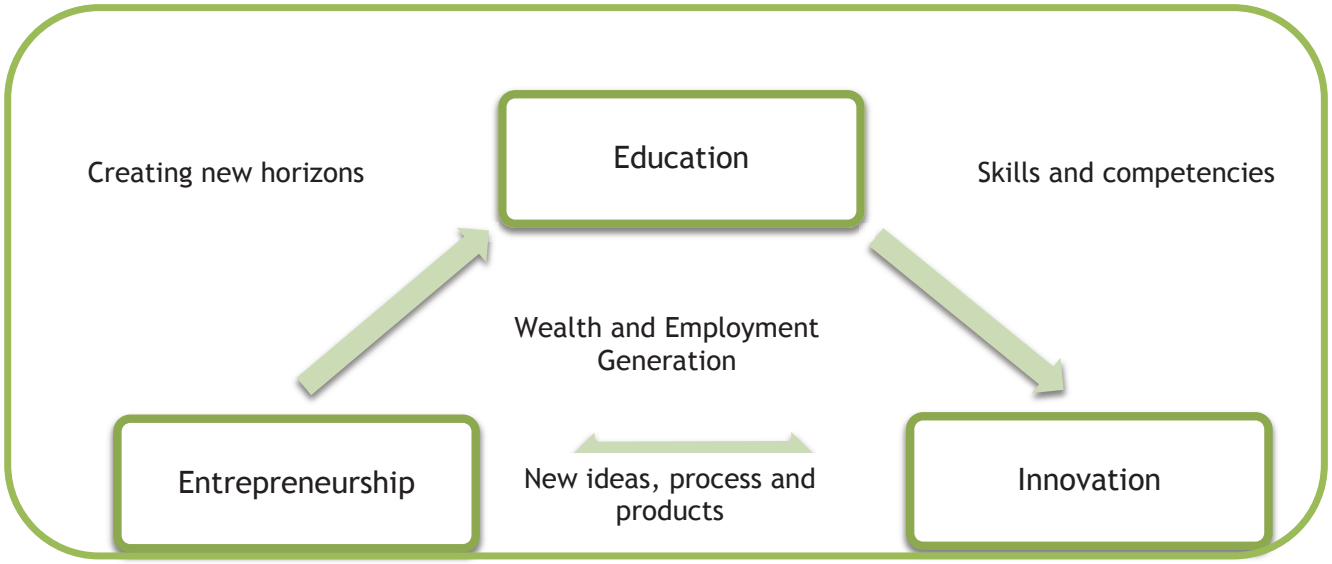
ICRISAT engages with the innovators, entrepreneurs and private sector through the AIP. The AIP aims to enhance agricultural prosperity through innovation, entrepreneurship and partnerships. It acts as the umbrella body for ICRISAT's three flagship programs:

- Innovation & Partnership (INP) program: focuses on developing strong collaborative research partnerships with public, private and allied sectors to benefit small holder farmers across the agricultural value chain.
- NutriPlus Knowledge (NPK) program: aims to achieve growth through value addition and post harvest management in the agri-food sector through innovative processing and product development.
- Agri-Business Incubation (ABI) program: promotes entrepreneurship in agriculture and nurtures innovations.

Source: AIP-ICRISAT (2011)

Agribusiness provides an opportunity for the thousands of agricultural graduates who pass out from the SAUs with a chance to start an own venture. Entrepreneurship culture would help in creation of wealth from knowledge; innovation on the other hand would result in new markets being discovered and promotes entrepreneurship in the agricultural value chain. A dynamic entrepreneurial environment supported by a vibrant and supporting academia linked to innovation will definitely help in making agribusiness a livelihood option for many (**Figure 5**).

Figure 5. Dynamic entrepreneurial environment



Source: Entrepreneurship, National Knowledge Commission, Govt. Of India (2008)

The training and curriculum imparted from SAUs needs to be modified to include quality vocational training and skill development can help graduates to become entrepreneurs, who can then organise farm cooperatives, agri-clinics, agro-parks etc and help in improving the efficiency and economics of farming. *Earn while you learn* and *Catch them Young* programs help in inculcating the spirit of entrepreneurship in students. The campus can become the breeding ground for innovations and spotting opportunities in starting ventures in the long value chain. The support of the faculties and the agricultural knowledge of the SAU would definitely help the would-be entrepreneurs, who can later be provided with incubator support services. Grants and stipends, as the Youth-to-Youth Fund provided by Youth Entrepreneurship Facility of Africa, can be provided to selected agripreneurs to help them in starting their venture. Ethics, transparency and governance should be imparted along with regular courses to inculcate right environment for doing business.

Linkages with the agricultural industry, incubation centres, business chambers etc would help the students tremendously in believing in their start-up ideas and its potential. It will also aid in thinking out of the box and coming up with new ideas for meeting the industry requirements. Such an approach has already been made operational in Africa, through the Universities, Business & Research in Agricultural INnovation (UniBRAIN) project of the Forum for Agricultural Research in Africa (FARA). Supported by the Royal Danish Agency (DANIDA), the project is unique as it brings together agricultural research institutes, business entities and agricultural universities to form an Agribusiness Innovation Incubator Consortium (AIICs) or value chain based agribusiness incubator (**Box 9**).

Box 9. Leveraging African NARS for promoting agribusiness

The development objective behind the UniBRAIN project is to contribute to enabling African countries to create jobs and raise incomes through sustainable agricultural development. The project aims to achieve the following three key outputs:

- Output #1: Commercialisation of agribusiness innovations supported and promoted
- Output #2: Agribusiness graduates with the potential to become efficient entrepreneurs produced by tertiary educational institutions
- Output #3: Scaling up the innovative outputs, experiences and practices shared and scaled up.

To achieve these outputs, six AIICs were started in five countries-Mali, Ghana, Uganda, Kenya and Zambia, with each incubator focussing on one value chain-seeds, livestock, sorghum, banana, coffee and tomato. These incubators are run by professionals and governed by representatives from R&D, Private sector and SAU, which allows the incubator to be run in an efficient way by utilising the strengths of the three entities. The UniBRAIN project has external partners-ANAFE, PanAAC, ABI-ICRISAT, ASARECA, CCARDESA, and CORAF/WECARD, who also plays a role in ensuring that the project achieves its outputs, by mentoring the incubators, entrepreneurs and suggesting changes in the education curriculum.

Source: UniBRAIN Process Document (2012)

A similar initiative can be planned for the Indian agricultural sector so as to bring out more entrepreneurs from the SAU level itself. It will provide a platform allowing for much interaction with the private sector, R&D bodies, SAUs and incubators with entrepreneurs, allowing for innovations to be nurtured and revamping the extension machinery. One of the major benefits will be that the youth gets an opportunity to start their own ventures, supported by incubators and private sector and innovations can be spurred on, resulting in the growth of the local economy.

2.3 Linking Smallholder Farmers to Access Modern Marketing Chains

Small and marginal farmers constitute 80 percent of total farm households, 50 percent of rural households and 36 percent of total households in India. Thus, integration of smallholder farmers with the markets is the only way of ensuring better returns for their produce and thereby leading to enhanced livelihood opportunities.

In India, there exists a network of 7,700 regulated markets Agricultural Produce Market Committee (APMCs). These markets are accessible throughout the year and have been handling a range of commodities for decades. However, small and marginal farmers have remained out of the ambit of these markets.

Disorderly Markets

Smallholder farmers find it difficult to access regulated markets, as they are usually located away from these markets and these farmers lack surplus produce for sale, which is a prerequisite, to operate in these regulated markets. As a result, small and marginal farmers have no option but to sell their produce at the nearest market, or a rural *haat*. These rural markets are periodic in nature and do not have enough buyers to offer market-based price for the produce. These are unregulated markets, which lack proper infrastructure and market information system. As a result, farmers have no information about prevailing market prices and lack access to the price discovery mechanisms. These rural markets receive produce in a disorderly manner, leading to high post-harvest losses. In such an environment, the marketing experience of small and marginal farmers remains less remunerative and discouraging. In the above context, new

innovative and emerging mechanisms for linking smallholder farmers to markets, which shall also foster innovations in the agricultural sector, are discussed below:

1. Modern marketing chains

These chains have many features of buyer-driven value chains: an actor close to the consumers (usually a supermarket or a broker) dominates. These modern marketing chains involve organizing many producers and intermediaries, deciding who participates in the chain, overseeing all the links from the farm to the shelf, defining the nature of the interactions and commercial conditions, and setting quality and safety standards etc. Modern marketing chains focus on marketing specific products (vegetables, fruits, meat, and etc.) whose access to the chain is highly restricted.

Types of modern marketing chain

The First type of modern marketing chain,

- Supplies developed countries with fresh and processed fruits and vegetables, fish and fish products, meats, nuts, spices, and flowers.
- Traders and agro processors usually work with farmers under different associative forms; occasionally they provide financing and technical advice to smallholders.
- Both technical and organizational innovations are important in this chain, and local actors have to develop strong innovation capabilities to remain competitive in global markets.

The second type of modern marketing chain

- Triggered by the expansion of fast-food chains and supermarkets that supply mostly domestic markets, although increasingly they are also catering to foreign markets. This type of chain is a product of the internationalization of wholesaling and logistics, consolidation of rural and urban wholesale markets, emergence of specialized and dedicated wholesalers who organize procurement, growth in vertical coordination, and the introduction of private grades and standards.
- The better–off smallholders tend to sell through this channel (sellers in traditional channels tend to be less well off); they have more capital (especially irrigation facilities), easier access to credit, and greater specialization in commercial horticulture[15].
- Actors in these chains use sophisticated production packages, but the most important innovations are organizational: coordinating production by large numbers of farmers of products of consistently high quality (frequently highly perishable) and delivering them to numerous distant retail sales points (increasingly abroad). The same products, which are sold in traditional wet and wholesale markets, are sold in modern marketing chains; the difference is that the former usually handle products of mixed quality and operate with spot prices, whereas the modern chains must adhere to high quality standards, and deliveries and prices are set in advance. Such an arrangement is highly beneficial to our small-holder farmers.

[15] Retrieved from http://dyson.cornell.edu/faculty_sites/cbb2/Papers/agrifoodpercent20industrypercent20transformationpercent20working.pdf on October 6, 2012.

The third type of modern marketing chain comprises niche markets in their many forms. Examples include the following:

- Smallholders close to a large city, who sell directly to consumers in a process similar to the "locavore" movement (Local Food) in developed countries.
- Development projects that create new markets for traditional products and new products based on traditional crops, like the Madurai *Malli* Incubator project (**Box 10**).

Box 10. Madurai Jasmine all set to become global brand

Madurai Malli, the famous jasmine variety from the region, is all set to become a global brand. A special incubator to create value chain has been set up at the Agricultural College and Research Centre here to address production and marketing constraints. An action plan has been prepared by the Tamil Nadu Agricultural University and ICRISAT with support from the District Administration of Madurai.

Source: The Hindu-Business Line (September 2012)

2. Supporting the expansion of modern marketing chains through targeted investments

Private actors make most of the investments to develop modern marketing chains. These investments may support the formation of farmer groups, finance infrastructure and specialized equipment, build capabilities for farmers and their organizations to meet the standards required by private companies, and help provide market intelligence.

Another type of investment is the facilitation of *farmer–out grower schemes*. Farmers have proven their ability to produce to the standards required by modern chains. Supermarkets or specialized wholesalers encourage farmers to organize their neighbors to produce to the same standards; the only incentive the buyers offer is a guaranteed market opportunity. For a fee (usually a percentage of the final sales), farmers provide various services that may include production planning, technical assistance, access to inputs, market intelligence, sorting and packing, transportation to market, and financial administration. Investments to support these programs include financing farm equipment and capacity building for the farmers willing to work with the lead farmer, including paying for the time of the farmers.

3. Fostering coordination among actors in modern marketing chains

Modern marketing chains usually use sophisticated production and marketing mechanisms to bring perishable products from rural areas to urban consumers in developed and developing countries. In addition, the technologies and market requirements (such as the varieties grown and packaging methods) change often, forcing farmers to adapt. Greater coordination along the marketing chain helps smallholders to adapt by facilitating access to up-to-date information and financial resources. Successful coordination, however, requires coordinating organizations to respond to the needs of actors in the marketing chain and adapt themselves to changing conditions (**Box 11**). Otherwise, coordination results only in formal agreements with little impact on the ground. Investments include market intelligence, development of market and farm infrastructure, facilitation of interactions (usually by the actor that dominates the chain), and the formation of farmer groups, assisted by innovation brokers (innovation consultants, peer network, brokers etc.).

Box 11. Strengthening agricultural produce supply chain

Michigan State University and Tamil Nadu Agricultural University (TNAU) worked together to promote greater awareness of and capacity building for assisting small farmers to link into high value fruit and vegetable supply chains.

The partners collaborated and strengthen TNAU's competencies in all aspects of supply chain development, and ensuring inclusion for small- and medium-scale producers. They enhanced the relevant curricular and extracurricular learning opportunities; and built partnerships with the private sector, government agencies, non-governmental organizations, and farmer groups to improve TNAU's ability to support supply chain management. In addition, the Higher Education for Development (HED) partnership project helped leverage Rs.10.5 million (USD 210,000) grant from the ICAR to provide training for farmers in supply chain management.

Major accomplishments under this partnership included: faculty development in the area of supply chain management; significant revisions to the undergraduate curriculum in horticulture; and connecting local farmers with traders, processor, and exporters.

Consistent with its title, "*Building University Capacity to Improve Fruit and Vegetable Supply Chain Development and Management in India",* the partnership staged 26 training workshops and seminars for more than 1300 farmers, traders, processors, agribusiness managers, and scientists in Good Agricultural Practices, Good Management Practices, Good Harvest Practices, and phytosanitary issues. The program helped to establish the first banana and mango federations in the State of Tamil Nadu.

4. Developing niche markets

Niche markets are a particular form of innovation network; the investments in the networks, including financing innovation brokers and other actors that bring together potential partners and strengthening the innovation capabilities of nonpublic actors in the innovation system—for example, through consulting services, extension activities, technological interchanges, or seminars and workshops on the dynamics of innovation networks. Investments also include small, short-term grants for potential catalytic agents of innovation networks (researchers, extension agents, and groups of farmers) to facilitate interactions with potential partners (through meetings or electronic communications platforms), build capacity, and facilitate collective action.

Box 12. Maharashtra Agricultural Competitiveness Project (MACP)

The project development objective of the MACP is to increase the productivity, profitability and market access of the farming community in Maharashtra. This would be achieved by providing farmers with technical knowledge, market intelligence and market networks to support diversification and intensification of agriculture production aimed at responding to market demand. Farmers are assisted in establishing farmer organizations, developing alternative market channels outside of the regulated markets and in supporting the modernization of promising traditional wholesale markets. The three main components of the projects are:

- Intensification and Diversification of Market led Production,
- Improving Farmers Access to Markets,
- Project Management, Learning & Adjusting.

Source: The World Bank (2010)

5. Improving traditional markets to benefit smallholders

To modernize traditional markets and improve farmers' bargaining power, Investments in developing small-scale farmers' human and social capital by fostering the emergence of farmer organizations, providing technical and organizational support, facilitate smallholders' access to modern infrastructure (especially ICTs), services for business registration and incorporation which facilitates contractual relationships with retailers, offering training in modern marketing methods will foster innovations (**Box 12**). Finally, another investment to benefit smallholders is to modernize

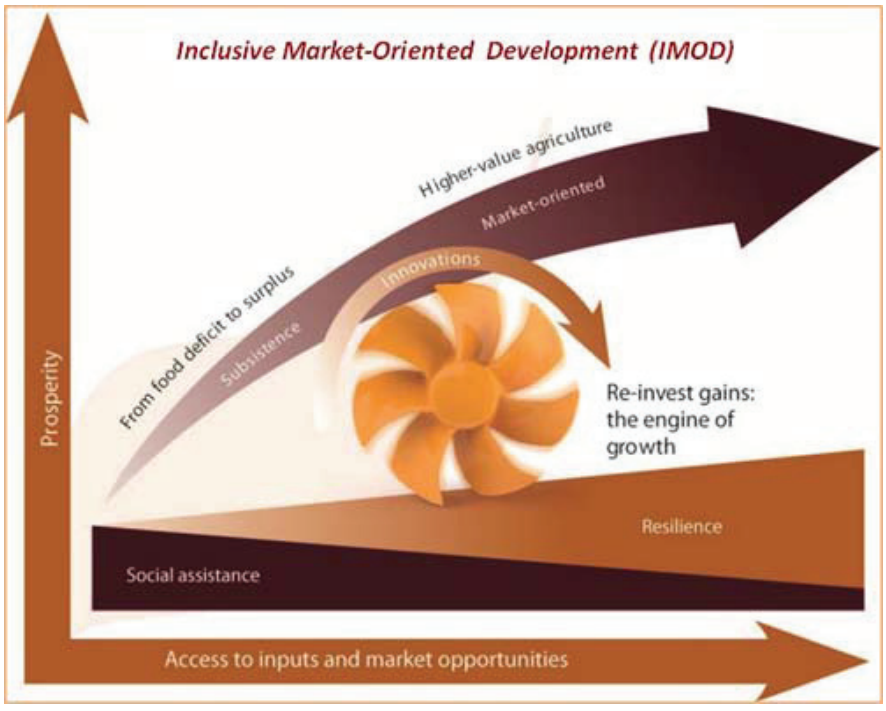
wholesale and wet markets by improving buildings, storage facilities, communications facilities, and roads.

6. Inclusive Market-Oriented Development (IMOD)

To enable the small hold farmers and their families to go beyond subsistence farming, ICRISAT's Strategic Plan to 2020 encompasses the principle of Inclusive Market-Oriented Development (IMOD). IMOD shall result in surpluses for the smallholder farmers that can be stored and sold to markets, paving the way for prosperity in the dry lands. This inclusive (broad-based) strategy focuses on bringing the small holder farmers into the mainstream to participate and reap the benefits of development. IMOD is an inclusive strategy that enables the poor, particularly women and the children, to participate, rather than be sidelined, in the development process.

Surplus produce, which is stored as food, serves as a buffer in times of hunger. Income from marketed produce enable farm families to purchase more food when needed, including inputs such as seeds, fertilizer, labor, tools, livestock, insurance and education. These will further raise farm productivity, kicking off a series of investments that bring about economic growth. As this is sustained, it creates a self-reinforcing pathway to prosperity.

Figure 6. Dimensions of ICRISAT's IMOD Strategy



Source: ICRISAT

There are two major dimensions of IMOD (**Figure 6**). The curve represents the power of market opportunities that offer prosperity to smallholders. The platform is the risk management dimension, which highlights the need for more effective social assistance programs to help the poorest connect to markets, in a way that builds their own resilience rather than creating dependency.

7. Policy Issues

Key policy issues related to modern marketing chains involve identifying ways for the chains to spur growth and reduce poverty, ensuring that modern chains are sustainable (some may require more public support than others), fostering more equitable access, clarifying appropriate roles for public and private investors, and identifying appropriate public investments.

Lessons Learned

- **Buyers establish different types of commercial relations, even with farmers in the same area; - projects should not try to impose a model of interaction.**
  Commercial chains use different suppliers according to the nature of the product and the type of farmers present in the procurement area. Small-scale farmers are more able and willing to follow highly labor-intensive field management practices needed by the companies; and small-scale farmers have reduced transaction costs by organizing. If a buyer has only small-scale farmers in its procurement area, it usually assists them with various inputs, credit, and technical advice.[16]
- **Social capital should be an important criterion to allocate funds.**
  Social capital is a significant factor in a group's ability to sell in modern marketing chains. Social capital is strong within mature groups with strong internal institutions, intragroup trust, altruistic behavior, membership in other groups, and ties to external service providers. Older groups that have built substantial social capital should be ranked above newer groups in consideration for support.
- **Capable and motivated program leaders are important.**
  Strong leadership with the appropriate experience is regarded as the most important factor for a group to identify and maintain market links, followed by the quality of external facilitation. It is very difficult for one person to have all the required qualifications. It is important to offer program leaders incentives to experiment and allow them to change programs as needed.

Key considerations for fostering successful innovations in agribusiness

- Do not impose specific interaction patterns as a condition for participating in projects.
- Support the modernization of traditional wholesale markets and traditional retailers, and help small-scale farmers to link with modern marketing.
- Develop small-scale farmers' human and social capital through sustained programs that include facilitation to form associations and training in modern marketing. Facilitate access to modern infrastructure, especially ICTs.
- Build the capabilities of field staff, project managers, donors, and policy makers to support small-scale farmers. Finance investments (cold storage, packaging, and so on) that target specific requirements of specific modern marketing chains.
- Develop new financial instruments to take advantage of the stable relationship between small-scale farmers (individually or organized) and the main actors in modern marketing

[16] Retrieved from http://dyson.cornell.edu/faculty_sites/cbb2/Papers/agrifoodpercent20industrypercent20transformationpercent20working.pdf on October 6, 2012.

chains. These actors, operating as intermediaries between banks and farmers, can help farmers obtain credit at market rates.

- Identify high value products through multi-stakeholder planning exercises that modern marketing chains must source from smallholders, such as low-volume and niche products, and support associations of market agents and small-scale farmers to provide them.

Potential benefits of fostering innovations linked to evolution of modern marketing chains

- For farmers who sell in modern marketing chains and for smallholders who access niche markets, easier access to input and output markets and other resources for innovation, such as technical advice, innovation networks, and participation in action-research projects.
- More effective use of human, social, physical, and financial resources for innovation
- Creation of jobs in rural areas, some exclusively for women.
- Better interaction and coordination among actors, resulting in a more dynamic innovation system for agriculture.
- In the case of niche markets, more inclusive market oriented development for the small-holder farmers helps them in better access to the market and realization of returns.

2.4 IPR Regime & Agriculture

After globalization and expansion of food market, agriculture has been recognized as an enterprise of investment and profit making. Agricultural sector has changed its shape from subsistence to market-oriented farming. The net result is that, as economic development progresses, modifications appear not only in the cost structure of agricultural production, but also in the agricultural innovation landscape. Innovation is the key engine to deliver new and improved goods, services and processes that increases consumer standard of living and economic growth, hence, like other business enterprise sectors, agriculture also demands continuous innovation activities in research and business. The innovation intensity of these agro-based industries often exceeds that of farm agriculture and some of them are really high-tech, spending major sums on research and development (R&D) and related innovation activities. Intellectual Property (IP)[17] regime operates as a driver for innovations benefiting the right holder and also society as a whole which catalyses PPP and supports knowledge-sharing.

Traditionally, Intellectual Property Rights (IPRs) were not important to agriculture, but emergence of several new tools for growth in farm sector including biotechnology, hybrid technology, bio-control agents, bio-fertilisers, vaccines, diagnostics, improved implements and machinery have recognized the art and strength IPR regime. The fast emerging trend is value addition and product differentiation in farm produce through technological innovations, design and branding in the Agro-Foods Value Chain; functional foods and food packaging. Patents are leveraging technical advancement in the Food Processing Industry. Trademarks, Geographical Indications, Industrial Designs are commonly used by companies to market products and

[17] Intellectual property (IP) is an essential legal instrument that is used by modern technology-based businesses, including agribusinesses, to fuel a stream of innovative products from research and development. There are seven forms of intellectual property rights recognized which include, Copyright and related rights, Trademarks, Geographical Indications, Industrial Designs, Patents, Layout-Designs (topographies) of integrated circuits, and protection of Plant Varieties.

services, and to improve their competitive position in the market. Protection of new varieties of plants is strategically critical for the Breeding Industry.

IPR has become increasingly important in many areas of agriculture including R&D, foreign trade, technology transfer, marketing and business, access to genetic resources and traditional knowledge. Government is providing right incentives for the private sector to invest in innovation by operating IPR regime (which grants the inventor a temporary monopoly on the use of the technology). The private sector has also recognised that the capital intensive frontier areas of technology generation require high investment and long gestation periods, and that IP protection is one of the important means of resource generation aimed at further enhancing the R&D in agriculture. IPRs can promote leveraging of private resources for resolving day-to-day problems. Sometimes Patents, the strongest form of IPRs, can delay important scientific advancements, deter investment in business, and impose crippling transaction costs on organizations if utilized in negative business approach. The privately owned technological advancement may create problem, because the company controlling them could exclude competitors not only in its own market but also the neighbouring market. Though the relationship between IP system and stimulation of innovation in agriculture has been an issue of debate, the current business practice demands limited monopoly power achieved by IPRs to encourage investment in innovative activities in R&D and advertizing. To many observers, IPRs are no more than a piece of legal document, but to a businessman who invests time, intellectual sweat and capital to turn ideas into profit making venture, IPRs simply help to protect his investments (**Box 13**).

Box 13. 'YO!® Sushi'- Trademark Protection

Sushi – Japanese-style raw fish with rice and vinegar – was quite a small market in the UK in 1997. Simon Woodroffe, founder of YO!® Sushi, took the risk to be different and opened a conveyor belt restaurant specializing in sushi. YO!® Sushi represents a concept that is popular and profitable. Simon understood the importance of establishing and protecting a brand image and registered his **trade mark** 'YO!® Sushi', a simple combination of the words 'YO!®', a Japanese greeting, and sushi – a Japanese food.

Registration of the trade mark YO!® gave the company exclusive rights over how the YO!® image is projected and the products and services that carry its name. It guards the colours, style and font of the logo, and the way it is displayed. The registration also gave it the right to take legal action against any company that it feels may be using it in an unauthorized way. Exclusive ownership of the trade mark gave YO!® confidence that it alone will gain benefit from investment in new projects and brand extension. The protection acquired from registering the YO!® Sushi brand enabled the business to build on its innovative and enterprising ideas, expand its number of outlets and enter new markets, without fear of anyone damaging its reputation by improperly using the brand name or logo.

The agricultural technology based business like food processing involves series of events ranging from theoretical conception (new ideas, collections of thoughts), technical invention (process of converting thoughts into a tangible product, service or process involving science and technology), and commercial exploitation (turning inventions into products that will improve company performance, management and business). The IPR management in agro-based enterprise requires a broad portfolio management that includes the fundamental need to link IPR protection with licensing, technology transfer, up scaling, commercialisation and safeguards. Strengthening the IPR management skill is the need and is an integral part of prudent business strategy to capture a larger part of the benefit stream generated by innovation activities.

It can be concluded that widening role of IPRs in governing the ownership and access of innovation, information, and knowledge makes business critical in ensuring that agri-based ventures benefit from the introduction of new technologies that could radically alter the welfare of end users.

South Asian lead country like India has become innovator and producer of new product, process and services therefore effective protection and management of Intellectual Property assets demands high priority to compete in international markets. Business houses should identify and use appropriate IP tool and complement it with relevant product differentiation, business and marketing strategies. As the evidence in **Box 14** suggests, failure to improve IPR practices, in agri-based industries, will eliminate them from significant development opportunities and potential business gains.

Box 14. Patents fostering Innovations

Pray and Naseem examined the role of patents in the development and use of platform technologies for rice genomics research, plant biotechnology-plant transformation techniques and structural genomics and found that patents were important in inducing private firms to develop these platform technologies. They concluded that the development led to commercialization of more genetically modified (GM) varieties more rapidly than would have been the case otherwise. The net impact of patents on research tools was found to be positive as they have stimulated research on these tools that have led to major increases in their technical efficiency. The evidence suggested that the benefits from patents on tools outweigh the costs.

Source: Pray and Naseem, AgBioForum (2005)

Government should create a healthy eco-system for IPRs in country by providing incentives and low cost services to start-up and SME sector on all matters concerning Intellectual Property with emphasis on access to information contained in Patent documents for technological advancements in food industry. Effective enforcement mechanism by the Government is also needed to attract companies' investment and to establish a smooth and functional IPR regime in agricultural sector.

3. Emerging Areas of Innovation in the Agricultural Sector

Innovation and Technology go hand-in-hand and hence in the context of the theme of the conference, *Seeding Success through Innovation and Technology,* it is important to understand the key drivers, technologies and processes that shall foster innovation in the agriculture and food processing sector. The previous section gave a detailed overview of the critical mechanisms that are required in order to enable establishment of an adaptive innovation system to foster innovation in the agricultural and agribusiness sector. This section looks at the innovative technologies, technological opportunities and challenges that shall form the backbone of successful AIS, established on strong mechanisms for fostering innovation.

3.1 Mechanisation for Fostering Innovations in Agricultural Sector

Mechanisation and innovations in mechanisation and machinery is a critical technology input towards establishing and enabling successful AIS. Continuous innovations in mechanization and machinery are required at various stages of the agricultural value chain and beyond in order to keep pace with the demands of market-led agricultural development.

Agricultural mechanisation in India is linked to market-led agricultural development

The progress of agricultural mechanization in the country has been closely linked with the overall development in production agriculture. Until 1950, very few farmers possessed prime movers like tractors, engines and motors. Heavy agricultural tractors and machinery were imported by government organizations mainly for land reclamation and development of large government farms. The picture changed quickly during the early sixties with the introduction of high yielding varieties of wheat and other crops, which needed irrigation facilities. The progressive farmers soon realized that the traditional water lifts, which were driven by draught animals or operated manually, could not meet the water requirement of the high yielding varieties of different crops. Lift irrigation was, therefore, quickly mechanized through the use of electric motor or diesel engine powered pumps.

The rising production of food grains resulting from the extending area under high yielding varieties could not be handled within the normal harvesting and threshing periods. The farmers in North India suffered heavy losses as a result of damage to harvested wheat during the late sixties and early seventies because the threshing of increased wheat production could not be completed before the onset of pre-monsoon rains. Large scale adoption of threshers operated by electric motors, engines and tractors that followed in early seventies onwards was a result of the need to complete threshing operation quickly. Then came the extensive use of tractors for primary tillage and transport and the use of tractor powered or self-propelled harvesting equipment[18].

Farm mechanization helps in effective utilization of inputs to increase the productivity of land and labour. Besides, it helps in reducing the drudgery in farm operations. Equipment for tillage, sowing, irrigation, plant protection and threshing has been widely accepted by the farmers. Even farmers with smallholdings utilize many improved farm equipment through custom hiring to

[18] Retrieved from http://www.centroesteroveneto.com/pdf/Osservatoriopercent20Mercati/India/Ricerchepercent20dipercent20Mercato/2009/Agriculturepercent20Machinerypercent20Sector.pdf on October 24, 2012

ensure timeliness of farming operations. The present trend in agricultural mechanization is for high capacity machines through custom hiring and for contractual field operations. However, mechanization of horticulture, plantation crops and commercial agriculture is yet to be introduced in the country. The pace of farm mechanization in the country accelerated with the manufacture of agricultural equipment by the local industries.

Status of Farm Mechanization in India[19]

Even though farm mechanisation shows an increasing trend, there are wide ranging disparities in the levels of mechanisation across states.

- Northern States such as Punjab, Haryana, Uttar Pradesh (particularly Western and Tarai belt) have achieved a faster growth in mechanization.
- The pace of mechanization in North-Eastern States has not been satisfactory due to constraints such as hilly topography, socio-economic conditions, high cost of transport, lack of institutional financing and lack of farm machinery manufacturing industries
- Mechanization in Western and Southern states of the country viz., Gujarat, Maharashtra, Rajasthan and certain areas of Tamil Nadu, Andhra Pradesh etc., has increased with the increase in area under irrigation and also with the growing awareness among farmer
- The sale of other implements and machines like combine harvesters, threshers and other power-operated equipment have been increasing almost throughout the country.

In this new scenario, agricultural mechanization[20] plays a double role:

- Allowing smaller and specialized/niche products farms to reach high quality levels as to enable farmers to increase their added value.
- Allowing larger farms to reduce their production costs, in order to let them better face international price-based competition.

Future Thrusts in Agricultural Mechanization for fostering Agricultural Innovation[21]

Majority of the farmers have limited surplus money to modernize farms or to invest in improved inputs. Mechanical power for tillage, irrigation, harvesting and threshing will be preferred, including options for on-custom hiring basis. As India was a signatory to the General Agreement on Tariffs and Trade (GATT), and a member of WTO, prospects of agro-export are likely to increase and in order to meet the product quality standards stipulated under WTO, more and more farmers need to adopt modern agricultural production technologies.

India's agricultural equipment industry has a diverse product portfolio, which caters to requirements across the value chain (**Table 3**).

[19] Retrieved from http://www.agrievolution.com/atti/ficci.pdf on October 24, 2012
[20] Agrievolution (2008). 'First world Summit on agricultural machinery.'
[21] Retrieved from http://agricoop.nic.in/Farmpercent20Mech.percent20PDF/05024-09.pdf on October 25, 2012

Table 3. The agricultural equipment industry activities across the value chain

Land development, tillage, seed bed preparation	Sowing and planting	Weeding, inter cultivation, plant protection	Harvesting and threshing	Post-harvest and agro processing
1.Tractors	1.Drill	1.Shovel /Plough	1.Harvester	1.Seed extractor
2.Levelers	2.Seeder	2.Harrow	2.Thresher	2.Dehusker
3.Ploughs	3.Planter	3.Tiller	3.Digger	3.Huller/ Dehuller
4.Dozers	4.Dibbler	4.Sprayer	4.Reaper	4.Cleaner
5.Scrapers	5.Transplanter	5.Duster	5.Sheller	5.Grader
			6.Sickle/ Dao	6.Mill
				7.Dryer

Source: IBEF[22]

However, tractors, tractor-driven devices and tillers are the main products of the organized market. The future agricultural mechanization technology package therefore may have to:

- be eco-friendly utilizing land water and bio resource catering to the varied group of farm holders,
- facilitate farming operations which are arduous and hazardous,
- increase productivity and conserve resources through effective utilization of chemical, biological and mechanical inputs, and
- Modernize commercial agriculture to facilitate agro-export.

Keeping in mind the above objectives, the mechanization policy may have to be distinctly different to serve hill agriculture, low lying water logged soils, rainfed and irrigated lands and regions having agro export potential.

Hand tool/machines

Hand tools for handling of soil, improved sickle, weeder, sprayer, duster, sheller, decorticator, etc., are being manufactured by unorganized and organized sector and these are being used within the means and resources of the farmers.

- The quality of the existing equipment will further improve as demand picks up and general quality consciousness increases among farmers.
- Tools for horticulture and forestry will have growing demand.
- The present gap in their availability could attract manufacturers to import these. This would prompt manufacture of better design and better quality tools in India.

[22] Retrieved from http://www.ibef.org/download/Agricultural_Equipment_171109.pdf on October 25, 2012.

Tractors, Power Tillers, Diesel Engines and other Agri-Machinery

➢ Tractors

The export of tractors from India has been growing, particularly to Africa, and many Asian and CIS countries. The tractor manufacturers are aware of these possibilities and some of them have already taken steps to make their products more export worthy through their own R&D and joint ventures (**Box 15**).

Box 15. Polycentric Innovations from MNC R&D in India

John Deere developed a new, low-cost series of tractors for Western markets, the 5003 series designed by a team of Indian and US engineers in Deere's research facility in Pune, India. The series was inspired by the success of the Indian tractor maker Mahindra & Mahindra in selling tractors in the United States to a market Deere had largely ignored. This product targets hobbyists and bargain hunters who do not require advanced features and want two key qualities that Indian farmers also value, affordability and manoeuvrability.

Deere, taking a cue from Mahindra, in 2002 transplanted a slightly modified version (with softer seats and higher horsepower) of the Indian line of tractors, which it markets as the 5003 series in the United States at a starting price of $14,400. Today, about half the tractors that Deere manufactures in India are exported overseas. Deere is reaping financial benefits from transplanting Indian innovations, born out of *frugal engineering* that minimizes cost with greater efficiency, to the United States and other Western markets.

- The present tractor use in India is limited to tillage, transport and stationary operations and, thus has a lower annual utilization.
- In future, use of tractors will extend from primary to secondary operations like sowing, spraying, intercultural, harvesting, agro-forestry, tree harvesting, plantation, land development, excavation for drainage, mulching, drilling etc. These will require introduction of specialized tractors.
- The latest package of computer integrated flexible manufacturing system will be economical and provide better industrial environment which will foster new process in the approach of agricultural operations.

➢ Power tillers

The demand for Power tillers has not picked up in the country due to availability alternative power sources. However the demand still exists and the following concerns need to be addressed:

- For mechanization of hill agriculture and orchards, lightweight power tillers with matching equipment for different farm operations would be required.
- The present designs may not suit this requirement and, therefore, more suitable designs, including imported machines, should be introduced with adequate incentives and credit support to popularize their use.

➢ Irrigation equipment

Demand for irrigation equipment including drip and sprinkler is increasing, particularly in water deficit regions.

- The drip system is likely to increase for application of chemicals and fertilizers.
- Solar photovoltaic pumps and windmill pumps have potential especially for drip irrigation systems.

- Electric motors or diesel engines operate the pumps. While quality of electric motors is satisfactory, the farmers continue to use horizontal and vertical type diesel engine operated pumps. These engines, though cheap, have higher operational costs due to poor quality and life, and high fuel consumption.
- Efficient lightweight diesel engines have to be developed, manufactured and promoted.

➢ **Power operated agricultural machinery**

Machines for primary and secondary tillage operations, of varying quality, are commercially available to meet the farmer's needs. In the absence of quality promotion measures, the quality of these machines is rather poor.

- A policy should be devised to promote the manufacture of these machines conforming to BIS specifications, and their sales subject to BIS quality certification.
- Several designs of sowing and planting machinery have been developed and commercialized. The utility of these machines in rainfed agriculture has been demonstrated adequately.
- The R&D Institutions and BIS should work together to screen the designs for their standardization to promote manufacture of good quality implements.

➢ **Machines for transplanting/planting**

Transplanting of Rice, Sugarcane, Vegetables and Trees are yet to be developed to an acceptable level before these are taken up for commercial production and adopted by farmers.

- R&D Institutions and industries should take this up on priority. Initial importation may accelerate the pace of development.

➢ **Machines for application of manure and liquid nitrogenous fertilizers**

Equipment for application of manure and liquid fertilizers are not available in India. Handling and application of biogas slurry is also manual.

- These require special attention of R & D Institutions.

➢ **Plant Protection equipment**

Hand and power operated machines are manufactured by large number of industries some of which have obtained ISI certifications.

- Machines for tall crops and trees including Ultra Low Volume (ULV) and electrostatic sprayers are yet to be taken up for manufactured by the industries. The development of horticulture sector is likely to increase the demand of such sprayers.

➢ Reaper harvesters

The power tiller, self-propelled reapers and reaper attachments for power tillers can provide an economical alternative for farmers who cannot afford combine harvesters due to economic and land topography reasons.

- The pace of development and adoption of reaper is slow which needs to be accelerated.

➢ Combine harvesting and other harvesting equipment

Combine harvesting is in vogue in some States and the industry is capable of meeting the present demand. The combine harvesting at present is limited to cereal crops only. However, most of the straw is left in the fields and burned.

- Alternative straw handling and disposal technology may have to be developed and promoted, as burning of straw is creating environmental pollution and farmers are losing valuable animal feed material.

Maize, sorghum, cotton, potato, peanut, sunflower, safflower, soybean and pulses are predominantly harvested manually. Large and commercial farming of these crops would require alternative harvesting and handling machinery.

- Initially demand could be met through limited importation, which will lead to local adoption and manufacture.

Similarly, harvesting of fruits has to be mechanized for timely and damage free harvesting. Their use will also reduce danger and drudgery involved in fruit harvesting.

- A suitable strategy and programme should be put together for selection of appropriate designs, their field evaluation, design optimization and manufacturing in India.

➢ Threshers

Threshing technology is well accepted by the farmers. The demand for cheap threshers led to design of threshers with inadequate safety measures resulting in large number of fatal accidents. Subsequently, the Government enacted the *Dangerous Machine (Regulation) Act 1983*. Since, the agricultural machines are manufactured by unorganized sector; the enforcement of the Act has been difficult.

- A policy decision should be taken to make it mandatory to display the manufacturer details/source of origin of the machinery for ensuring adherence to minimum safety standards by the manufacturers.

➢ **Specialized farm machinery**

Machines for land development, excavation for drainage channels, mulching, trench cutting and posthole digging are not commonly available. Fodder production, tree felling, pruning etc. are performed manually. In the absence of machines for such operations, even an assessment of their requirement is difficult.

- Limited introduction through importation may help in projecting their utility and creating the likely future demand.

➢ **Quality Greenhouses**

With the shift in agriculture towards diversification and agri-business, substantial areas will go under horticultural crops. This will also help create an export market for good quality high value agri-products and provide better returns to farmers through more foreign exchange earnings. The green house technology offers ample scope for increasing productivity particularly of high value cash crops like exotic fruits, flowers and transgenic plants. Design of green house with environmental control mechanized cultivation and product-handling technology package will assume greater importance.

Challenges and Way Forward

Presently little effort has been made to mechanize hill agriculture, where there is tremendous potential of growing horticultural crops, flowers etc. In future, this calls for developing appropriate technologies for mechanization.

However, the constraints experienced in the growth of farm mechanization so far need to be dealt with so that the farmers are enabled to adopt new methods to produce more, to earn more through gains in productivity, quality of produce, higher prices, etc., for raising their standards of living and better life styles.

The critical constraint factors are:

- Reliability and quality of agricultural machinery.
- Availability of products, spare parts and after sales- services in close proximity.
- Availability of Bank credit on terms where currently the farmers have to mortgage both the equipment purchased and his land.
- Lack of effective consumer protection in rural areas for redressal of cases of product problems, and poor after-sales- services, etc.

3.2 Innovations in the Indian Food Processing Industry

The activity of food processing is one of the most important links in the agricultural value chain that enables value addition and reduction of post-harvest losses to agricultural produce. Food processing engages and impacts all the stakeholders involved in the AIS and is constantly involved in understanding the consumer and market needs (nutritional and aspirational) and delivering innovative products to satisfy these needs.

Food processing is one of the most heterogeneous sectors of manufacturing covering marine products, dairy products, grain, meat products, fruits and vegetables, sugar, edible oils, and beverages. This sector has, however, been one of the fastest-growing segments in manufacturing in the current year contributing 27 per cent to average industrial growth, more than three times its weight in the index of industrial production (IIP)[23]. Growth rates of some of the important products in this sector are indicated in **Table 4**.

Table 4. Rate of growth of output of key processed food products

(Percent)

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012 (Apr-Dec)
Sugar	30.8	15.2	-33.9	-6.0	30.2	38.3
Fruit Pulp	-22.4	87.0	-2.0	5.0	35.1	30.4
Fruit Juices	26.6	20.9	41.0	46.6	16.8	26.0
Cashew Kernels	64.8	8.4	-4.2	-0.9	-7.9	22.2
Instant food mixes	24.3	30.8	19.4	20.8	10.6	17.9
Mineral water	21.0	29.4	6.9	28.3	19.9	15.4
Chocolate	28.4	8.9	24.2	11.3	13.7	13.3
Malted foods	6.1	8.5	-36.8	-8.8	8.4	6.4
Butter	-6.2	4.8	3.4	-22.7	-4.7	0.1
Biscuits	14.1	-0.9	29.2	10.4	-1.4	-1.6
Frozen meat	-39.6	-12.9	76.8	27.4	-21.8	-1.7

Source: Ministry of Statistics and Program Implementation (MOSPI)

A vibrant agrarian and rural economy requires establishing forward linkages in the form of the food processing industries. Such linkages improve the income levels of the producers and help reduce wastages, which are crucial for food and livelihood security. A recent study by the Central Institute for Post-Harvest Engineering Technology (CIPHET) in 2010 has assessed that the post-harvest losses of agricultural products amount to around Rs.44,000 crore annually. The Ministry of Food Processing Industries formulates appropriate policies and implements targeted schemes to reduce wastage and increase value addition in the food chain (**Box 16**). By catalyzing investment in this sector, the Ministry has helped create employment opportunities and upgraded

[23] Ministry of Finance (2012). 'Economic Survey 2011-12'

human capital formation in the rural sector. Consumers are also benefitted by getting a wider and healthier choice of food products at affordable prices.

Box 16. Schemes of the Ministry of Food Processing (MOFPI), GoI

1. ***Infrastructure Development***
2. ***National Mission on Food Processing (NMFP)***

The Government of India has approved launching of NMFP main scheme for implementation through States/UTs during 2012-13 of the 12th five year plan. This scheme will be implemented as a new centrally sponsored scheme in all the States in the ratio of 75:25 (Govt. of India and States) except for North Eastern States, where the ratio would be 90:10. All the UTs would be funded on 100percent grant basis. During the 1st year of the 12th Plan (2012-13), only those components will be implemented by the state governments / UTs, which were part of the 11th Plan central sector schemes implemented by the Ministry, following the old guidelines. Necessary changes will, however, be made when the proposal for full-fledge scheme is placed before the competent authority for approval for the remaining period of 12th Plan. During the first year of 12th Plan (2012-13) the states will implement the following components:-

(i) Technology Up-gradation/ Establishment/ Modernisation of Food Processing Industries.
(ii) Cold Chain, Value Addition and Preservation Infrastructure for non-horticultural produce.
(iii) Human Resource Development.
(iv) Scheme for Promotional Activities

3. ***Setting up/ Up-gradation of Quality Control/ Food Testing Laboratory/R & D and Promotional Activity***
4. ***Strengthening of Institutions***

Source: *Ministry of Food Processing Industries, 2012*

Trends in calorie intake and consumption pattern to guide innovations in the food processing industry

➢ Trends in calorie intake

A look at the trends in percentage break-up of calorie intake by food group on an all-India basis gives us an indication of the consumption pattern of different food categories in the country and also shows the opportunities the exist for the food processing industry to explore and develop new innovative nutritionally balanced food products to address the calorie needs of the Indian population. **Table 5** shows the percentage break-up of calorie intake over nine food groups – cereals, roots and tubers, sugar and honey, pulses, nuts and oilseeds, vegetables and fruits, meat, eggs and fish, milk and milk products, oils and fats, and miscellaneous food products and beverages – for rural and urban India for four years spanning the period 1993-94 to 2009-10. The share of cereals in total calorie intake from the nine food groups has declined over the 16-year period by nearly 7 percentage points in the rural sector and by about 3½ percentage points in the urban areas. The share of oils and fats has risen by 3 percentage points in both sectors. The share of milk and milk products has grown by about 1.4 percentage points in the urban sector but only 0.6 percentage points in the rural sector. The contributions of vegetables and fruits, as well as sugar and honey, appear to be falling over time, especially in urban India, while the contribution of meat, eggs and fish shows a slight rise followed by a fall.

The share of energy intake contributed by cereals was about 60 percent for rural India and about 50 percent for urban India. Non-cereal food contributed about 40 percent of calorie intake in rural India. The percentage break-up of this part of calorie intake (the part coming from non-cereal food) was: oils and fats: 23 percent; miscellaneous food, food products and beverages: 20 percent; milk and milk products: 16 percent; sugar and honey: 11 percent; pulses, nuts and oilseeds: 11 percent; roots and tubers: 9 percent; vegetables and fruits: 7 percent; meat, eggs &

fish: 3 percent. Non-cereal foods contributed about 50 percent of calorie intake in urban India. The percentage break-up of this part of calorie intake was similar to that in rural India, though the share of roots and tubers was noticeably lower at 6 percent.

Table 5. Percentage break-up of calorie consumption: 1993-94 to 2009-10

(In percent)	Rural				Urban			
Share of calorie intake from food group	1993-94	1999-2000	2004-05	2009-10	1993-94	1999-2000	2004-05	2009-10
Cereals	71.03	67.55	67.54	64.16	58.53	55.05	56.08	55.01
Roots & Tubers	2.65	3.25	2.95	2.78	2.54	2.9	2.82	2.59
Sugar & Honey	4.8	5.14	4.78	4.61	6.21	6.15	5.69	5.66
Pulses, nuts & Oilseeds	4.92	5.46	4.98	4.54	6.05	6.86	6.68	5.94
Veg & Fruits	2.02	1.97	2.23	1.84	3.26	2.94	3.17	2.62
Meat, Eggs & Fish	0.68	0.77	0.76	0.72	1.02	1.12	1.05	1.00
Milk & Milk Products	6.15	6.17	6.42	6.79	8.00	8.23	8.61	9.37
Oils & Fats	5.34	7.37	7.36	8.53	8.79	11.24	10.58	11.92
Misc. food, etc.	2.41	2.32	2.98	6.04	5.6	5.52	5.32	5.87

Source: NSS 66th Round Report, MOSPI, Government of India

- **Trends in consumption pattern**

As seen from the consumer expenditure data since 1987-88, the share of food is seen to have declined by about 10 percentage points to 53.6 percent in the rural sector and by about 16 percentage points to 40.7 percent in the urban sector over a 22-year period. Since the last quinquennial survey (held 5 years previously), the share of food has fallen by about 1½ percentage points in rural India and nearly 2 percentage points in urban India. Cereals have registered the largest decline in share among all the item groups – from 26.3 percent to 15.6 percent in rural India and from 15 percent to 9 percent in urban India (**Table 6**).

In the urban sector, practically all the food groups have suffered a decline in share. In the rural sector, beverages category shows a distinct rise in share, while pulses, edible oil, sugar, and salt and spices have shown a fall, and for other groups, the evidence is not very conclusive.

Table 6. Trends in percentage composition of consumer expenditure since 1987-88

Item Group	Rural					Urban				
	Share in total consumer expenditure in									
	1987-88	1993-94	1999-2000	2004-05	2009-10	1987-88	1993-94	1999-2000	2004-05	2009-10
Cereals	26.3	24.2	22.2	18.0	15.6	15.0	14.0	12.4	10.1	9.1
Gram	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1
Cereal substitutes	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
Pulses & Products	4.0	3.8	3.8	3.1	3.7	3.4	3.0	2.8	2.1	2.7
Milk & Products	8.6	9.5	8.8	8.5	8.6	9.5	9.8	8.7	7.9	7.8
Edible Oil	5.0	4.4	3.7	4.6	3.7	5.3	4.4	3.1	3.5	2.6
Egg, Fish & Meat	3.3	3.3	3.3	3.3	3.5	3.6	3.4	3.1	2.7	2.7
Vegetables	5.2	6.0	6.2	6.1	6.2	5.3	5.5	5.1	4.5	4.3
Fruits & Nuts	1.6	1.7	1.7	1.9	1.6	2.5	2.7	2.4	2.2	2.1
Sugar	2.9	3.1	2.4	2.4	2.4	2.4	2.4	1.6	1.5	1.5
Salt & Spices	2.9	2.7	3.0	2.5	2.4	2.3	2	2.2	1.7	1.5
Beverages Etc.	3.9	4.2	4.2	4.5	5.6	6.8	7.2	6.4	6.2	6.3
Food Total	**64.0**	**63.2**	**59.5**	**55.1**	**53.6**	**56.4**	**54.7**	**47.9**	**42.5**	**40.7**
Non-Food Total	**36.0**	**36.8**	**40.6**	**45.0**	**46.4**	**43.6**	**45.3**	**51.9**	**57.5**	**59.3**
Total Expenditure	***100.0***	***100.0***	***100.1***	***100.1***	***100.0***	***100.0***	***100.0***	***99.8***	***100.0***	***100.0***
*URP estimates shown except for 1999-2000, for which only MRP estimates are available										

Source: NSS 66th Round Report, MOSPI, Government of India

Given the above background of consumer trends in calorie intake across different food categories and also the scope of increasing consumer expenditure in foods, the Indian food industry has a major opportunity and role in addressing the nutritional requirements of the consumers and increase the share of the consumer spending's in foods, by tapping into the non-food expenditure with innovative products, technologies and processes and needs to focus on the following key areas:

Focus areas for innovation in the Indian food processing industry

- **Research with focus on unravelling indigenous knowledge** in the area of health and nutrition to provide data and new concepts on how to build successful nutrition promotion programs addressing the needs of the local population is one of the areas that needs to be strengthened leading to innovations in the food processing industry.
- The great diversity of cultures and ecosystems known and used by rural indigenous people contains a wealth of knowledge on biodiversity of foods, many of which are now threatened with extinction in the face of technological advancement. **Understanding the nutrient composition and nutraceutical benefit** of these often unique foods and cultural practices for their harvest, preservation and preparation is required in order to revive their use and develop innovative processes and products.

- Consumers are turning to online sources for product information especially on nutrition. Consumers rely on various sources such as retailer sites, mobile apps, blogs, and shopper and diet information sites to communicate with consumers. With growing customer awareness on the importance of nutrition and health, it is essential to **develop innovative mechanisms for cataloguing and accessing nutritional information**, especially relevant to the Indian food products.
- Innovation in the food processing industry is mostly lead through value addition. Value addition can be achieved through interventions starting at the farm level. **Innovative basic infrastructure related to post-harvest management practices and technologies** for efficient primary processing, sorting and grading of farm produce capable of reducing postharvest losses should be explored. The food processing industry should be a major stakeholder in implementing such initiatives. Such initiatives need to be linked to **institutional innovations** like farmers cooperatives that can provide the farmers with the strength and capacity to engage with different stakeholders in the value chain and enhance their ability to directly bargain for the right price of their produce.
- Value addition in the food processing industry should also be understood in the context of growing consumer perception of food as a source of **health beyond nutrition**. The success of any food processing industry is defined by its ability to quickly identify and address this consumer demand, through development of innovative food products. New product development through modification of existing products, new innovative products such as: sugar and fat replacement products, natural (additive free) low glycaemic (diabetic friendly products), low sodium products, antioxidant rich products capable of preventing cardiovascular diseases, cancer etc., shall be the focus of innovation in the food processing industry.
- In order to deliver new innovative food products addressing different platforms of health and wellness as well as convenience the food processing industry shall be exploring new innovative application of processing technologies. **Innovative use of both traditional and new processing technologies** such as irradiation, high pressure processing, microwave drying and cooking, super critical carbon dioxide extraction etc. shall form the basis of such innovations in food product development as well as preservation.
- **Access to mass production technologies** shall be driving innovation in the food processing sector. This is clearly evident in the Indian milk product market which is estimated at Rs 65,000 crore[24]. This market is the largest in value after liquid milk and is estimated at US$3 billion in India and US$1 billion overseas. Around 900,000 tonnes of *khoa* valued at Rs. 45,000 million and 1,200,000 tonnes of *channa* valued at Rs 6,000 million is produced in India under the milk product category.
- A major trend in the dairy sector in India is the **phenomenal growth of the traditional dairy product sector**. India ranks first in the world in milk production, which went up from 17 million tonnes in 1950-51 to 121.84 million tonnes in 2010-11. The per capita availability of milk has also increased from 112 grams per day in 1968-69 to 281 grams in 2010-11. However, world average per capita availability was 284 grams per day in 2009-10 compared to 273 grams per day for India[25].
- In addition the dairy sector is leading the **functional food revolution** in India with a range of probiotic product launches. Similar innovations in other product categories are needed for all other food product categories.
- However the dairy industry in India still needs to address some of the key challenges that continue to be a major area of concern: (i) **Reducing the cost of milk production** given the lower milk yields of Indian cows as compared to yields in other countries, (ii) **Reducing the cost**

[24] Retrieved from http://www.fnbnews.com/article/detnews.asp?articleid=32702&sectionid=40 on October 23, 2012
[25] Ministry of Finance (2012). 'Economic Survey 2011-12'

on milk handling by looking at alternative models of milk processing by encouraging small dairies at taluka and district levels and (iii) **Production of clean milk** which is presently carried out in unhygienic conditions at the dairy farms, in the unorganized sector, resulting in poor quality milk in India. Such products cannot be exported even if there is good demand and surplus production in the country. Keeping the animals clean, maintaining clean surroundings, use of clean vessels for milking and storage of milk are essential to maintain the quality of milk. There is also scope for introducing a small scale bucket type milking machine which is cost effective and helpful to produce clean milk without any direct contact with the farmers and the surroundings[26].

- **Innovations in Food Safety, Quality Control and adherence to International Food Safety** standards is mandatory for improving the export of both unprocessed and processed food products from India. These efforts will help in achieving the quality standards of foreign countries comprising of European and other developed countries. Adherence to food regulations of different countries is essential in line with WTO sanitary and phytosanitary measures agreement (**Box 17**). Further, the Food Safety and Standards and Authority of India (FSSAI)[27], has been established under Food Safety and Standards Act, 2006 which consolidates various acts & orders that have hitherto handled food related issues in various Ministries and Departments. FSSAI has been created for laying down science based standards for articles of food and to regulate their manufacture, storage, distribution, sale and import to ensure availability of safe and wholesome food for human consumption.

Box 17. Sanitary and Phytosanitary requirements and quality standards

- WTO provided an International framework by adopting Sanitary and Phytosanitary Measures (SPS). Sanitary and Phytosanitary standards, as covered under the SPS agreement include health, hygiene standards or regulations to avoid the spread of animal and plant diseases and epidemics. These have been adopted by the Codex Alimentarious Commission (CAC) of Food and Agriculture Organization (F.A.O.) and World Health Organization (W.H.O.). WTO member countries are encouraged to use International standards by framing their own laws, regulations, etc. India being member of W.T.O, is also adopting these regulations.
- The Agricultural and Processed Food Products Export Development Authority (APEDA) has also been taking various steps for promotion of quality and its control. APEDA provides assistance in the form of subsidy up to 25 percent for setting up laboratories for analyzing quality parameters like pesticide residue, metal content, etc. APEDA also promotes quality control by giving 50 percent subsidy for installing quality management, quality assurance and quality control systems such as ISO series, HACCP, TQM, KOSHER,BRC,GAP, Organic Certification and ERP based traceability etc. including consultancy, quality improvement and certification etc.

Source: APEDA, 2012

Innovations in the Indian Food Packaging Industry

The Indian packaging industry is growing at the rate of more than 15 percent pa and expected to touch US$ 14 billion (€ 11.2 billion) in the present financial year (2011 – 2012)[28]. Further, the growth is expected to double in the coming two years. Packaging plays an important role in the launch of new products. In India the retail sector is driving the innovations in the packaging industry. The growth of the packaging industry in India is driven by the growth in demand for Fast Moving Consumer Goods (FMCG), especially in the second-tier cities. All major FMCG

[26] Retrieved from www.baif.org.in/doc/Livestock_Devt/WTO%20Challenges%20for%20Indian%20Dairyl%20Farmers.doc on October 29, 2012

[27] Retrieved from http://www.fssai.gov.in on October 23, 2012

[28] Retrieved from http://www.fnbnews.com/article/detnews.asp?articleid=31985&sectionid=1 on October 23, 2012

companies are involved in aggressive advertisement and market launches of new innovative products, involving innovative packaging concepts. With India now being party to WTO, there is also the need to comply with international standards, and hence the Indian packaging industry has to align to the international packaging standards. This is possible through new innovations and introduction of innovative technologies by the packaging and allied industries.

The food packaging industry in India has tremendous growth potential as the country's per capita consumption of packaging still stands merely at 0.3 kg, far below Japan's 15 kg, Australia's 13.5 kg and USA's 13 kg. The industry has been growing at a healthy CAGR of above 15percent during the past several years. The domestic consumption of food & beverage (F&B), milk, vegetables, food grains and pharmaceuticals has given strong impetus of the packaging industry and is expected to maintain the same trend in the future. In addition, the processed food segment is supporting the industry through its heavy demand for tinplate and foil packaging materials. Some of the key highlights of the packaging industry in India are as follows:

- The total demand of F&B packaging segment stand at around $ 16.2 billion and accounts for around 85 percent market shares followed by pharmaceuticals and other market segments. At present, flexible, rigid and metallic food packaging metallic food packaging materials account for around 55percent of the total food packaging material market, while printed cartons and rigid packaging segments together represent 28 percent market shares in value terms. Flexible materials such as food packaging laminates, flexible packaging foils, cookies packaging etc. constitute close to 24 percent of the overall packaging material market followed by rigid food packaging material segment.
- The total import of India's food processing and packaging machinery in 2010 was approximately 360 million Euros. However, the increasing investments by both domestic and foreign companies in the Indian food processing sector, especially in beverages, dairy products, processed food, edible oil, and marine products have expanded the market for packaging machinery. India processes only 2 percent to 3 percent of its food produce that explains the scope for expansion of the packaging industry.
- In India's packaged food segment, dairy led the market with a share of around 11.2 million tonnes. It was followed by bakery products (3.5 million tonnes), oils and fats processed food (0.7 million tonnes) and confectionery (0.2 million tonnes).
- Packaged dairy industry is expected to reach 15.6 million tonnes by 2014, whereas bakery will touch 4.2 million tonnes by 2014, Likewise oils and fats will contribute 2 million tonnes dried processed food 1.2 million tonnes and confectionery 0.4 million tonnes by 2014.

Key drivers of Innovation in the packaging industry

- The organized retail market has received a boost with the government having recently approved 51 percent Foreign Direct Investment (FDI) in multi-brand retail. The growing middle class population rising health consciousness and competition from the West is the key drivers for packaging and packaging machinery industry in the country.
- The packaging industry in India is a heterogeneous mix of both organized and unorganized sectors. The industry comprises a large number of manufacturers of basic materials, converted packages, machinery and ancillary materials. Domestic demand for packaging has been anticipated to flow by over 100 percent within the next 5 years.

- The industry is gearing itself to adopt new, innovative, scientific and functional packaging. The market is expected to grow at an average annual growth rate for 10 percent over the next five years. In India, packaging machinery manufacturers find most of the demand for their products in the food processing sector. Approximately 50 percent of the packaging machinery and materials produced is absorbed by the food processing sector, personal products constitute 1 percent, the tea and coffee industry 10percent and industrial products account for the remaining portion of the demand.
- Another factor, which has provided substantial stimulus to the packaging industry, is the emphasis for the rapid growth of exports. The export policy has been placing emphasis on value addition. With this, the need for adopting better packaging methods, materials and machinery to ensure quality, has become a priority for Indian food products in the international market which demands high quality standards. The packaging machinery manufacturers and packaging material producers are integrating their efforts to meet the future needs of the rapidly developing domestic and export markets. Imports of packaging machinery to India are currently estimated at approximately US $ 172 million (€139 million). The major equipment suppliers to the Indian markets include Germany with a 42 percent share, Italy 20 percent share, the US 10 percent, Switzerland 8percent and other including Taiwan, the remaining 20 percent.

Innovations in food packaging need to address the following important functions[29]

1. **Containment:** Most products must be contained before they can be moved from one place to another. To function successfully, the package must contain the product. This containment function of packaging makes a huge contribution to protecting the environment. Faulty packaging (or under packaging) can lead to spillages and result in major losses and serious damage.
2. **Protection and Preservation:** Packaging plays a vital role in protecting products as they go from the manufacturer to the consumer. Packaging is designed to ensure that the product reaches the consumer in good condition. The product is protected during transport and distribution; from climatic effects (heat and cold, moisture, vapour, drying atmospheres); from hazardous substances and contaminants; from infestation.
3. **Supplementary Product Protection:** Packaging can also provide supplementary product protection. This may be achieved by forms of cushioning such as shredded papers, sheets of corrugated paperboard, foamed plastic or wrappings. Packaging therefore contributes to food safety, quality and nutrition. Packaging technology has made major contributions to advancing food science and food safety and reduction of food spoilage.
4. **Communication:** 'A package must protect what it sells and sell what it protects'. Modern methods of consumer marketing would fail were it not for the messages communicated on the package. The information provided on packaging allows the consumer to make informed decisions on the product's purchase and use.
5. **Convenience:** Packaging plays an important role in allowing products to respond to the demands and needs of modern consumers. Frozen food packs, microwavable containers, wine cardboard casks, easy-open beverage and food cans, innovative packaging for

[29] Retrieved from http://www.centroesteroveneto.com/pdf/Osservatoriopercent20Mercati/India/Ricerchepercent20dipercent20Mercato/2009/Packagingpercent20Industry.pdf on October 26, 2012

handling ready-to-eat and drink foods and beverages on the go, and aseptic cartons are good examples of convenience packaging. These types of packaging reflect the demand for convenience and quick food preparation in a way that guarantees freshness.

6. **Environmental Aspects:** Packaging reduces the amount of waste going to landfill. Without the benefit of packaging to preserve food, a higher proportion of food would become spoiled and consequently consigned to garbage collection for land disposal. When the food is packaged, the unwanted portions such as skins, outer leaves and trimmings, remain at the processing point where they can be economically recovered and used in the manufacture of valuable by-products.
7. **Reduction of Pilferage:** Packaging of a wide variety of products sold from self-service counters is designed to reduce stealing. The product may be sold in a blister package sealed to a large paperboard backing. The large card makes the package more difficult to conceal and steal. Other examples of security packages are lock-on caps and tamper proof closures.
8. **Marketing Trends:** Marketing trends are placing increasing emphasis on the look, sales appeal and quality of retail packaging. Packaging helps sell products by providing product differentiation and presentation, greater brand awareness and convenience. The continuously changing demands of consumers will require higher quality graphics and promotional links between graphics and advertising to support brand identities, plus the ability to reflect current consumer trends and images.
9. **Intelligent and Active Packaging:**
   There is an important distinction between package functions that are smart/Intelligent, and those that become active in response to a triggering event, for example, filling, exposure to UV, release of pressure etc. and then continue until the process is exhausted. In 'intelligent' packaging, the package function switches on and off in response to changing external/internal conditions and can include a communication to the customer or end user as to the status of the product. A simple definition of intelligent packaging is 'packaging which senses and informs'. Some smart packaging already exists commercially and many other active and intelligent packaging concepts are under development. Examples of active packaging concepts are Oxygen scavenging, Anti-microbial, Ethylene scavenging, Heating/cooling, Odour and flavour absorbing/releasing, Moisture absorbing, Time-temperature history, Microbial growth indicators, Light protection (photochromic), Physical shock indicators, Leakage, microbial spoilage indicating

3.3 Biotechnology in Agriculture

Since the days, some 10,000 years ago, when humans first began to save the seeds of one plant variety and discard those of another, they favoured the ones that produced the plumpest grains, the earliest maturities, the highest yields. They also selected hardy specimens, varieties that could withstand the heat and the cold and all the blights that cursed and killed their crops. They were farmers, but they were also seed scientists, consciously transforming wild grasses into harvestable grains.

With the advent of modern biotechnological tools, this trend of innovation has become easier, by adopting integrated strategies that include breeding for resistance, the judicious use of biological, crop management and chemical control methods. With the growing population and ever-growing

challenges of agriculture, increasing the productivity and income per unit of the scarce natural resources is possible only through understanding, integrating and deploying new advancements in science and technology in agricultural production. For a developing economy like ours, it therefore, becomes essential to use the well-established technology platforms by creating newer biotechnology based solutions and industries.

Biotechnology can create competitive advantage and commercial success for farmers and agricultural industries as well as benefit rural communities. Mapping research themes to specific sectors in the agricultural value chain will enable a rational assessment of the potential applications of biotechnology and genetics in the agri-food sector by identifying and prioritizing research needs across the agricultural value chain, and assessing the societal implications of this emerging technology. Various high-yielding crop varieties released till date have contributed substantially to improving agricultural productivity. However, new biotechnological innovations have the potential to provide solutions by giving a make-over to the existing cultivated varieties. Availability of genome sequences of more and more crops, investigation of the alteration at transcriptomic, proteomic and metabolomic level, whole genome transcriptome sequencing, and RNA sequencing, are some essential biotechnological tools which can be exploited for crop improvement and enhanced production. Genetically engineered or "Biotech" crops have a great potential to bring about the second green revolution in India, however the path towards adoption of these crops in India is not been easy (**Box 18** [30,31,32]).

In addition to Bt cotton, several Indian seed companies and public sector research institutions are working on the development of various biotech crops, mainly for pest resistance, herbicide tolerance, nutritional enhancement, drought tolerance and yield enhancement. The crops currently being developed by public sector institutions include banana, cabbage, cassava, cauliflower, chickpea, cotton, eggplant, rapeseed/mustard, papaya, pigeon pea, potato, rice, tomato, watermelon and wheat. Indian seed companies are also focusing on cabbage, cauliflower, corn, rapeseed/mustard, okra, pigeon pea, rice and tomato, and next generation technologies (stacked events) for cotton. In 2011, field trials were conducted for castor bean, cotton, corn, rice, mustard, peanut, potato, and sorghum.

[30] Agricultural Biotechnology Annual, 2012. USDA foreign Agricultural Service, Global Agricultural Network Information (GAIN) Report Number: IN2098 retrieved from http://gain.fas.usda.gov/Recentpercent20GAINpercent20Publications/Agriculturalpercent20Biotechnologypercent20Annual_Newpercent20Delhi_India_7-17-2012.pdf on October 29, 2012

[31] Retrieved from http://articles.economictimes.indiatimes.com/2012-10-20/news/34606534_1_field-trials-gm-crops-gm-corn on October 29, 2012

[32] Retrieved from http://indiagminfo.org/wp-content/uploads/2012/10/SC-TEC-interim-report-oct17th-2012-GMO-PIL.pdf on October 29, 2012

Box 18. Status of Biotech crops research and use of biotech food/agricultural products in India

- Genetically Modified Organisms (GMOs) and products thereof including GM crops are regulated products in India under the "Rules for the Manufacture, Use/Import/Export and Storage of Hazardous Micro Organisms/ Genetically Engineered Organisms or Cells" notified by the Ministry of Environment and Forests through Notification No. 621 in Official Gazette of Government of India on December 5, 1989 under the provisions of the 'Environment (Protection) Act, 1986'. These rules and regulations commonly referred as 'Rules 1989' cover areas of research, as well as large scale applications of GMOs and their products.
- Bt cotton is the only commercially approved biotech crop in India.
- In 2010, the Government of India (GOI) announced a moratorium on the approval process for Bt brinjal (eggplant).
- In May 10, 2012, on the Writ Petition (Civil) no. 260 of 2005 of Aruna Rodrigues Vs Union of India, the Supreme Court of India instituted a six-member Technical Expert Committee to review and recommend biosafety risk assessment studies for genetically modified (GM) crops.
- This Technical Expert Committee has recommended stopping open field trials on all genetically modified crops until a new set of conditions is enforced and a ten year moratorium on field trials of Bt transgenics in all food crops.
- Under current Indian regulations, all biotech food/agricultural products or products derived from biotech plants/organisms must receive formal approval from the Genetic Engineering Appraisal Committee prior to commercialization or imports (the GEAC is India's apex biotech regulatory body).
- Soybean oil derived from Round-up Ready soybeans (glyphosate-resistant soybeans) is the only biotech food/agricultural product currently approved for import.
- In India processed food products derived from genetically engineered products (where the end-product is not an LMO - a living modified organism) do not require approval from GEAC for production, marketing, import and use in India. As processed food products are not replicated in the environment, they are not considered to be an environmental safety concern under the 1989 EPA. However, imports of products that are LMOs continue to be under the purview of GEAC and the 1986 EPA.

Similarly, with the use of emerging technologies like bio-prospecting of novel genes from stress tolerant plants as well as other organisms and allele mining would help combat the changing global climate. Such developments will help to extend crops to fallow lands, increase productivity and income, and enhance sustainability of agriculture in some of the most deprived regions. Development of diagnostics and vaccines for animal diseases, technology development for fish breeding, advances made in identifying beneficial microbial and fungal populations, popularization of vermi-compost technology, development and dissemination of technology in a wide variety of agricultural and allied disciplines etc., are some of the other achievements in the area of biotechnology.

3.4 ICT based Innovations & Agriculture

Farming is an important part of Indian economy and it involves a wide range of stakeholders, of whom the small holder farmers are the largest group. Information sharing on new production processes with the farmers was prominent in the sixties which was the key to the success of the Green Revolution. Agricultural extension, the process of enabling farmers and experts to exchange information with each other, has been institutionalized by now to a high degree and is assessed to be not as effective as it had been a generation back. The advent of digital, technology-mediated information and knowledge management was thought to offer significant new opportunities for Indian farming as a whole. These hopes led to the launching of a host of initiatives in different parts of India, which has emerged as the host of the largest number of rural development projects where contemporary information and communication technology play a pivotal role.

While analyzing the outputs of such initiatives, many studies have pointed out that farming is not a priority concern of most of them. On the other hand, we can notice a non-complimentary strand of ICT in agriculture projects operated by a number of institutions with ICT resources playing a key role in some of them. Almost two decades later, the original hope remains unfulfilled. The availability of digital content in relation to the farming sector is small when compared to equally important development sectors such as public health. This has considerably limited the opportunities for various stakeholders to build viable online services on production, marketing and meteorology for farmers and other stakeholders.

What we now have is a collection of project activities that are fragmented in their overall understanding and approaches. What we need is an approach that can bring together the two strands, namely, of ICT in rural development and ICT in agriculture. Such an effort, however, needs a new IT architecture to be built for aggregation of content and to make services available in multiple modes.

Two groups of projects in India, namely, the agropedia (**Box 19**) and KISSAN-Kerala, have built large prototypes and human capacities using unprecedented innovations in web technology areas and have been able to link these up with different modes of delivery including mobile telephony.

Box 19. agropedia: The Knowledge & Interaction Hub for Indian Agriculture

agropedia is a one stop shop for all information, pedagogic or practical knowledge related to extension services in Indian agriculture. agropedia is sponsored by the National Agricultural Innovation Project (NAIP), Indian Council of Agricultural Research (ICAR). Using state of the art practices and techniques of the semantic web, agropedia is a platform where both specialists in agricultural research and education domain and students and others interested in agriculture can make contributions to the knowledge base. The users have a choice to contribute towards the *gyan dhara* (certified content) or participate in the interaction space to contribute to *janagyan* (emergent knowledge). Thus, the users of agropedia are the architects of the knowledge, which is lifeblood of agropedia, and they do so through an easy to use and attractive web interface. agropedia has developed in two phases- Phase I concentrating on content development and development of the web platform and Phase II on the delivery platform for extension services.

Objectives:

- To develop an agricultural repository and to build a Digital Ecosystem in agricultural domain for proper knowledge circulation
- To prepare a bridge between Explicit knowledge holders (like agricultural researchers, scientist, experts) and Tacit knowledge holders (like farmers and other field workers)
- To deploy extension services for agricultural development

Source: *agropedia, 2012*

With their advent, a wider range of solutions to the challenge of developing a novel architecture for information services for farming in India are now feasible and need to be researched upon.

Given that countries that offered models for extension in farming in an earlier generation do not require innovations for mass outreach for prosperity through farming, India needs to build solutions, processes and structures of its own so that the advantages accruing from its export oriented IT sector can flow to the benefit of its farmers. There is a task to be accomplished, contrary to the prevalent understanding in the leadership of farm education, research and extension sector that all the ICT solutions needed are available. Technology will drive the future growth in Indian agriculture.

In order to push the frontiers of productivity, generation and harnessing of state-of the-art agricultural technology becomes inevitable. India currently uses technology of the first green revolution era which is seed-fertiliser intensive. Plant breeding techniques have been extensively used in agriculture to develop high yielding varieties for drastic improvement in production. Similarly crop improvement technologies, crop protection technologies and machinery-based technologies are used. The common technology outreach mechanism used still continues to be agricultural extension services of agriculture departments and universities. Recently many states have also introduced IT based outreach mechanisms. The private sector has a vital role in filling up the void of the extension services through use of ICT.

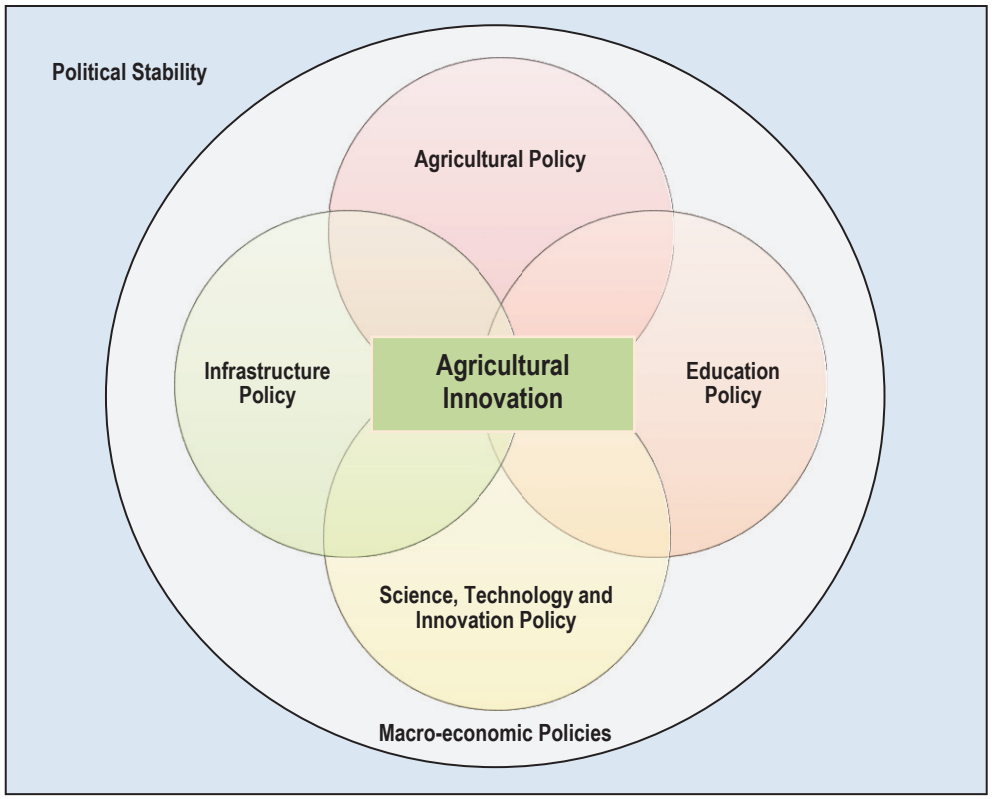
4. Role of Policy in Creating an Enabling Environment for Agricultural Innovation System

As elaborated earlier, the innovation system should not be a source of supply driven interactions. Rather, the system should be developed within an enabling environment that allows for two-way flow of knowledge and information, which leads to generating more innovations and effective location specific-interventions. Capacity development of end-users of the innovations and technologies in terms of ability to access and share knowledge and learnings and ability to collaborate is therefore extremely important for developing such an environment. This capacity enhancement needs lot of coordination between public agencies, private sector and civil society, with the Government providing the overall support framework.

4.1 Need for Agricultural Innovation Policy

Sector specific innovation policies usually replicate the national level innovation policy, but will have lesser influence in the policies in other domain to suit their needs and condition. The role of policy for facilitating an enabling environment in the sector takes great importance as the factors that positively influence agricultural innovation are controlled by policy domains other than agricultural innovation policy. An agricultural innovation policy seeks coordination with these other domains to ensure that together they enable agricultural innovation. **Figure 7** shows the most relevant policy domains that shape agricultural innovation.

Figure 7. Policy domains and agricultural innovation



Source: The World Bank (2012)

Political stability is most vital for providing a conducive environment for other policies to operate. In a globalised market, macro-economic policies like taxation, market and trade policies etc play a major role on the relative competitiveness of the sector. Government has a critical role to play in strengthening the innovation ecosystem, providing policy interventions that strengthen knowledge infrastructure, create markets for innovations through the stimulus of Government procurement, improve inter-institutional collaborations, provide a mechanism for funding business innovations at all levels especially SMEs, and provide vision through a national level roadmap for innovations. To that end the Government of India had set up a National Innovation Council (NInC) with the mandate to formulate a Roadmap for Innovations for 2010-20 with a focus on inclusive growth[33].

At the meso-level (**Figure 7**), there are four policy domains that have direct influence on agricultural innovation. There is considerable overlap between the domains but as the scope of each domain is vast, it is important that the Agricultural Innovation Policy is able to effectively coordinate with the activities of these domains so that it creates the enabling environment for agricultural innovations to happen.

- **Agricultural Policy domain**: which deals with all issues of agriculture also needs to look at enabling farmers to access markets; market institutions and regulations therefore become important in such transformations.
- **Education Policy domain:** as elaborated earlier, agricultural education sector in NARS can be leveraged upon to promote agribusiness amongst agricultural graduates and youth. The effectiveness of agricultural extension machinery needs feedback from the end-users (farmers) to refine the mechanisms, for which farmers should be educated. Skill enhancements can also be thought about under tertiary agricultural education. Introducing vocational training in agriculture at school level can also advance agricultural innovations.
- **Science, Technology and Innovation Policy domain:** is becoming more relevant as the crucial role of innovation in transforming the economy has been realized. Research and extension services in the public agricultural sphere needs to change to accept this innovation philosophy into their work culture.
- **Infrastructure Policy domain:** plays a vital role as opportunities for innovations depends on adequate infrastructure like transportation modes, utilities and irrigation systems to name a few. High input costs and lack of such facilities cuts down on the profits and hinders agricultural productivity. Access to the market place is key to understanding and adopting new practices, technologies and scaling up innovations.

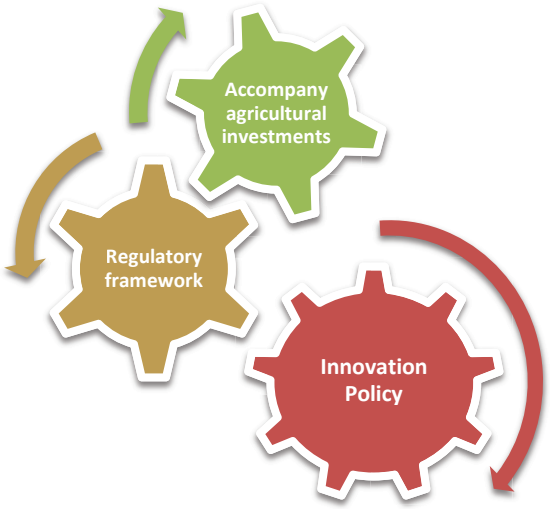
The key enabling factors in the wider agricultural policy landscape that is critical for developing an Agricultural Innovation Policy are broadly (**Figure 8**):

- *Innovation policy* and corresponding governance structures to strengthen the broader framework for agricultural innovation policies,

[33] Planning Commission of India. (2012). 'Faster, Sustainable and More Inclusive Growth: An Approach to the Twelfth Five Year Plan.' Retrieved, from http://planningcommission.nic.in/plans/planrel/12appdrft/appraoch_12plan.pdf on October 18, 2012

- *Regulatory frameworks* that stimulate innovation directly (such as IPRs, Biosafety) or indirectly (standards that stimulate trade) or steer innovation towards certain preferred outcomes (safer food),

Figure 8. Enabling factors for agricultural innovations



- *Accompanying agricultural investments* such as in rural credit, infrastructure (like roads, storage spaces), and markets will help in improving productivity, reducing market costs, increasing profit margins thereby opening up new opportunities for innovation.

These policies, investments, and regulatory reforms will trigger significant changes, such as improving the access of agricultural products to foreign markets, increasing private investment in agricultural R&D, and fostering the use of more sustainable agricultural practices. Policy measures will be needed to ensure that people are not left behind and make the transition to more promising economic activities.

4.2 Focus Areas for Policy Intervention

The critical areas for enabling innovation in Agricultural systems that need immediate attention of policy makers are highlighted in this section.

1. Curriculum change in higher Agricultural Education

Effective and quality higher agricultural education is essential for fostering innovation in agriculture and agribusiness. Demand for curriculum change should be expressed by the Agricultural Education and Training Systems and supported by key stakeholders. This is an important precondition for gaining support from the ministries-in-charge of education and agriculture as well as from planning and finance decision makers.

Policy issues

- Policies are required to support curriculum change, to make it clear that change is a priority.

- Policies to encourage educational institutions to monitor the quality and relevance of their programs in relation to the evolving needs of agriculture and rural development.
- Policies which provide guidance on governance of the educational institutions, especially the role of stakeholders in providing feedback on graduates' readiness for the modern agricultural workplace and in alerting the institutions to changing requirements for knowledge and skills.
- Establishment of systems that continuously and critically evaluate the programs of education institutions with respect to the changes in agriculture sector, the information from the system should flow continuously to decision and policy makers to update, upgrade, or create polices that give institutions authority to act.
- An essential policy that allocates funds to support change and ensures that such findings are sustained.

2. Agricultural Education and Training (AET) to support AIS

Sound polices are essential to address the recurring weakness of AET, but the weak and fragment AET fails to present an united front to gain the support from government or policy makers[34].

Policy issues

- Policies that reinforce agricultural education and training need to recognize agriculture's broad contributions to the economy: as a producer of basic and export commodities, source of employment, provider of nutritional health, and engine of poverty reduction. Policies should be updated as changes occur in the sector.
- Appropriate policy instruments, strictly enforced, which prevent political interference in the university administration. Because most agricultural universities, Technical and Vocational Education and Training (TVET) colleges, and training institutes are public entities, they are subject to political influence of one kind or another.
- Addressing the gender imbalance through appropriate policy that stipulates active recruitment, especially women. The policy should also support gender balance in the faculty and teaching staff of universities, TVET institutions, and training centers.
- Investment is uneven in research, extension, and education—the three pillars of agricultural knowledge and information systems. Policies should be in place to ensure that research, extension, and education work together to capitalize on their respective strengths and present a holistic picture of their interdependence in bringing knowledge and services to the sector.

3. Designing agricultural research linkages within an AIS Framework

Consensus is growing that new ways of conducting agricultural research are needed. To date, the operational implications of these changes and strategies for making them efficient, effective, and sustainable have not been addressed. Lessons on strengthening the connectivity between agricultural research and other innovation system actors are viewed through the lens of three types of economies—agriculture-based, transforming, and urbanized—and two strategies:

[34] The World Bank (2012). 'Agricultural Innovation Systems: An Investment Source Book.'

- Investing in "demand articulation" mechanisms to better identify the needs of different user groups
- Designing "organizational interfaces" that help transform research into real goods and services.

Cases are there for both market and non-market approaches to improving demand articulation and organizational interfaces. They include investment in formal mechanisms that provide stakeholder input to research organizations, more participatory mechanisms that bring researchers and farmers together to solve problems, innovation platforms that address larger, more complex challenges with diverse actors, commercialization programs that move research into the marketplace, and financing mechanisms that encourage collaborative research.

Policy issues

Most issues related to the policies and governance structures that enable research institutions to participate more successfully in the Agricultural Innovation Systems are as follows:

- Research organizations organize their personnel and assets by disciple, which is costly to bring together to solve the problems in agricultural value chains. To achieve sustainability, policies should be around managerial and structural reforms.
- To interface with other user groups, research organizations need considerable time, effort, and resources. To realize this, policies focusing on long-term support for institutional change and reforms will be amiable.
- Policies to create a climate that supports private sector participation, development and conducive investment environment.

4. Policies enabling Public-Private collaboration

Governments are minimizing direct intervention with the adoption of the market-economy model. Wherever appropriate, government delegates or contracts implementation to the private sector. E.g. In closing the rural finance gap, the preferred approach now is to involve commercial banks (often by subsidizing them to take on less profitable rural loans) or microfinance schemes rather than to establish government-owned rural banks. A primary objective of innovation policies is to create the right incentives for private investment in innovation. Governments can use five important instruments to stimulate private investment in innovation:

- IPR legislation
- Tax deductions and subsidies for R&D
- Antitrust legislation (because a competitive environment stimulates innovation)
- Subsidized risk capital (either directly or through tax deduction facilities) and business incubators
- Restraining bureaucratic procedures for introducing new products and technologies.

5. Policy issues related to co-designing Innovations: Research by engaging multiple stakeholders

The major policy issue in co-design innovation is strengthening the capacities of stakeholders and improving their ability to interact with each other and with their institutional and socioeconomic environment. Such interaction allow the visions and concerns of a specific

stakeholder group to become visible and legitimate to other stakeholders, and hence may eventually influence the scope and nature of the innovations being developed, the distribution of benefits among stakeholders, and other outcomes.

6. Social capital

Social capital, (the institutions, relationships, and norms that shape the quality and quantity of a society's social interactions) an enabling factor that often stands out as critical to stimulate innovation success in agriculture, is also fostered by appropriate policy support.

Policies featuring importance of social capital's role in the management of irrigation schemes, self-help groups in microfinance initiatives, communal road maintenance, the establishment of value chains, and similar efforts will foster agricultural innovations.

7. Policy issues related to promotion of Agricultural Clusters

A specific challenge to agriculture relates to common pool resources, in which exclusion of beneficiaries through physical and institutional means is especially costly and exploitation by one user reduces the availability of the resource for others[35].

Policy issues

- The most prominent policy issues concerning the agricultural clusters are power imbalances, social and environmental issues, as well as a need to define public versus private sector roles[36].
- Policy focusing on creating programs and projects that guarantee equal opportunity of access and competition with a view to sustaining the cluster.
- Policies that eliminate commercial interests of a cluster, that infringe upon local communities and their way of life, leading to social tensions and hampering the cluster's prospects.
- Potential externalities have to be factored into policies and programs and should reflect the interests of all potential stakeholders.

8. Policies for accelerating development of agribusiness enterprises through Business Incubators

The policy issues that arise most often with business incubators include their sustainability, the public sector's role in creating an environment in which business incubators can operate successfully, and adapting incubator models to address social concerns.

Specific policy instruments that governments can use to support incubators include tax incentives and early-stage soft funding such as grants. Since most incubators operate as nonprofit organizations, the public sector can play an important role in providing physical space for the incubator as well as financing to cover operating costs.

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[35] Ostrom, E., J. Burger, C.B. Field, R.B. Norgaard, and D. Policansky.1999. *Revisting the Commons: Lessons, Global Challenges.* Science 284(5412):278-82

[36] Parrilli, M.D. 2006. *Cluster Trajectories in Developing Countries: A Stage and Eclectic Approach Applied to Survival Clusters in Central America.* In Clusters and Globalisation: The Development of Urban and Regional Economies.

As explained earlier, business incubators can target specific sectors such as agriculture or certain segments of society, such as women entrepreneurs. Incubators that have a specific focus may require additional public support, given that they aim to serve a small sub segment of the market and not the market as a whole, which means that they are more challenging to sustain.

9. Investment in Extension and Advisory Services

Extension and advisory services are integral to the AIS, where now more than ever they play a brokering role, linking key actors such as producer organizations, research services, and higher education. For strong extension and advisory services, it is important to have coordination and linkage within the pluralistic, multi-stakeholder Agricultural Innovation System.

Policy issues related to pluralistic advisory services and extension include the changing roles of various extension providers, the comparative advantage for different providers in carrying out specific extension functions and advisory services, sustainability, and equity.

Policy issues

- **Proceed with extension system reform without relying on a single grand model,** as one model cannot accommodate all situations: Extension is to be location- and even value chain-specific.
- **Increase downward accountability** to farmer organizations
- **The enormous need for human capacity development** in management and implementation.
- **Move away from projects** to programs based on long-term vision and commitments.
- **Balance investments in extension supply and extension demand,** because both types of investment are needed for effectiveness (introduce new public management principles).
- **Move from standard packages to tailored services** provided at the right place, at the right time, and in the right format. Critical thinking and problem solving are integral to developing tailored services.
- **Address equity issues.** It remains a challenge to ensure that extension adequately reaches different groups of farmers and entrepreneurs: women, youth, the landless, resource-poor farmers, minority ethnic groups and castes, and others.

10. Evaluating AIS Interventions

Policy issues related to the evaluation of innovation system interventions are partly but not entirely similar to those for monitoring. Policy priority in evaluating agricultural system interventions are as follows:

- *Build capacity in evaluating innovation system interventions:* Innovation system interventions are relatively recent, the evaluation principle and approaches are not familiar and experience remains limited.
- *Clearly demarcate responsibilities for monitoring and evaluation:* Investors are not to be tempted to include the collection of impact evaluation data within the intervention, because the ultimate impacts may not emerge until sometime after the interventions ends.

- *Sufficient resources must be available to use a combination of evaluation methods:*As greater rigor in measuring impacts, investigating result chains, and testing the validity of theories of change. Inevitably, evaluations will take longer and cost more.
- To *benchmark innovation capacity developed in sectors and subsectors through innovation system interventions:* Benchmarking with international comparisons will track macro-level progress and help target subsectors, sectors, and countries for investments to strengthen innovation capacity or for other investments that require certain levels of innovation capacity as a precondition.

11. Poverty reduction and environmental sustainability

Improvements in agricultural productivity have been traditionally used to measure the impacts of investments in agriculture innovations; however, in recent years, environmental sustainability and poverty reduction has assumed equal importance. This has changed the perspective of assessing the investment in agricultural innovation and the investments.

Hence, policies that encourage enabling factors such as investments in rural infrastructure or rural credit, targeted far more specifically to poor will foster agricultural innovation; in the sense, innovation in itself is a crude poverty alleviations instrument.

12. Supportive financial system and mentoring

Access to finance is a crucial element in enabling the environment for innovations. Innovators need finance at the early stages to convert their ideas to prototypes and later models so as to test it in the market place. Venture capitals funds, Angel investors, Banks are some of the commonly mentioned sources of funds. However, given the risks involved in funding an idea/innovation in agricultural sector at such an early stage, there is an apprehension to fund them by agencies in India. The seed funding pipeline remains constricted though the venture capital industry has grown considerably. Mentoring the start-up ventures in handling their operations and addressing the market demands is also lacking in the current ecosystem.

The NInC's proposed move to setup an India Inclusive Innovation Fund for investing in enterprises engaged in providing solutions for the bottom of the pyramid that will help in the upliftment in the lives of the millions engaged with the agricultural sector is a welcome initiative. Mentoring is also being considered under this plan. The proposed move from the ICAR to setup more agribusiness incubators is also a welcome initiative, since the incubators can be used as the channel for delivering the funds for enterprises and innovators that has been nurtured by them.

5. Conclusion

The Indian agricultural sector needs to be revitalised to meet the demand of food and nutritional security of a growing population amidst challenging situations. While the first Green Revolution helped in meeting the production demands in the 1960s, the next revolution needs to focus on holistic development of the sector and sustainable in the long run. The key to revitalising the Indian agricultural sector lies in successfully establishing an *Agricultural Innovation System* based on a convergence strategy, in which the civil society, public and private sector comes together to develop solutions to sustain productivity, provide opportunities for innovation leading to growth of sector and thus boost the economy. The system should leverage on the strengths of each stakeholder and harness innovative technologies in order to reform the sector which will help in supporting the livelihood of millions of people engaged in the agricultural value chain.

The revitalised agricultural sector, including agribusiness and food processing, has to help the small and marginal farmers in sustaining their livelihood. It will need to provide end-to-end services to the farmer, linking him to the market and facilitating access to better technology and other resources. The dairy revolution in the country is a prime example of such an approach. An Inclusive Market-Oriented Development (IMOD) approach can revolutionise the agricultural sector and attract the youth to take up agriculture and allied activities as another business venture. An agribusiness development path involving greater productivity and growth throughout the agribusiness value chain provides for a solid foundation for rapid, inclusive economic growth and poverty reduction. Improving the skill levels of the farmers, through appropriate technological interventions, can help in diversifying and minimising the risk from the sector. This will also foster an ecosystem for innovations from within the community.

References

ASSOCHAM. (2011). *2nd Green Revolution: Growth Engine for Transformation*. New Delhi: ASSOCHAM.

Bainbridge, D. I. (2009). *Intellectual Property*, Harlow: Longman.

Boldrin, M. & Levine, D. K. (2008). *Against Intellectual Monopoly*, Cambridge University Press.

Department of Agriculture and Cooperation. (2011). *Annual Report 2010-2011.* Retrieved April 13, 2011, from http://agricoop.nic.in/Annualpercent20report2010-11/AR.pdf

Department of Agriculture and Cooperation. (2012). *Annual Report 2011-2012.* Retrieved October 8, 2012, from http://agricoop.nic.in/Annual%20report2011-12/ARE.pdf

Dr Ramaswami, B. (2009, March). *Agriculture Sector Study: Critical Issues and Strategic Options.* Retrieved May 28, 2011, from http://www.adb.org/Documents/Assessments/Agriculture/IND/Agriculture-Assessment.pdf

Dr Lopez-Claros, Augusto. (2011). *The Innovation for Development Report 2010-2011: Innovation as a Driver of Productivity and Economic Growth.* New York: Palgrave Macmillan.

Federal Trade Commission. (2003). *To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy*.

FAO. (2012). *The State of Food Insecurity in the World*. Retrieved October 21, 2012, from http://www.fao.org/docrep/016/i3027e/i3027e.pdf

Gregory D. Graff, Brian D., Wright, Alan B. Bennett, David Zilberman. (2004). Access to intellectual property is a major obstacle to developing transgenic horticultural crops, *California Agriculture*, volume 58, Number 2, pp 120-126

Heller, M. A. & Eisenberg, R. S. (1998). *Can Patents Deter Innovation? The Anti-commons in Biomedical Research*, Science Vol. 280.

ICAR. (2011). *ICAR Vision 2030.* Retrieved February 24, 2011, from www.icar.org.in/files/ICAR-Vision-2030.pdf

IFPRI. (2005). *Indian Agriculture and Rural Development: Strategic Issues and Reform Options.* Retrieved May 10, 2011, from www.ifpri.org/sites/default/files/pubs/pubs/ib/ib35.pdf

IFPRI. (2007). *Public-Private Partnerships in International Agricultural Research.* Retrieved May 23, 2011, from CGIAR: http://www.cgiar-ilac.org/files/workshops/Partnership/Resources/Spielman_PPPpercent20inpercent20Intpercent20Agr.pdf

IFPRI. (2006, August). *The Private Sector in Agricultural R&D.* Retrieved May 28, 2011, from ISNAR Division: http://www.ifpri.org/sites/default/files/publications/isnardp06.pdf

Indian Institute of Science. (2001). *Pursuit and Promotion of Science: Chapter 21.* Retrieved May 10, 2011, from http://www.iisc.ernet.in/insa/ch21.pdf

*info*Dev. (2009). *Mixed Use Incubator Handbook: A start-up guide for incubator developers.* Retrieved August 26, 2010, from http://www.infodev.org/en/Publication.733.html

Juma, C., & Yee-Cheong, L. (2005.) *Innovation: Applying Knowledge and Development. Report of the United Nations Millennium Project Task Force on Science, Technology and Innovation,* Earthscan, London. 69.

Kumar, S., & Prasad, T. (2007). *State of Food Security in India.* Retrieved April 10, 2011

Ministry of Finance. (2011). *Economic Survey 2010-11.* Retrieved April 8, 2011, from http://indiabudget.nic.in/index.asp

Pal, Suresh., Choudhary, Uree N., & Mittal, Rashi. (2008). Towards Agricultural Innovation Policy. *S&T for Rural India and Inclusive Growth.* Retrieved October 22, 2012 from http://www.nistads.res.in/indiasnt2008/t6rural/t6rur23.html

Phillips McDougall. (2005). *Agrochemical industry Research and Development Expenditure*.

Planning Commission of India. (2012). *Faster, Sustainable and More Inclusive Growth: An Approach to the Twelfth Five Year Plan.* Retrieved October 18, 2012, from http://planningcommission.nic.in/plans/planrel/12appdrft/appraoch_12plan.pdf

Planning Commission of India. (2008). *Eleventh Five Year Plan (2007-12): Volume III: Agriculture, Rural Development, Industry, Services and Physical Infrastruture.* Retrieved May 2, 2011, from http://www.planningcommission.nic.in/plans/planrel/fiveyr/11th/11_v3/11th_vol3.pdf

Planning Commission. (2007). *Report of the Working Group on Risk Management in Agriculture for the Eleventh Five Year Plan (2007-12).* Retrieved May 28, 2011, from http://planningcommission.nic.in/aboutus/committee/wrkgrp11/wg11_risk.pdf

Pray, C.E., & Naseem, A. (2005). *Intellectual property rights on research tools: Incentives or barriers to innovation? Case studies of rice genomics and plant transformation technologies,* AgBioForum, 8(2&3), 108-117

Ramakumar, R. (2009). *Indian Agriculture under Economic Reforms: A prelimanary review.* Retrieved May 10, 2011, from http://www.networkideas.org/ideasact/jan09/PDF/Ramakumar.pdf

Roseboom, J. (2003). *The contribution of agricultural input industries to agricultural innovation. International Journal of Agricultural Resources*, Governance and Ecology 2 (3/4): 295-311.

Schumpeter, Joseph.A, (1942). *Capitalism, Socialism and Democracy*. Retrieved May 24, 2011 from http://www.business.aau.dk/~esa/evolution/esapapers/esa06/druid06.pdf

Swaminathan, MS (2008). *Beyond the green revolution*. Retrieved May 17, 2011, from India-Seminar: http://www.india-seminar.com/2008/589/589_m_s_swaminathan.htm

The World Bank. (2012). *Agricultural Innovation Systems: An Investment Sourcebook,* Washington, DC: The World Bank

The World Bank. (2006). *Enhancing Agricultural Innovation: How to go beyond the strengthening of research systems*. Retrieved October 15, 2012, from http://siteresources.worldbank.org/INTARD/Resources/Enhancing_Ag_Innovation.pdf

THINK kit. (2007). UK Intellectual Property Office

About FICCI

Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence and its subsequent emergence as one of the most rapidly growing economies globally. FICCI plays a leading role in policy debates that are at the forefront of social, economic and political change. Through its 400 professionals, FICCI is active in 39 sectors of the economy. FICCI's stand on policy issues is sought out by think tanks, governments and academia. Its publications are widely read for their in-depth research and policy prescriptions. FICCI has joint business with 79 countries around the world.

A non-government, not-for-profit organization, FICCI is the voice of India's business and industry. FICCI has direct membership from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 83,000 companies from regional chambers of commerce. FICCI works closely with the government on policy issues, enhancing efficiency, competitiveness and expanding business opportunities for industry through a range of specialised services and global linkages. It also provides a platform for sector specific consensus building and networking.

Partnerships with countries across the world carry forward our initiatives in inclusive development, which encompass health, education, livelihood, governance, skill development, etc. FICCI serves as the first port of call for Indian industry and the international business community.

ICRISAT Science with a human face

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid or dry land tropics has over 2 billion people, and 644 million of these are the poorest of the poor. ICRISAT and its partners help empower these poor people to overcome poverty, hunger and a degraded environment through better agriculture.

ICRISAT is headquartered in Hyderabad, Andhra Pradesh, India, with two regional hubs and four country offices in sub-Saharan Africa. It belongs to the Consortium of Centers supported by the Consultative Group on International Agricultural Research (CGIAR). ICRISAT conducts research on five highly nutritious, drought-tolerant crops – chickpea, pigeonpea, pearl millet, sorghum and groundnut.

It also develops sustainable management of semi-arid tropic (SAT) systems through efficient and sustainable management of natural resources, and enables policies and institutions for improving livelihoods and achieving food, nutrition and health security while protecting the environment.

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