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Debates on Food Technologies in India: R&D Priorities, Production Trends and Growing Expectations

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Abstract: Technological interventions have contributed to increased yields and food security. Given the diverse needs and objectives policy makers have to deploy different technologies and strategies in food and agriculture. This discussion paper examines the use of three different technological options in the Indian agriculture. It shows that support to organic farming is increasing but at this stage innovation related inputs are least and traditional plant breeding has played a key role in agriculture. Examined in the context of ethics in S&T, these applications indicate that a mix of suitable policies can result in beneficial outcomes by enhancing food security and reducing the vulnerability of farmers. A discourse analysis in terms of innovation, risk and power and control reveals that innovation discourse plays a key role in legitimising policy decisions while risk and control discourses are invoked by critics. In the Indian context, the ethical dimension in S&T policy can be explored in terms of Access, Inclusion and Equity (AIE) Framework. It is important to confer how far India has been able to work out the policy options for developing an effective framework which can address emergent agricultural challenges and the issue of AIE. This paper outlines the application of this framework in agriculture and food sector in India.

Keywords: Science, technology and innovation, biotechnology, GM, organic agriculture, traditional breeding

1. Introduction

In the last sixty years or so Indian agriculture has passed through major challenges like extreme shortage of food. Throughout the post Independence period of 1947 to 1952, India was dependent on food aid

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programmes of the USA and other major food suppliers like Canada Australia, etc. In the 1943 Bengal famine, India lost around 4-5 million people. With this backdrop, need for technological intervention for higher yields was widely felt all across the policy circles. Eventually, the Green Revolution was introduced in 1967-68, that dramatically captured peoples' imagination of using technology in the context of agriculture.

The Green Revolution was promoted by the Indian government as a technological response to the rising gap between food demand and food availability. It brought about significant changes in Indian agriculture and transformed India from a food deficient country to a leading food producer. In fact it resulted in a record grain output of 131 million tonnes in 1978-79. This established India as one of the world's biggest agricultural producers; yield per unit of farmland improved by more than 30 per cent between 1947 (when India gained political independence) and 1979. The crop area under high yielding varieties of wheat and rice also grew considerably during the Green Revolution.[1]

However, the Green Revolution has attracted intense criticism largely due to the inequalities it led to in Indian agriculture, its impact on environment and stagnation of benefits. Switching from traditional subsistence farming to industrial monocropping had negative effects on small farmers. They found themselves trapped in the cycle of high interest rates on seeds, fertilisers, and pesticides which they had to buy on credit. Because they were often working with only one dealer, there was no competition and prices remained very high (Sebby 2010). However, over the years, agriculture R&D infrastructure continued on the same track. The Indian Council of Agriculture Research (ICAR) has developed a comprehensive institutional infrastructure including four deemed universities, 47 central institutes, 17 national research centers and 25 project directorates to carry out its research objectives. This may facilitate greater access to new technologies.

There was evidence of negative socio-economic and environmental impacts of the green revolution leading to sharp controversies that are still alive today (IAASTD 2009). The institutional and economic conditions for using the GR technology effectively and safely were not in place or the services needed for small scale producers to gain access to or to realise the benefits were inadequate, especially for the resource poor, the indigent and the marginalised producers (IAASTD 2009).

Since then debates have been on solutions and possible way forward. The debate on the environmental impact due to excessive input used led to the introduction of various measures for organic production. Several state governments have come up with plans to support organic food production. However, number of people facing hunger and post-production losses of perishable and semi-perishable products are extremely high. This is estimated to be between 5.8 and 18 per cent and between 6.8 and 12.5 per cent, respectively. Technological interventions are important to guide on this issue. At this point, India has double malnutrition burden. India is among the countries with highest prevalence of anaemia affecting 75 per cent children below 5 years, 51 per cent of women of 15 to 59 years and 87 per cent pregnant women (AVARD 2013). In the urban areas, there is growing problem of obesity and overweight and in poor and rural areas of underweight and anaemia.

The other debate was on inequality in access to green revolution. It was claimed that large part of India was left out of green revolution, as it was confined only to the rich northern states of Punjab, Haryana, parts of Uttar Pradesh, Madhya Pradesh and Maharashtra. This has led to supplementary programmes like the one recently launched called BGREI (Bringing Green Revolution to Eastern India) under the *Rashtriya Krishi Vikas Yojana* (National Agriculture Development Plan, RKVY) in Assam, Bihar, Jharkhand, eastern Uttar Pradesh, Chhattisgarh, Orissa and West Bengal to address the issues of rice-based cropping system in these states. These supplementary programmes are for improving food security at the sub-regional level.

The impediments for enhanced food production emanate not only from skewed access to technology but also from growing urbanisation and market incentive structures that are adversely affecting area under cultivation across different crops. Brahmanand *et al.* (2013) find that the area under cereals as percentage of gross cropped area declined from 56.53 per cent in 1991 to 51.74 per cent in 2008, i.e. from 103.68 million hectares it has come down to 99.08 million hectares. At the same time, the area under oil seeds has expanded from 13 per cent to 14 per cent and expansion is also evident in other areas of urban demands like for fruits, where it has expanded from 1 per cent to 3 per cent and for vegetables where the expansion is from 2 per cent to 4 per cent. Kannan *et al.* (2000) projected that there might be a continued shortfall of food grains of around 36 to 64 million tonnes in the decades to come. The other challenge is of necessary machinery for farmers. About 85 per cent the farmers of India have small land holdings of less than two hectare, which restricts their full potential for production.[2] The relevant size of machinery for small and marginal farmers at a cost that is affordable requires new technological solutions. Overall cost of cultivation, largely an outcome of input costs, in any case, has gone up in a major way, pushing up overall food prices.

In addition, the idea of targeting the frontier technologies for economic development is now gradually becoming an important component of public policy formulation in India. This has led to policy documents like the National Biotechnology Vision and the National Biosafety Guidelines.

The socio-economic parameters for India are also not very impressive. According to the Global Hunger Index (GHI) 2013, India is one of the nineteen countries which have “alarming” or “extremely alarming” levels of hunger. GHI measures three different dimensions of hunger including undernourishment, child underweight and child mortality. Although India’s GHI has declined from 32.6 in 1990 to 21.3 in 2013, it is still very high relative to other developing countries. India ranks 63rd in GHI out of 120 developing countries. This calls for institutional and financial synergies in strategies and policies

In this context, we try to explore how far the innovation priorities reflect the current concerns and debates in the food sector, across its various stages of value chain. We also try to explore associated linkages with risks and power discourse. The last section draws out concluding remarks.

2. Framework and Main Actors

Technological changes have played an important role in the Indian agriculture; however, the total factor productivity (TFP) which at one point played a key role in overall growth of agricultural output has been slowing down since 1980s (Ramasamy 2013). The growth rate, as calculated by various different authors, which ranges from 0.9 to 4.0. The slowing reflects declining inputs from agriculture R&D (Ramasamy 2013).

The technological interventions can be described in three broad categories. They are agriculture biotechnology including genetically modified crops and non-GM options in agricultural sector, traditional plant breeding and lastly the organics, where at this stage innovation related inputs are the least. In addition to these are the techniques used traditionally for plant breeding. The following section takes up these categories for detailed discussions.

There are several groups of NGOs and concerned scientists who have stood up against the GM crops. The NGOs have demonstrated on roads, pressurised the Environment Minister, moved Supreme Court and encouraged scientist to raise their key concerns through letters and submissions. In a letter written to the Prime Minister of India in 2009, as many as 17 distinguished scientists from the US, Canada, Europe and New Zealand pointed out that the claims relating to higher yield and protection of environment made for GM crops are false (Dogra 2012). There are also NGOs which have placed literature in favour of GM crops. For instance, the Foundation for Biotechnology Awareness and Education (FBAE), based in Bangalore, has tried to rationalise the debate and placed their own views on the matter.

Major actors in terms of regulating food technologies in India are the Indian Council of Agriculture Research (ICAR) and the Department of Biotechnology (DBT) which are apex national organisations involved in planning, conducting and promoting research, education, training and transfer of technology.

In case of organics, the Organic Farming Association of India (OFAI) has emerged as an important institutional linkage. It has established major network of farmers for distributing organic seeds. The objective of this organisation is to lobby with government agencies and departments to pay more attention to sustainable agriculture and to assist farmers in successfully moving out of chemicals.

With regard to the institutional arrangements, the Task Force was of the view that GEAC should consist of members with the requisite expertise and should be headed by an outstanding biosafety and biotechnology experts. The structure of the Atomic Energy Regulatory Board could be suitably adapted for establishing an autonomous statutory National Biotechnology Regulatory Authority (NBRA) in the place of the existing GEAC. With rapid growth in R&D efforts in biotechnology, a statutory and autonomous National Biotechnology Regulatory Authority will soon become necessary. The NBRA should have two wings – one for agricultural and food biotechnology and the other for medical and pharmaceutical biotechnology. The NBRA is essential for generating the necessary public, political, professional and commercial confidence in the science based regulatory mechanism in place in the country. The Task Force while taking cognizance that agriculture is a state subject, said that it will be desirable to establish a State Agricultural Biotechnology Regulatory Advisory Board in each State to maintain liaison with the NBRA and to ensure that steps are taken to prevent the illegal release and proliferation of GM seeds.

The ethical matrix below tries to establish a linkage between the technologies and their socio-economic aspects, environmental sustainability, influence of global/external factors and equitable access. The proponents of GM technology base their arguments on the environmental sustainability of this technology where products are resilient to stress. On the contrary the opponents of GM technology argue that the R&D infrastructure is very expensive and the regulatory system is weak in India. Table 1 clearly describes the linkage between technologies and the three discourses.

Table 1: Matrix on Food Technologies

		Socio-Economic Considerations	**Environmental Sustainability**	**Global/External Factors**	**Access, Inclusion, Equity, (AIE)**
Innovation	**Biotechnologies (GM/Non-GM)**	Costly R&D Infrastructure with scope to enhance yield	Resilient to stress (drought, salinity, pest etc.) Protocols to ensure minimal implications	Patents, Collaboration	Large Players MNCs, Food Security
	Traditional Breeding Technologies	R&D Set-up Available with stagnating yield	Vulnerable to biotic and abiotic stresses	R&D capacity and changes in technology	Presence of domestic enterprise, public sector R&D
	Organic Approach	Low Input Cost, scope to enhance yield unclear	Vulnerable to biotic and abiotic stresses	Minimal External Control	Local Farmers
Risk	**Biotechnologies (GM/Non-GM)**	Recurrent high input cost	Gene Flow, Contamination, Human Health, Place of Origin	International Conventions/ Laws, Trade Barriers, Labeling, Traceability	Limited access due to high cost

Table 1 continued...

Table 1continued...

		Socio-Economic Considerations	Environmental Sustainability	Global/External Factors	Access, Inclusion Equity (AIE)
	Traditional Breeding Technologies	Affordable with Public support	Minimal Risk	Minimal Risk	Accessibility; Inclusive
	Organic Approach	Viable depending on demands	Minimal Risk	Niche Market and Standards	Overhead makes it Exclusive
Power and Control	**Biotechnologies (GM/Non-GM)**	Targeted gains	Unpredictable outcomes on account of non-scientific factors	MNCs, International Conventions/ Laws (e.g. Codex), Trade, IP Regime	Control over production, process and markets
	Traditional Breeding Technologies	Declining yield and economic returns	Suitability of technology to meet needs and competing technologies	Less External Control	Accessible and Inclusive
	Organic Approach	Niche market; High returns	Perceived to be Safe	Global standards	Accessible and Inclusive

3. Traditional Plant Breeding

Given the growing incidences of malnutrition, micro-nutrient deficiencies and nutritional insecurity, it is important that entry points are identified for possible technological interventions.

The current innovation priorities require focus on challenges like emerging water crisis and research on additional genetic material for better varieties. Indian agricultural innovation focused on water balance is extremely important consideration at this point. At the global level, demand for water is growing at 2.4 per cent annually. It is estimated that 20 per cent of globally cultivated area uses 70 per cent of global water usage (Brahmanand 2013). In India, around 63 million hectare area is irrigated, most of which uses groundwater. Around 80 million hectare of the cultivated area is rainfed. In this backdrop, innovation in agriculture has to address draught resistance as a major source for technological intervention. The Water Technology Center at the Indian Agricultural Research Institute (IARI) is a lead research center, working on drought tolerance across various different crops. The center is working on drought tolerant wheat and rice varieties and has also worked on efficacy of different *in-situ* moisture conserving bio-engineering measures (viz. basin tillage, ridge and furrow, trench-cum-bund, bund) for enhancing crop productivity through pearl millet-mustard based cropping system in rainfed areas.

In case of planting material, it is the National Bureau of Plant Genetic Resources (NBPGR) which leads the research through collection and evaluation. Plant Exploration and Collection Division coordinates and conducts explorations for collecting germplasm. Germplasm Evaluation Division is entrusted with the prime responsibility of characterisation and evaluation of all the indigenous and exotic germplasm collections for their field performance and other important traits like resistance to biotic/abiotic stresses and phytochemical attributes along with maintenance and regeneration. Apart from the NBPGR, respective crop-specific research institutes maintain their own germplasm base. The ICAR has many institutions involved in collecting, classifying, analysing and storing germplasm with the NBPGR as national level institution.

Budget allocation for conventional plant breeding is mainly received from the ICAR and CSIR with very specific monetary support from the Department of Biotechnology. Plant breeding is encouraged by the government and the output is expected to increase. New innovations in plant breeding like Marker Assisted Selection have the capacity to increase yield and productivity and contribute to food security. Innovation priorities in this discourse are limited to certain technologies whereas there are several other technological options which are not utilised effectively.[3]

Current R&D priority in this area is to focus on breeding tools and techniques such as molecular breeding (genetic engineering, gene manipulation, molecular marker-assisted selection, genomic selection, etc). Integration of molecular breeding in current research priorities can serve as a key to improved yield and disease resistance. The major challenge faced today is to develop crops with complex traits which are insect resistant, drought resistant, flood resistant, and salinity resistant and presently there are three major crops rice, wheat and maize which have been paid attention.[4]

Presently, technology has not been exploited to its potential, where the ideal approach of molecular technology is yet to come in India. Germplasm collection has also not been used properly as half of the genes in the gene bank are not evaluated.[5]

Focus has to be laid on orphan crops like sorghum and millets which constitute good mineral elements and nutrient value. Hymavathy (2013) argues that traditional foods like millets needs to be included in the food technology basket. Sorghum, finger millet, pearl millet and other minor millets have been the traditional diet of many communities, they have a dual advantage of being-less water intensive to grow; and more nutritious with higher mineral, dietary fibre and vitamin B content. She further adds that efforts are needed to develop Ready to Eat (RTE) convenience foods from millets, usinf technologies like blanching, acid treatment, malting, fermentation, and dry heating to increase the digestibility and shelf-life of millet products.

The issue in traditional plant breeding is of stagnating yield. With the advent of new technologies and changing innovation systems, millets and sorghum, which were the primary diet of rural India in the past, are in a situation of crisis at present. There has been a decrease in total cultivated area under millets and also their consumption which is now being addressed through giving a push to cultivation of millets and offering incentives for the same.

The socio-economic issue in traditional plant breeding has been non controversial as it has been in use for many decades and is necessary to meet the challenges of stagnating yield and reducing vulnerability to biotic and abiotic stresses. Traditional plant breeding is a sector in which public sector is active and can provide new variety of crops for many farmers who cannot afford other technologies. Traditional plant breeding in public sector should be supported to meet the needs for public goods and this calls for not only increased funding but also targeted interventions in terms of technology, extension services and planning.

4. Agricultural Biotechnology

Agricultural biotechnology has grown by leaps and bounds in many countries and is considered as a successor to Green Revolution in agriculture. India is a pioneer in agricultural biotechnology among developing countries. Broadly speaking agricultural biotechnology can be subdivided as GM biotechnology and Non-GM biotechnology. While the former is well known through Genetically Modified crops, the latter is not so well known. India is using both types of technologies in agriculture. These two are complementary and are necessary for realizing the potential of biotechnology in agriculture.

4.1 GM Biotecnology in Agriculture

This is one area of agricultural R&D where both private and the public sector have increasingly enhanced their allocations. Since the setting up of the National Biotechnology Board in 1983 the institutional frameworks have continuously evolved over the years. Major debates on innovation priorities in the agriculture biotechnology led the government to appoint a task force under the chairmanship of the renowned Indian agriculturist M.S. Swaminathan. It was set up by the Ministry of Agriculture to deal with the objective of formulation of a long-term policy on applications of biotechnology in agriculture.

The Swaminathan committee met and discussed with representatives of farmers, NGOs, associations of seed industry, association of industry, representatives of the State Governments and representatives of media. The report categorically mentioned that the infusion of new technology is necessary to make Indian agricultural enterprises competitive and remunerative. It recommended that the general approach in this respect should be as follows:

(a) Biotechnology applications, which do not involve transgenics such as biopesticides, biofertilisers and bio-remediation agents, should be accorded high priority. They will help to enforce productivity in organic farming areas.

(b) Transgenic approach should be considered as complimentary and resorted to when other options to achieve the desired objectives are neither available nor feasible.

(c) High priority should be accorded in transgenic approach to the incorporation of resistance to insect-pests and diseases including viruses and to drought and salinity (i.e. biotic and abiotic stresses).

(d) Transgenic research should not be undertaken in crops/ commodities where our international trade may be affected, e.g. Basmati rice, soybean or Darjeeling tea.

(e) The international guidelines being set up by the FAO-WHO Codex Commission for assessing and managing the health risks posed by GM foods should be closely followed. These risk analysis guidelines call for safety assessments to be conducted for all GM foods prior to market approval.

(f) In addition, core information about gene exchange taking place among modern cultivars, traditional varieties and wild relatives should be gathered to assess concerns of transgene escape and establishment. Data should also be gathered on the impact of transgenics on biodiversity in crop fields, as has been done on an extensive scale in the United Kingdom.

In India there was considerable debate on protecting and conserving precious agro-biodiversity in its pristine purity. The suggestion of this widespread debate has been that key biodiversity rich areas should be earmarked as 'agro-biodiversity sanctuaries.' In such areas, the cultivation of GM crops should be prohibited. The above mentioned report supported this position. The recently appointed expert group by the Supreme Court, details of which we discuss little later, has also suggested that release of GM varieties for those crops should not be allowed for which India is a centre of origin.

GM technology does not relate to increasing yield, productivity, or environmental sustainability, in the form of resilience to stress (drought, salinity, pest, etc.). For farmers the trade-off is determined by many factors including cost of inputs and expected returns. But farmers are also vulnerable for failure on account of other factors like drought, excessive rain, poor quality of the seeds, and price volatility. Insurance to protect farmers from such factors, supply of quality seeds and educating them about proper use of technology are necessary to derive the best gains from GM technology but as this is not happening it results in less than optimum gains for farmers. Farmers are often unaware of the need for refugia or do not follow the norms set out for environment protection.

One such example is Bt cotton which has been enveloped in controversies due to alleged farmer suicides because of seed monopolies but still Bt cotton accounts for 93 per cent of cotton grown in India (Jayaraman 2012). But these Bt cotton seeds are expensive and as they are hybrids farmers have to buy seeds every cropping season (Shiva 2013). In China public sector took the initiative to develop varieties that could compete with varieties developed by Monsanto and this in turn helped to make seeds more affordable. More importantly it demonstrated the capacity of public sector to rise to the occasion and Monsanto could not become the most dominant player in the market. Agricultural biotechnology R&D programmes were overwhelmingly financed and implemented by China's public sector (Linton and Torsekar 2010). In India this did not happen and the failure of public sector has resulted in issues relating to exorbitant seed prices, and virtual monopoly in the market resulting in state governments intervening to bring down price of seeds. Domestic and foreign firms spearheaded the adoption of Bt cotton in India as the Indian public sector had little involvement in the product's R&D and commercialisation (Linton and Torsekar 2010). In 1995, Mahyco obtained permission to import Bt cotton technology from Monsanto and in 1998 Monsanto purchased a 26 per cent share in Mahyco. The two companies then formed Mahyco-Monsanto Biotech (MMB), which became a 50-50 joint venture to commercialise biotech products in India (Linton and Torsekar 2010). The innovation issue is thus linked with socio-economic issues and the diffusion of innovation is influenced by these issues in India. With India opting for more GM crops the lessons from Bt cotton are important.

4.2 Non GM Biotechnology in Agriculture[6]

There is huge emphasis on developing non-GM options in agricultural sector by the public sector research institutions. This is largely to develop new varieties of different crops (See Table 2). The IARI developed a new rice variety having higher yield (37 q/ha) than Pusa Basmati 1. Pusa 1460 (IET 18990) by pyramiding bacterial leaf blight (BLB) resistance genes (xa13 & Xa21) in the background of Pusa Basmati 1 through marker assisted backcross breeding, which was released in 2007 (ICAR 2007). Another rice variety, RP BIO 226

(IET 19046) is developed by Hyderabad based Directorate of Rice Research. This variety is a near isogenic line containing the bacterial blight resistance genes, Xa21, xa13 and xa5 developed in the genetic background of an elite fine grained rice variety, Samba Mahsuri. It is developed through marker assisted backcross breeding. The National Research Centre on Rapeseed-Mustard (NRCRM), Bharatpur, has developed the first Indian mustard hybrid, viz. NRC Sankar sarson (NRCHB 506), which was released in 2008. This hybrid of Indian mustard developed through heterosis breeding using moricandia cytoplasmic genetic male sterility system is the first CMS based hybrid of Indian mustard. It is largely seen as an important milestone in *Brassica* research programme of the country.

Table 2: Non-GM Agri Biotechnology from India Public Research Institutions

Crop	**Nature of Technology**	**Status**
Rice (Improved pusa basmati I)	Marker Assistant Selection	Released (2007)
Mustard NRC-Sankar Sarson (NRCPB+ NRCRM, Bharatpur)	Cytoplasmic Male Sterility (CMS) derival from protoplant fusion**	Released (2008)
Improved Samba Mahsuri (Directorate of Rice Research, Hyderabad)	- Marker Assistant - Bacterial Blight Resistant	Released (2008)

Notes: * Resistance to bacterial blight dimension;
** High yielding hybrids

Source: Chaturvedi (2013).

One of the major paradigm shifts in the working of the public sector funding agencies is to encourage network approach in agriculture biotechnology. This is being tried across various crops with different objectives, depending on the specific expertise of various agencies and scientists. The Department of Biotechnology (DBT) has been spearheading this network approach. Key national institutions are being encouraged to collaborate with many smaller crop specific institutions. The idea is to develop superior genotypes for using biotechnological interventions like transformation, hetrosis breeding, molecular breeding and marker aided selection. There are two major projects in the area of functional genomics of rice. Public sector institutions due to access to quality germplasm and ability to introduce technology in their own popular hybrids, would have an important role in days to come.

Innovation discourse in non-GM biotechnology research highlights the unused potential of biotechnology as a supplement to other technologies in India. The idea is to develop superior genotypes by using biotechnology in traditional breeding resulting in better varieties and also varieties that could meet new and unmet needs. Increasing productivity and developing varieties that are more suited to different agro-climatic conditions through non-GM biotechnology is possible and desirable. The socio-economic issue here is food security, making access to such varieties affordable and enhancing productivity.

The realisation of the potential of such innovations needs more investment in R&D, capacity building and also continued commitment to public sector R&D particularly plant breeding. Since the private sector is not likely to deploy these technologies in crops and regions where they do not see much potential for profit, therefore, public sector has to play an important role in this. The socio-economic benefits from these innovations in agriculture R&D are such that there is a need to replicate the green revolution model in gene revolution taking into account environmental sustainability, needs of small and medium farmers and expanding the scope of such interventions to millets, etc.

5. Organic Agriculture

Globally, there has been significant sensitisation during the last ten years towards environmental preservation and assurance of food quality. Organic farming is being promoted as an ideal alternative which not only addresses the environmental, food safety and sustainability concerns, but also has the potential to feed the world.[7]

As per the definition of International Federation of Organic Agriculture Movements (IFOAM), the organic agriculture is a production system that sustains health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than on the inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

5.1 Initiatives by Government

At present, innovation in this area has very little systemic support. There are very few initiatives taken by the government to promote innovation in organic agriculture. As the training and extension system for promotion of organic agriculture is weak, it is important to link organic agriculture in one way or the other with the existing support services present in the country.

Some of the projects initiated by the government are National Project on Organic Farming (NPOF), National Horticulture Mission (NHM), Horticulture Mission for North East and Himalayan States (HMNEH), Rashtriya Krishi Vikas Yojana (RKVY) and Network Project on Organic Farming of the Indian Council Agricultural Research (ICAR). The NPOF came into effect with the Tenth Five Year Plan with an outlay of Rs 57.04 crore; however, the government has increased the funding in the Eleventh Five Year Plan to Rs. 101 crore. There have been state initiatives also in this domain; nine states in India have drafted organic farming policies. Out of these, four states, viz. Uttarakhand, Nagaland, Sikkim and Mizoram, have declared their intention to go 100 per cent organic.[8]

5.2 Low R&D Investments

Research and technological development conducted within functioning organic systems is essential to overcome some of the technical problems which still exists and to improve further increase in the potential of organic farming in the country. Current organic practices have been developed primarily by existing farmers who have been practising organic farming by default due to lack of resources and finance against the background of scientific knowledge. Therefore, significant public funding for research and development is crucial to boost organic farming sector further. Despite recognising the immense potential in organic farming, India accounts for only US$ 123 million in a US$ 40 billion global organic food market (Charyulu 2010).

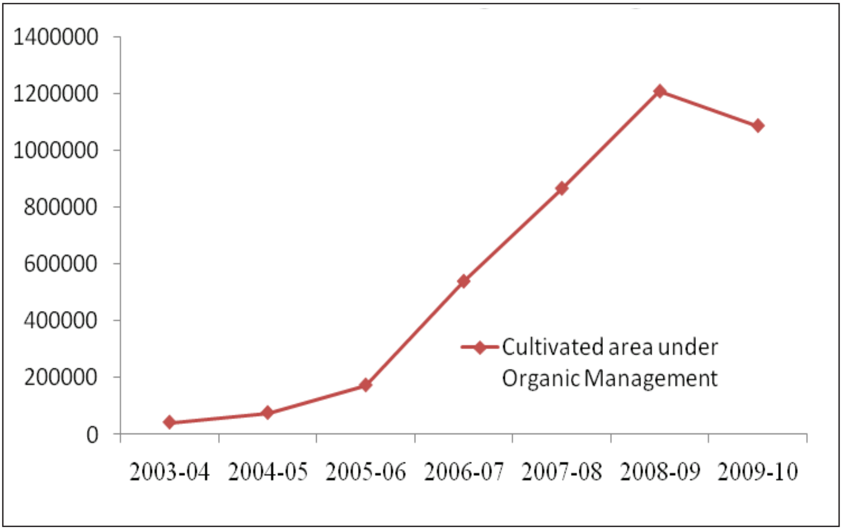
5.3 Increase in Area under Organic Cultivation

There are fervent supporters of organic agriculture in India who feel that organic farming can serve the purpose of meeting food security. Despite lack of support, there has been considerable growth of area under organic cultivation in India since 2003-2004. Figure 1 provides information on yearly growth of cultivated area under organic cultivation.

With the phenomenal growth in area under organic cultivation and growing demand for wild harvest products, India has emerged as the single largest country with highest arable cultivable land under organic cultivation. India has also achieved the status of single largest country in terms of total area under certified organic wild harvest collection (Yadav 2011).

In order to encourage systemic support a National Centre of Organic Farming was established in 2004 which launched several institutional majors for extending support for soil testing, product certification, resource-base assessment, manpower development, etc. At present, India has 4.4 million hectare of land (2010-11) under certified organic production (including wild harvest). India produces around 3.88 million MT of certified organic products which include basmati rice, pulses, honey, tea, spices, coffee, oil seeds, etc. India exports organic products worth US$ 157 million. Table 3 refers to category wise production of certified organic products for the year 2010-11.[9]

Figure 1: Area under Organic Cultivation



Source: National Project on Organic Farming, Department of Agriculture and Cooperation, GoI, 2010-11.

5.4 Certification

Largely public sector institutions are engaged in certification and ensuring quality for the products. Regarding certification, Ministry of Commerce had introduced regulation for organic products in 2001, whereby organic products can be exported only if they are certified by government-approved accreditation agencies (UNESCAP 2003). The Agricultural and Processed Food Products Export Development Authority (APEDA) is the nodal agency which looks after the certification of products as per the National Standards for Organic Production. In India, the genetically modified organisms are not allowed in the National Programme for Organic Production. This is due to incompatibility of the GMOs with Organic agricultural principles. According to the International Competence Centre for Organic Agriculture (ICCOA), global demand for organic products is growing at 15-25 per cent, although this demand is concentrated in Europe and the USA, but new markets are also expected to emerge in the Asian region.[10]

Table 3: Category wise Production of Certified Organic Products

Products	**Total Production (M.T)**
Cereals (Except Rice)	171684.66
Coffee	13122.03
Cotton	552388.47
Dry Fruits	52369.09
Fresh Fruits & Vegetables	335863.11
Medicinal & Herbal Plants	1792014.86
Oil Seeds	360837.17
Pulses	42721.61
Rice	176683.17
Spices-Condiments	129878.46
Tea	27684.26
Misc	221191.96
TOTAL	3876438.85

Source: APEDA, National Centre of Organic Farming.

5.5 Socio-economic Issues

There are several socio-economic benefits which can be provided by organic agriculture in terms of quality products, price premiums for the products, independence in terms of technology and increased sustainability in agriculture. With increasing safety concerns, demand and awareness about food quality, organic agriculture can be seen as providing safer food, sustainable livelihoods to several farmers and a possible alternative to technologies like biotechnology. State governments have initiated several programmes for sustainable agriculture focusing on organic farming. The Department of Science and Technology (DST) has sponsored research projects on this while the National Bank for Agriculture and Rural Development (NABARD) has also been supporting projects that are oriented towards diffusion of organic agriculture among small and marginal farmers. In view of demands of farmers who lack access to irrigation or depend on rain only as major source of water, the need for developing an agriculture that could meet their needs is obvious. In this also there are many projects that are in demonstration phase now. Although these projects and areas covered by them are not large, they have the potential to bring in enhancing innovation in organic agriculture and make it affordable. Some projects promote group and co-operative farming while some others train farmers in meeting norms in standards. The challenge lies in scaling up these efforts and in developing a policy framework that helps farmers to gain from organic agriculture.

Innovation discourse in organics is confined to low systemic support in terms of R&D extension, budget allocations and limited number of projects in promoting organic agriculture, but despite impediments, there has been considerable growth in organic output and the area under organic cultivation.

5.6 Policy Issues in Organic Agriculture

The National Project on Organic Farming (NPOF) is a continuing central sector scheme since Tenth Five Year Plan. The Planning Commission approved the scheme as pilot project for the remaining two and half years of Tenth plan period with effect from 1 October 2004. The NPOF is being implemented by the National Centre of Organic Farming (NCOF) at Ghaziabad and its six Regional Centres at Bangalore, Bhubaneswar, Hisar, Imphal, Jabalpur and Nagpur. Besides working for realisation of targets under the NPOF, NCOF and

Regional Centres for Organic Farming (RCOFs) are also performing specific roles in promotion of organic farming.[11]

There is a growing demand for organic products worldwide, and certification of organic products is a prerequisite for ensuring quality and preventing fraud. Standards and regulations for organic farming vary from country to country, and generally involve a set of production standards for growing, storage, processing, packaging and shipping which include:

- No human sewage sludge fertiliser should be used in cultivation of plants or feed of animals;
- Avoidance of synthetic chemical inputs that are not on the National List of Allowed and Prohibited Substances (e.g. fertiliser, pesticides, antibiotics, food, etc.), genetically modified organisms, irradiation, and the use of sewage sludge;
- Use of farmland that has been free from prohibited synthetic chemicals for a number of years (often, three or more);
- Keeping detailed written production and sales records (audit trail);
- Maintaining strict physical separation of organic products from non-certified products; and
- Periodic on-site inspections.[12]

In India, the regulatory system is defined by the National Programme on Organic Production and it is regulated under two acts, viz. Foreign Trade Development and Regulation Act (FTDR) and Agriculture Produce, Grading, Marking and Certification Act (APGMC). The standards set by the National Standards for Organic Production (NSOP) for production and accreditation system have been recognised by the European Commission and Switzerland as equivalent to their country standards. Similarly, the United States Department of Agriculture (USDA) has recognised the National Programme for Organic Production (NPOP) conformity assessment procedures of accreditation as equivalent to that of the US. With these recognitions, Indian organic products duly certified by the accredited certification bodies of India are accepted by the importing countries.[13]

Maity and Tripathy (2011) point out that presently in India, there are six authorized accreditation agencies which have been approved by the Ministry of Commerce, Government of India. They are Agricultural and Processed Food Product Export Development Authority (APEDA), Coffee Board, Spices Board, Tea Board, Coconut Development Board, Cocoa and Cashewnut Board.

In addition there are four certification agencies accredited by APEDA. The NSOP has been formulated by the Department of Commerce, Government of India for NPOP. Any production certified as per NSOP may use the term, "Organic". A product can be labelled as, "For Export only" when it has been produced in India to an Organic Standard other than NSOP, for example EU Regulations, Internatioanl Federation of Organic Agriculture Movements (IFOAM), etc. (Maithy and Tripathy 2011).

There is a growing demand for organic products worldwide and in India. The market for organic products is aniche with high returns and products are considered to be safer compared to GM products. Indian standards have been clearly laid for the certification of organic products where the accreditation system has been recognised by European Commission and Switzerland as equivalent to their country standards where recertification of organic products is not required during exports.

6. Risks, Risk Perceptions and Risk Discourses in Different Technologies

6.1 Risk Discourse and Risk Perception in GM Agriculture

Risk discourse on food technologies in India has mostly been centered on GM crops and packaged food. But for the purpose of present study, we focus on the issue of applying two different sets of food technologies, viz. GM and non-GM technologies. Risk discourse basically emanates from the application of GM technology in food. In both these issues, the role and relevance of modern food technologies have been questioned in terms of risk they can pose to human, animal and environment health. In this section, we would address concerns emanating from various debates in these areas. In this paper we are not getting into the issues related to packaged food. However, from the socio-economic perspective it is important to explore challenges from traditional breeding and organics.

Any technology intervention in food articles is sure to create apprehensions in the minds of people regarding health and environment safety. These apprehensions tend to amplify when there are debates among the various stakeholders resulting in ambiguous claims and non-consensual outcomes. To address these prime concerns, there are various methodologies.

Debates and deliberations relating to the GM crop have intensified in India over the last decade, though issues related to various concerns have been raised since late 1980s (RIS 1988). Some scholars such as Chaturvedi (2001, 2003 and 2004) and Chaturvedi *et al.* (2007, 2011, 2012, 2013) had ever since discussed the issues of risk and regulation related to genetically modified foods in India. Similarly, various other scholars, groups and committees have discussed and debated on this issue.[14]

On the issue of regulatory mechanisms for bio-safety, the Swaminathan Task Force suggested that while the present system of granting approval for contained and open field trials for biosafety may continue to rest with the Review Committee on Genetic Manipulation (RCGM)[15], the multi-locational farmer's field trials for Value for Cultivation and Use (VCU) should be the sole responsibility of Indian Council for Agricultural Research (ICAR) and the concerned company or institution. The Monitoring and Evaluation Committees

(MEC) should report to the Genetic Engineering Approval Committee (GEAC), which may continue to handle biosafety and environmental safety issues of GM crop candidates until the proposed National Agricultural Biotechnology Regulatory Authority comes into existence. 'Commercial release'/notification/registration, however, should be with ICAR/Department of Agriculture and Cooperation (DAC) as the release for use by farmers comes under the domain of the Ministry of Agriculture. No GM crop variety should be allowed to be released for use by farmers by any agency other than ICAR/DAC who has a system of VCU evaluation and also a regulatory mechanism for release and notification of varieties.

The ICAR was also suggested to devise a mechanism to concurrently run the VCU trial of such GM crop candidates for which GEAC clearance has been given and for which large-scale seed production/multiplication has been recommended by GEAC. An All India Coordinated Research Project (AICRP) solely responsible for the testing of GM crop varieties should be organised by ICAR with the requisite technical expertise. Multi-locational and regional testing should be carried out with the help of the concerned State Agricultural University centers under the AICRP. The Agricultural Production Commissioner of the concerned State should be given full details of trials with GMOs in the respective State.

One of the major concerns stems from genetic invasions. It was proposed that the State Agricultural Biotechnology Regulatory Advisory Board would also take steps to ensure that farmers are properly educated on the raising of 'refugia' and the adoption of Integrated Pest Management (IPM) procedures, so that the pest resistance properties of GM crops do not break down. It can also help to supervise the trials conducted with GM strains within the State.

On the issue of food safety, the Task Force felt that there was a need to put in place food safety standards. It said that the Ministry of Science and Technology along with the Indian Council of Medical

Research (ICMR) and the Ministry of Health should take the lead and play a greater role in setting *codex alimentarius* standards in the area of GM foods. The safety impact should be assessed in the case of both animal feeds and human foods. The Department of Biotechnology (DBT), ICMR, ICAR, Central Food Technological Research Institute (CFTRI), Council of Scientific and Industrial Research (CSIR), Ministry of Environment and Forests, Ministry of Agriculture, Ministry of Health and the Law Ministry should jointly develop a National Food Safety Protocol, which covers both the production and post-harvest (processing and consumption) phases of GM crops. The protocol should cover all stages in the production, processing, marketing and consumption chain. It should take into account the potential impact of GM crops on the environment and the health of human and animal populations. As a signatory to the Cartagena Protocol, (i) biosafety clearance of these mechanisms may be expeditiously provided and operationalised, (ii) a Biosafety Data Base System be established, (iii) the trans-boundary movement of Living Modified Organisms (LMOs) be monitored/regulated, and (iv) provisions of the Advanced Informed Agreement (AIA), etc. be effectively executed. The need for putting in place a mechanism to facilitate segregation, identity preservation and certification and labelling of GM/non-GM products is also felt.

This report also looked into the risk from the socio-economic perspective. It acknowledged that since the cost of GM seeds being high, farmers will get indebted if crops fail. It said that a special insurance scheme for GM crops may, therefore, be devised and introduced by the Ministry of Agriculture**.** There is a need to explore the possibility of the seed company selling GM seeds providing farmers with an insurance cover, so that they may get some relief if crops fail. Switzerland adopted in 2003 a Gene Technology Law with a strong liability regime. A similar procedure may be advisable since a vast majority of farmers in India have smallholdings with no or poor risk taking capacity. A Technical Task Force may be set up by DAC for developing an insurance system for GM crops and animals.

Companies selling GM seeds to small and marginal farmers should also provide them with insurance cover. An insurance system for GM crops needs to be developed speedily, so that small farmers who take institutional credit for buying expensive seeds do not suffer in case of crop failure. An integrated GM Seed-cum-Crop Insurance System will help to ensure that desirable new technologies confer benefits to resource poor small farm families.

The Task Force, in the end, also proposed that it will be advisable for the Government of India to prepare a Biosecurity Compact, comprising precise action plans to face the challenges such as (a) invasive alien species (introduced with the import of food grains and seeds); (b) sanitary and phytosanitary measures to avoid mycotoxins, salmonella and other forms of infections in food; (c) food, environment, and bio-safety relating to GMOs; and (d) bio-ethical considerations in research. Thus, the Task Force tried to deal with a range of issues related to risk and regulation of GM food in a balanced way.

Subsequently, the national deliberations led to various different responses by the policymakers. High profile global NGOs like the Greenpeace entered in the scene.

The Parliamentary Standing Committee (PSC) on Agriculture in its 2012 report titled ‘Cultivation of Genetically Modified Food Crops: Prospects and Effects’ elicited views of various persons/ stakeholders on the risk factors associated with GM crops. In particular, it considered views of three scientific studies and reports and sought explanations from various departments/experts/institutions on these reports. These scientific studies and reports were IAASTD Report, Report of Six Science Academies and Report of Prof. David Andow on Bt Brinjal.

Responding to cases before Supreme Court, it appointed a Technical Expert Committee (TEC) to review and recommend the nature of sequencing of risk assessment (environment and health safety) studies that need to be done for all GM crops. TEC in its final recommendations sought a ban on research and commercialisation of all GM crops in India. It said that "based on the deliberations of the TEC and particularly the examination/study of the safety dossiers, it is apparent that there are major gaps in the regulatory system. These need to be addressed before issues related to tests can be meaningfully considered. Till such time it would not be advisable to conduct more field trials" (TEC 2013). It also highlighted challenges in institutional governance and in the regulation of these crops. The Supreme Court is yet to announce its verdict on this input by TEC.

Currently, all GM crops are evaluated for safety and efficacy as per the protocols and procedures prescribed under the rules 1989 of Environment Protection Act (EPA, 1986) and biosafety guidelines issued from time to time. The Review Committee on Genetic Manipulation (RCGM) and Genetic Engineering Appraisal Committee (GEAC) are the committees they provide case by case clearance based on procedures for comprehensive safety assessment.

Risk discourse in GM technology in India is a highly debated topic with concerns raised by farmers, NGOs and several scientists regarding the safety of GM foods. The role of modern food technologies in terms of risk they possess to human health, environment and contamination has been questioned. Balancing benefits from innovation with risks calls for more attention to socio-economic issues and technology regulation. A socio-economic assessment of such technologies is necessary to ensure that societal benefits are maximised while risks are reduced or minimised and no player is able to exert undue power and benefit from that.

6.2 Risks and Organic Agriculture

Export Oriented Organic Market

At this stage, organics is largely seen as an export opportunity where idea is to earn foreign exchange. Accordingly, the support structures are also geared towards the possible exporters and elite consumers within the domestic markets. Indian organic industry is mostly export oriented. The typical character of Indian organic food market is buyers/ consumers driven rather than producers/supply driven. The producers/ suppliers have no upper hand in the market (Charyulu 2010). Thus, the capital driven policies coupled with lack of open local market for sale of organic produce may negatively influence the bottom-up response on organic farming discouraging small farm holders who have currently no access to organic agricultural technology (Pandey and Singh 2012).

Table 4 provides detail on the overall quantum of Indian organic products exported to other countries. It also lays down the organic commodities which are receiving much attention in the international arena for potential price premiums.

Table 4: Quantam of Indian Organic Products

Quantum of Organic Products	Value
Total Organic Products Exported	135 Products
Total Volume	165262 MT
Organic Export Realisation	$ 374 million
Countries importing Indian Organic Products	EU, US, Switzerland, Canada, South Africa and South East Asian Countries
Export Products	Soybean (41%), Cane Sugar (26%), Processed food products (14%), Basmati Rice (5%), Other cereals and millets (4%), Spices (1%), Dry Fruits (1%) and others

Source: The Agricultural and Processed Food Products Export Development Authority (APEDA).

Shortage of Key Inputs

There is lack of awareness among the farmers about potential benefits from organic farming vis-à-vis conventional farming.

In addition many experts and well informed farmers are not sure whether all nutrients with the required quantities can be made available by the organic materials. The small and marginal cultivators have difficulties in getting the organic manures compared to the chemical fertilisers, which can be bought easily, if they have financial ability (Nayayanan 2005).

There is non-availability of bio-mass and other inputs for organic agricuture compared to chemical fertilisers, in addition proper usage of biomass and biofertilisers also needs expertise which is still an evolving process in the Indian case. Using chemical fertilisers for farming is a more established process. Indian farmers have been practicing organic farming in the form of conventional farming methods since ages, but the input costs of organic products are higher relative to the industrial inputs used in modern farming methods, hence small farmers find it difficult to practice organic farming.[16]

Production Inefficiency

Technical challenges facing certified organic agriculture revolve around sourcing organically produced seed and fodder, consistent product quantity and quality, traceability, liability insurance of growers and processors, appropriate product attributes and pack size. Commercial challenges include narrowing profit margins, regulatory overload, increased competition and the need for constant innovations to stay ahead of consumer trends (IAASTD 2009).

As a result, focus on issues like yield barriers continue to be a major challenge. The National Academy of Agricultural Sciences (2005) has pointed out that organic farming should not be confined to the age old practice of using cattle dung, and other inputs of organic/ biological origin, but an emphasis needs to be laid on the soil and crop management practices that enhance the population and efficiency of below-ground soil biodiversity to improve nutrient availability. In that context, it further points out that performance of cultural techniques for weed control and that of biopesticides for pest management need to be evaluated under field conditions, preferably under cultivators' management conditions.

Fertiliser consumption in the country has been increasing over the years and now India is the second largest consumers of fertilisers in the world, after China. As a result of over emphasis on chemical fertilisers and imbalanced fertiliser use, efficiencies have become low resulting not only in high cost of production but also causing serious environmental hazards. Measures to soil health improvement need to be comprehensively centred on addition of soil organic matter in substantial quantities over time (GoI 2013). For promotion of these inputs in conjunctive use with chemical fertilisers, and to promote organic farming, there is a need to formulate and define standards for unregulated organic and biological inputs and bring them under quality control mechanism (GoI 2013).

Another constraint in adopting organic farming in India relates to water availability, particularly in arid and semi arid regions where rainwater is not sufficient for obtaining the desired yield. Absence of surplus rainwater for harvesting and long periods of low soil moisture can limit the overall biomass production for recycling, green leaf manuring and on-farm composting (Venkateswarlu 2007). Non-availability of organic supplements pooled with non-availability of water can lead to a decline in the yield during conversion period; small and marginal farmers are reluctant to take the risk of decreased yields during the initial conversion periods to make the farms organic friendly. Conversion to organics from high-yielding conventional systems often results in a drop in gross yield of the marketable commodity, the degree of drop might vary considerably (IAASTD 2009).

Costly Certification Process

Organic certification is considered to be essential to assure quality of the products, and the cost of certification is very high; it cannot be afforded by small and marginal farmers. Pandey and Singh (2012) point out that access to certification, cost involved therein and a time lag of three years (conversion stage) often constrains farmers especially small land holders in India from adopting organic farming. In the *Hindu's* annual environmental report, P.V. Satheesh, Director of the Deccan Development Society, wrote, "It's a sobering thought that the farmers producing the best and cleanest food must pay extra to certify, instead of inorganic foods being certified as potentially bad for our health" (The Hindu 2012). There is a need for arranging low cost certification process which falls in line with promoting organic agriculture in the country. The new found governmental passion for organic farming should be translated into an enabling policy for small farmers. This can happen through a Community Certification process (Satheesh 2013).

Lack of Financial Assistance

In spite of the adoption of NPOP during 2000, the state governments are yet to formulate policies and a credible mechanism to implement them (Narayanan 2005).The organic supply chain currently suffers lack of infrastructure and high costs linked to handling small quantities for growing niche markets. Marketing and the distribution chain for organic products are relatively inefficient and costs are higher because of relatively small volume (Charyulu 2010). No financial support as being provided in advanced countries like Germany is available in India.

Socio-economic Issues Involved

Socio-economic issues like high price of organic products makes this technology exclusive for the elite. The reason for expensive products is labour cost as it requires more workers for tasks like hand-weeding, preparing manure and applying it , quality control, etc., whereas conventional farming makes use of chemicals and synthetic fertilisers with relatively lower cost of production as these are often subsidised. The other issue relates to yield which is relatively less compared to GM crops or crops developed using traditional breeding and that are geared towards chemical intensive agriculture. Small and marginal farmers cannot take the risk of low yields for the initial 2-3 years on the conversion to organic farming. There are no schemes to compensate them during the gestation period (Narayanan 2005). There is a premium for organic produce but that alone may not be a sufficient incentive if farmers can be better off by practicing chemical and energy intensive agriculture. The need for more support in terms of technology, extension and monetary and non-monetary incentives has to be explored by policymakers so that farmers gain the most by practicing sustainable agriculture that has distinct socio-economic advantages in terms of environmental sustainability and health.

All the regulations and standards regarding certification of organic products have been clearly laid by the regulatory agencies. But as standards are set by agencies and others with farmers having no control over it, the power and control dimension is obvious. The paradox here is that as organic agriculture becomes more global it is getting oriented more towards global needs in terms of standards, demands and consumer acceptance. In many countries organic culture is linked with community supported agriculture and urban agriculture and/or state sponsorship as in case of Cuba. While India can learn many lessons from such initiatives, organic agriculture's potential for delivering socio-economic benefits should not be lost sight of.

Risk discourse in organics is not a contentious topic in India as it does not possess any risk to human health and environment, the only risk involved is low yield as compared to GM or conventional breeding.

6.3 Risks in Traditional Breeding

Global demand for food in 2050 has been presented as one of the crucial challenges ahead and production has to increase substantially to counter this challenge. Food security is an international issue present on every government's agenda.

Productivity stagnation is the biggest challenge that the green revolution varieties are facing at this stage. Efforts are on to explore options that different crops may come up with, particularly drought- and pest-resistant varieties. In absence of adequate R&D investment traditional breeding has limited options. The need is to have crops with traits like submergence-tolerant rice and drought-tolerant maize and provide options that reduce farmers' risk.

Less importance is given to marker assistance selection (MAS) and molecular breeding which have emerged as a valuable tool for plant breeding and have resulted in less than optimum use of this technology. It is a technique which does not replace traditional breeding but improves its efficiency. The scope for Private-Public Partnerships in this can be explored. Traditional plant breeding is a well established practice in India where risk assessment is not required and the Risk discourse is less controversial as compared to GM. Experience with plant breeding has been so extensive that it has no ill effects on environment is already proven. The challenge lies making it more relevant in future.

7. Power and Control Discourse

The Food Safety and Standards Authority of India (FSSAI) was established under the Food Safety and Standards Act, 2006 as a statutory body for laying down science based standards for articles of food and regulating manufacturing, processing, distribution, sale and import of food so as to ensure safe and wholesome food for human consumption. The FSSAI Act stipulates that 'no person shall manufacture, distribute, sell or import any novel food, genetically modified articles of food, irradiated food, organic food, food for special dietary uses, functional food, nutraceuticals, health supplements, proprietary foods and such other articles of food which essential may notify'. In this way, FSSAI has responsibility for all different kinds of food; however, in practice the GEAC is the agency dealing with approval of all GM organisms including GM food.

The Ministry of Consumer Affairs, Food and Public Distribution notified mandatory labelling of all GM foods sold in packaged form from 1 January 2013. This was based on a 2006 proposal from the Ministry of Health. Bansal (2013) points out that the regulation does not specify tolerance level, i.e. the level beyond which a specific food would be regarded as a GM food, as the legislation makes not only the primary products, but also processed products which may be derived from GM ingredients like edible oil, additive and flavours and meat and animal products from animals fed with GM feed as GM food. It was largely owing to this dilemma that India had withdrawn an official order from the Ministry of Commerce in 2007 banning import of all GM food products in India.[17]

Power and control discourse in India relates to the government agencies handling the regulatory system of GM technologies in India where public opinion is not playing an active role in decision making.

8. Conclusion

Debates on food technologies in India highlight several challenges that Indian food production in particular and agriculture in general is going through. Some of which are contemporary challenges of food insecurity, declining productivity, depletion of natural resources, increased risk from climate change, rising input costs, changing food habits, and extremely high post-harvest losses.

Food production techniques have diversified and have moved beyond their domain where multi-polar convergences are appearing across cutting-edge technologies like bio-sensors, genomics, biotechnology and nanotechnology. It is important that technology-led path brings in prosperity for the farming community which is being emphasised at different points by the policy but it is equally important to ensure that technology brings in prosperity which is not debasing sustainability of the agriculture itself. It becomes all the more important, in a country like India, where agriculture ris primary provider of livelihood security.

In India, many farmers are experimenting with indigenous practices of alternative agriculture, based on lesser resources. This change is not only about the production process but also reflects farmers' stress emanating from declining returns even when inputs are disproportionately enhanced. This paradigm is hardly getting any major recognition when considerations for systemic support come up and consequently much lower support in terms of R&D inputs as compared to their counterpart in dominant technological paradigm. However, a counter trend with additional and advanced technological solutions by better off farmers is also discernible. This is largely led and supported by private sector seed firms and adopted by elite farmers.

The three discourses on innovation, risk, power and control are overlapping while socio-economic aspects issues cut across them. There is a substantial body of literature available on possible impact of technologies beyond the health and the environmental dimension. The term 'socio-economic' may seem to be too vague or too broad but it is possible to identify the key issues involved and link them with technology assessment.

The key lessons from this analysis of food technologies in India are as below:

1) Innovation issues cannot be divorced from broader concerns relating to socio-economic impacts and less than optimum use of innovation can result if they are ignored. But keeping them in forefront in innovation policy and management of technology will result in better benefits to society thereby enhancing more acceptability and wider diffusion.

2) Power and control through technologies should be understood in terms of impacts and how they can result in distorted markets, less than optimum use of technology and result in resistance. The examples from India show that regulation is often a contested terrain as different stakeholders are involved. The stakeholders who are questioning the technology and power and control often use the socio-economic discourse to highlight their concerns and also to make counter claims on benefits and risks. This results in controversies that are often taken to different fora for resolution as all stakeholders are not evenly placed in terms of power and control. Using these fora directly/indirectly to question and regulate technology is not a phenomenon unique to India. While controversies are inevitable attention to socio-economic issues and taking them into account in regulation and policy is a must.

3) Various technological options have to be assessed and promoted for maximising the gains from technology. Here the assessment in terms of socio-economic issues can play an important role in policy formulation. For instance, as discussed elsewhere technological options like non-GM biotechnology, traditional plant breeding and organic agriculture can be supplemented with GM biotechnology in agriculture and laying too much emphasis on one technology can result in skewed outcomes.

4) Food technologies have to play an important role in enhancing food security, ensuring better productivity and environmental sustainability. Access, equity and inclusion can be a criteria in deciding and applying technologies while socio-economic issues have to be addressed in different phases from deploying innovation to protecting farmers from vulnerabilities and risks arising from technologies.

Endnotes

1 See 'Agriculture' in Economic Survey 2012-13, Ministry of Finance, Government of India.

2 In India, 64.7 per cent of holdings are marginal (upto 1 hectare) and 18.52 per cent are small (01-02 hectare), which is 83.29 per cent; however, out of this only 43.14 per cent area is under cultivation.

3 Personal communication with Dr. Ravi Khetarpal.

4 Personal communication with Dr. Vibha Dhawan and Dr. Nidhi Chandana.

5 Personal communication with Dr. Ravi Khetarpal.

6 This part is based on Chaturvedi (2013).

7 See http://www.iccoa.org/about-organic-sector

8 See http://pib.nic.in/newsite/efeatures.aspx?relid=72921

9 See APEDA website.

10 See http://www.iccoa.org/about-organic-sector

11 See NCOF website.

12 *ibid.*

13 See APEDA website.

14 For example, see Pray *et al.* 2005, Lalitha *et al.* 2008 and Scoones 2003.

15 Please see Annex 1 for details on current Indian regulatory system.

16 Personal communication with Dr. Vibha Dhawan.

17 See Chaturvedi (2013) for details.

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Annexure 1

Operationalising the Regulation of Genetically Modified Foods in India
Food Safety and Standards Authority of India

Operationalising the Regulation of GM Foods in India

In India, the regulation of all activities related to GMOs and products derived from GMOs is governed by "Rules for the Manufacture/Use/Import/Export and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells, 1989" (commonly referred to as Rules, 1989) under the provisions of the Environment (Protection) Act, 1986 through the Ministry of Environment and Forests (MoEF).

The Rules, 1989 are primarily implemented by MoEF and the Department of Biotechnology (DBT), Ministry of Science and Technology through six competent authorities: the Recombinant DNA Advisory Committee (RDAC); the Review Committee on Genetic Manipulation (RCGM); the Genetic Engineering Approval Committee (GEAC); Institutional Biosafety Committees (IBSC); State Biosafety Coordination Committees (SBCC), and; District Level Committees (DLC). The Rules, 1989 are very broad in scope and essentially capture all activities, products and processes related to or derived from biotechnology including foods derived from biotechnology, thereby making GEAC as the competent authority to approve or disapprove the release of GM foods in the marketplace.

The Food Safety and Standards Act, 2006 (*FSSA, 2006*)

Following the promulgation of the Food Safety and Standards Act, 2006, which empowers the Food Safety and Standards Authority of India (FSSAI) to regulate genetically modified (GM) foods, MoEF published Notification No. S.O. 1519(E) dated 23-8-2007 in the Gazette of India. This notification exempted "food stuffs, ingredients in foodstuffs and additives including processing aids derived from Living Modified Organisms where the end product is not a Living Modified Organism" from Rule 11 of the Rules,1989. At the time of Notification No. S.O. 1519(E), the FSSAI had yet to publish rules that described how GM food stuffs (i.e., processed foods containing one or more ingredients derived from a genetically modified organism) would be regulated under the FSSA, 2006 and consequently MoEF published a series of additional notifications that have kept Notification No. S.O. 1519(E) in abeyance so that GM foods could, as an interim measure, continue to be regulated under Rules, 1989.

The FSSAI now intends to meet its regulatory obligations by implementing a safety assessment and approval process for GM foods that leverages existing regulatory capacity within the Government of India, notably within DBT, MoEF and the Indian Council of Medical Research (ICMR).

1.1 Organisational Structure

In order to manage the administration of the regulatory programme for GM foods, the FSSAI will establish a new secretariat within the FSSAI, namely the Office of GM Foods and the GM Food Safety Assessment Unit Initially staffed with two Scientific Officers, the Office of GM Foods will be responsible for:

- Coordinating the receipt of GM food safety applications;
- Conducting administrative reviews of applications;
- Verifying submitted documents;
- Managing communication and correspondence with applicants;
- Managing the tracking of applications;
- Providing a secretariat function for the GMFSAU and Expert Committee on GM Foods (e.g., meeting coordination, report taking, document tracking); and
- Managing communications and outreach with stakeholders and the public (e.g., ensuring that information about GM food

regulation, policy and decisions are made promptly available on the FSSAI website).

Table 1 : Responsibilities of governmental authorities as regards the regulation of GMOs in India (excluding pharmaceutical applications)

Activity	Responsible Authority
Contained research (laboratory and greenhouse)	RCGM (DBT)
Event selection trials/BRL 1 trials	RCGM and GEAC (MoEF)
Food safety assessment of GM foods (viable and processed)	FSSAI
Environmental risk assessment of GM organisms	GEAC
Approval for commercial release of GM foods (processed)	FSSAI
Approval for commercial release of GM foods (viable i.e. LMOs)	GEAC
Approval for environmental (commercial) release of GM organisms	GEAC

The GMFSAU will be comprised of a multi-disciplinary team of scientists trained in GM food safety assessment and will include each of the following (at a minimum): molecular biologist; biochemist; immunologist; food allergenicity specialist; toxicologist; and nutritionist. The GMFSAU will be situated at the National Institute of Nutrition, Hyderabad. NIN has experience in GM food safety assessment and already provides science advice to RCGM and GEAC in this regard. Further the sientists at GMFSAU will have to access to the library and other facilities at NIN for accessing the latest literature on the subject. The GMFSAU will report administratively to the Director, NIN and operationally to the FSSAI. The FSSAI and

NIN will be committed to ensuring that the member scientists of the GMFSAU have the appropriate combination of subject-matter expertise, are free from conflicts of interest, and are provided with opportunities to maintain and enhance their scientific knowledge and safety assessment experience.

The FSSAI will also establish the Expert Committee on GM Foods which will: oversee a public consultation process1; consider and respond to comments received during public consultations; and recommend any conditions to be stipulated for product approvals keeping in view the safety assessment report by GMFSAU. The Expert Committee on GM Foods will be comprised of the following members:

- Chief Executive Officer (CEO), FSSAI (acting as Chair of the Expert Committee on GM Foods);
- Principal Scientific Officer, FSSAI;
- Chair, Scientific Panel on GM Organisms and Foods;
- Director, National Institution of Nutrition;
- Advisor, Department of Biotechnology;
- An eminent scientist with experience related to food safety;
- An expert in socioeconomic and/or consumer issues related to food safety.

The process for selection of scientists and experts will be laid down separately.

1.2 The Interim Process: Applications, Safety Assessment and Decision Making

The steps in the interim process are as follows:

1. Applications for a GM food safety approval will be submitted to the Office of GM Foods. Applications must meet the information and data requirements as described in the “2008 Guidelines for the Safety Assessment of Foods Derived from Genetically

Engineered Plants" and companion protocols2. A proforma will be developed by FSAAI to standardize the format of the application.

2. The same application and assessment procedure applies to GM events that may be developed domestically or imported (see section 1.3 below).

3. The Office of GM Foods will complete an administrative review of each application to verify submitted documentation and to ensure that each required section of an application has been completed (e.g., applicant name and address). This is not a technical review. Applications that are deemed complete will be entered into an 2 http://igmoris.nic.in/files/Coverpage.pdf and http://igmoris.nic.in/files/Coverpage1.pdf. application tracking system and an acknowledgement will be provided from the Office of GM Foods to the applicant within 10 days. Applications that are deemed incomplete will be returned to the applicant with an explanatory letter also within 30 days. Applicants will be permitted to re-submit applications without prejudice when errors or omissions have been corrected.

4. The application is provided to the members of the GMFSAU and the safety assessment process begins: Applicants will not be permitted to communicate directly with members of the GMFSAU and vice versa. Communications between applicants and the GMFSAU will be facilitated by the Office of GM Foods and may occur during one or more of the following three stages:

   - During product development and prior to submission of an application to the FSSAI (e.g., during BRLI and BRLII confined field trials) when product developers may seek guidance or clarification about experimental protocols and design, data collection and/or data interpretation relevant to the "2008 Guidelines for the Safety Assessment of Foods Derived from Genetically Engineered Plants" and companion protocols;
   - Dossier development; and/or

- During the GM food safety assessment by the GMFSAU when the Unit may seek clarification or additional information from the applicant. It is common that during a safety assessment, the evaluators may require clarifications about information, data or studies and these can be requested from the applicant. Additionally, the evaluators may encounter deficiencies in the information provided by the applicant (e.g., a required study may not have been provided or required data may be missing). In both of these cases (clarifications and deficiencies) the safety assessment stops until the additional information is provided by the applicant. If the applicant cannot or does not provide this information within a reasonable amount of time, the application will be returned to the applicant and the file will be closed.

5. Upon completion of the safety assessment, the GMFSAU will prepare a Safety Assessment Report that summarizes the information that was taken into account during the safety assessment and states the decision of the GMFSAU as to whether the GM event that is the subject of the application may be considered as safe as its conventional (non-GM) counterpart in the context of its proposed uses as food. The safety assessment, preparation and submission of the Safety Assessment Report should be completed within the prescribed period of time (90 days) excluding the time required by an applicant to address any clarifications and/or deficiencies (which may extend the total time of the assessment to 6-12 months).

6 In cases where NIN is involved in performing any studies for safety assessment of GMOs, the GMFSAU will co-opt two or three additional excerpts from outside NIN to give opinion. The Safety Assessment Report will be submitted to the FSSAI.

7. The CEO, FSSAI will convene the Expert Committee on GM Foods which will consider the Safety Assessment Report , oversee the public consultation process and make a recommendation to

approve/not approve the subject event. This recommendation will be taken in a timely fashion (within 90 days of receiving the Safety Assessment Report).

8. In the case of GM foods that are not LMOs, the FSSAI will take a decision to approve/not approve the subject event based on the recommendation of the Expert Committee on GM Foods.
9. In the case of GM foods that are also LMOs, the FSSAI will forward the recommendation of the Expert Committee on GM Foods to the GEAC.
    a. GEAC will take a decision to approve/not approve the subject event based on the recommendation of the Expert Committee on GM Foods provided by the FSSAI. This decision will be taken in a timely fashion.
    b. Decision-making should be determined by the recommendation provided by the FSSAI to the GEAC. However, if it is decided that other non-safety considerations should also be included in the decision-making process, GEAC will ensure that these are consistent with the Rules, 1989, the FFSA, 2006 as well as any other pertinent obligations that India has under international agreements. The inclusion of non-safety considerations must be carefully considered as a matter of policy and then defining regulations and guidance should be developed. This is essential to ensure that there is consistency and impartiality in how such considerations may be used to inform product-specific decisions.
    c. The GEAC will communicate its decision to the FSSAI.
10. The FSSAI will publish decision summaries of all GM food approvals and these will be posted on the FSSAI website.
11. The approval of an event by FSSAI or GEAC will apply to all foods that contain that event, whether imported or produced domestically. This will exempt the need for food importers and processors to submit applications to the FSSAI for the safety assessment of the same event.

1.3 Other Key Operational Elements

1. The FSSAI will assess GM foods at the level of an "event3". Approvals will apply to foods derived from the event, its progeny (including derived hybrids and varieties produced through conventional plant breeding) and any food stuffs that contain ingredients derived from the approved event and its progeny.
2. The safety assessment of an event will include the evaluation of the whole or primary food product in the forms that are commonly consumed in India. For example, the food safety assessment of a GM soybean event may include compositional and nutritional data for raw soybean seed as well as processed fractions of soybeans, such as toasted meal, defatted non-toasted meal, protein isolate, protein concentrate and oil. It will not include the safety assessment of biscuits that include soy oil as an ingredient (see point 1 above) as the soy oil will have been evaluated during the approval process for the subject soy event to be as safe as conventional soy oil.
3. Processed foods that contain ingredients derived from an approved GM event will not be subject to further regulation.
4. The Scientific Panel on Genetically Modified Organisms and Foods will have the responsibility of discussing issues related to regulatory policy and will provide strategic advice to the FSSAI. The Panel will have no responsibility for, or role in, product-specific safety assessments and subsequent decisions to approve/disapprove these products.
5. While applications to approve GM livestock feeds are submitted to GEAC, GEAC may seek comments based on GM food safety assessment from FSSAI on such applications as these feeds may potentially enter into the food chain.
6. All rules, regulations, policies, standards, guidance and decisions related to the regulation of GM foods will be made publicly available by the FSSAI and GEAC.

1.4 The Development of Guidelines

The FSSAI will notify guidelines that clearly describe the regulatory framework for GMFoods. These guidelines will provide details about the interim process for the regulation of GM foods as described below and will be in place until such time as new regulations are notified under the FSSA, 2006:

- The scope of the interim process;
- Application procedures and process;
- GM food safety assessment procedures and process including the format of the safety assessment report A genotype produced from the transformation of a single plant species using a specific genetic construct. For example, two lines of the same plant species transformed with the same or different constructs constitute two events.
- Decision-making procedures and process;
- Time standards;
- Protection of information;
- Draft standard for GM foods for incorporation in regulations;
- The role of the Scientific Panel on Genetically Modified Organisms and Foods;
- The purpose, constitution and operations of the Office of GM Foods, FSSAI; and
- The purpose, constitution and operations of the GMF SAU,

The "Guidelines for the Safety Assessment of Foods Derived from Genetically Engineered Plants" and the complementary GM food safety protocols that were approved by GEAC and RCGM in 2008 are will be adopted and implemented by the FSSAI. The 2008 Guidelines provide a safety assessment framework that is consistent with international standards developed by Codex Alimentarius. Additional guidance will also be developed for documentation and quality standards for applications submitted to the FSSAI.

1.5 Capacity Building

The FSSAI is committed to ensuring that sufficient institutional, financial and human resource capacity is put in place to implement this interim process and will work to achieve this by participating in, and building upon, initiatives already taken up by MoEF and DBT. In particular, the FSSAI will provide the necessary administrative and technical training to establish:

- The Office of GM Foods;
- The GMFSAU, including advanced training in GM food safety assessment for the GMFSAU member scientists;
- Diagnostic laboratories for detection of unapproved GM events, including advanced training in sampling and detection methodologies, test validation and potentially developing a nationally (or internationally) accepted laboratory certification scheme. The capacity that is built under the interim system will be transitioned to the permanent food safety assessment and approval process for GM foods that will be established when the necessary rules and/or regulations for GM foods are notified under the *FSSA, 2006*.

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