

Sustainability and Increasing the Yield of Crops in India: Agricultural Scientists, Farmers and the Knowledge Systems

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Abstract: The yield of most important food crops has shown increasing trend for years but now undergoing a tough phase of sustaining and increasing the yield. The chemical fertilizers, sprays etc have reached a stage where crops are not able to respond to the chemical inputs in increasing the yield. A paradigm shift is in the process of displacing the chemical fertilizers to the products of biotechnology in increasing the yield. But there are also other knowledge systems like the organic farming, agroecological methods, traditional knowledge to increase yield and also have high prospects of sustainability. The states tend to promote the lab science rather than the farmers' knowledge and expertise learned over years. The promotion of particular agricultural science over others raises doubt about the real interest of the state in promoting sustainability. But the major challenge is about whose knowledge is going to bring sustainability and growth to agriculture which can feed the growing population?

Keywords: Biotechnology, Yield, GM Crops, Knowledge, Sustainability

Introduction

The success of producing enough food with the advent of green revolution technologies is an achievement accepted as a revolutionary attempt of science and technology over traditional and sustenance farming practiced in India. The milestone has given a pride that Indian government has the potential to manage food security of the people and possess the scientific capability to overcome any agricultural adversaries. Thus the scientific agriculture which has been promoted during the 1960s still being promoted as one of the successful practice which could secure food and livelihood to people engaged in farming. After achieving the status of self-sufficiency in food production, India has maintained the status of producing enough for its citizens all these years. Food grains production rose from

50 million tonnes in 1951-52 to 265 million tonnes in 2013-14¹. Although we are able to produce enough food, large section of population go without food which signifies issues to be addressed in the distribution of food grains.

To maintain the same productivity level is more becoming a tough task because the lands are not responding to the “modern” technologies once promoted during the times of green revolution. The vision 2020 of the government states that;

“Small and scattered land-holdings and their continued fragmentation; low and declining investment in agriculture; low input-use efficiency; inadequate credit support; weak agro-based industry; adverse terms of trade; inadequate marketing, storage, transportation, agricultural extension and IPR mechanisms. A long-term perspective plan is non-existent. The result is low productivity and yield plateauing in certain commodities”²

The yield in cereal cultivation especially rice and wheat has come to an average and maintaining recurring stagnating yields in areas of “green revolution” belt which once considered to be the forerunner in the crop production. The fact is established in many of the policy statements national as well as in the international circles that the yield of rice and wheat has stabilized throughout the world³. The scientific agriculture is witnessing stagnation and has come to a recession level which is making the policy makers, scientists, companies, progressive farmers etc to find new ways and methods in promoting the scientific agriculture.

The population estimates of the future is becoming a defining phenomenon which urges the Indian state to look for options to increase productivity in food and cash crops to keep vast majority of its population at peace. The increase in yield is also aimed to generate revenue and industrialize agriculture to bring good living standards of the farmers. The contribution of agriculture to the economy in enhancing other sectors is still a dominant phenomenon in the development ideas of the state.

The urge to increase the productivity of crops is a continuous aspect across generations for the farmers, scientists and administrators. Since the scientific agriculture has taken predominance in the present century, the urgency and the responsibility is slated to lie more with the agricultural scientists. The government circles also largely rely on the scientists and private companies to bring breakthrough in yield increment for the food security of the booming population. The urgency or the necessity is being motivated by agencies like UNO, World Bank, Consultative Group for International Agricultural Research (CGAIR), MNCs involved in the seed industry and government research institutes involved in agricultural research.

¹ Ministry of Agriculture, Government of India. *Agricultural Statistics at a Glance 2014*. New Delhi: Oxford University Press, 2015. pg. 42.

² Vision 2020: Indian Council of Agricultural Research. November 1999. pg. 25

³ Beverly D. McIntyre, Hans R. Herren, Judi Wakhungu and Robert T. Watson. ed. *International Assessment of Agricultural Knowledge, Science and Technology for Development: Global Report*. Washington, DC: Island Press, 2009. pg. 16

Biotechnology has become the buzz word which has offered to solve most of the problems in agriculture. It is considered to be an advance science far superior to the green revolution technologies in offering solutions to the ailing agriculture. The technology has created lot of hope as well as fears among various sections of population since it is being projected as the only alternative and less assessment on the impacts on the products of biotechnology. There are various other pertinent issues which need to be analysed before questioning or making opinions on biotechnology. They are as follows;

- a. The world is producing enough food for all, why then the urgency to promote biotechnology or increase the yield of crops?
- b. Has the governments of the world have adequately addressed the impacts created by the green revolution technologies?
- c. Why the other farming practices/knowledge which is native to the lands is not being promoted?
- d. Can the agriculture be conducted like a business and can the lands be equated with machines?
- e. How will the farmer thrive in the web of scientists, governments, volatile global market etc to adopt environment friendly farming practices etc.?

The article will analyse the above aspects and will focus on how states are carrying forward the idea of yield increase in crops with the promotion of scientific agriculture, the perspectives and policy options being promoted by the major policy promoters like the UNO, World Bank, Government of India etc; the neglect of diversity of knowledge in increasing the yield, the issues specific to India in maintaining the yield of crops and the steps taken to increase yield of different crops, how farmers being placed in knowledge based biotechnology revolution and critical assessment of the axis of science, scientist and politics in projecting views on biotechnology.

Science in agriculture

The orientation of science and technology in agriculture was to produce more and supply the needy to ensure that no human being in this world go without food. The world is now producing enough food⁴ with the help of advancements in human knowledge but some states of the world are not able to achieve the target due to social, economic and topographical conditions prevailing which hamper agriculture. Developed states are the role models for the poor states in successfully conducting agriculture and producing enough foodgrains for its citizens. If the food produced throughout the world be equally distributed we can achieve the status of food security for all. The developed states rather trade the food materials in the global market which has to be bought by poor states and sometimes the foodgrains are offered free with prescribed sanctions to be adopted in their governance.

⁴ C. Nellemann, MacDevette, M., Manders, T., Eickhout, B., Svihus, B., Prins, A. G., Kaltenborn, B. P. ed. *The Environmental Food Crisis – The Environment's Role in Averting Future Food Crises*. February 2009. pg. 15

States compete to become self-sufficient since it is considered to be one of the primary aspects of social life. It is the human knowledge gained over years is invoked in bringing more growth which has been hastened by the emergence of modern science. The statistics also do not deny the growth in productivity which has not declined in any of the crop after the advent of modern science or by the knowledge practice of the farmer which is gained by generations. India is one of the states in the world which was once a “begging bowl” emerged to be self-sufficient with advent of green revolution. The green revolution science and technology introduced in the 1960s paved way to bring remarkable yield in wheat and rice. The yield of food grains and self-sufficiency brought by the new knowledge system was given high credits and considered to bring industrialization in agriculture.

The green revolution technologies are primarily imported technologies which were made to suit the Indian conditions⁵. The hybrid seeds contained the germplasm of world which were hybridized to suit the Indian soil. The seeds produced through modern technique require lab conditions which have to be established in the fields. The basic infrastructure which are essential for a crop produced through lab conditions are the assured irrigation, rationed chemical manures and nutrients, timely spray of pesticides, machineries required from plantations to harvest etc. The success of a crop or establishing the yield of crops in science led growth is pre-defined, for example if the crop is not able to be irrigated according to the norms prescribed it won't give the desired yield⁶. Thus there are pre-defined established norms and infrastructure required in the science led growth in agriculture.

The established infrastructures are so necessary to successfully bring a crop which not only satisfies the basic needs of the people but also play an important role in the economic affairs of a state. The model of development being promoted is highly influenced by the scientific aspects built into the system of farming. Building of large dams, establishing research institutes, scientific collaboration with other states are some of the agencies of carrying forward the scientific theme build into the agriculture in the modern times of India. The new seeds supplied by the government necessitated the farmer to re-orient his knowledge in bringing up the crop and manage the farm according to the choices available to him. The knowledge which a farmer has earned through generations of bringing up a crop has become redundant since the new seeds carry with them a lot new expertise which the farmer has to master himself from the experience or from state sponsored agencies⁷.

The yield of a crop increase only when lab conditions are provided in the field. The lab conditions are not a necessary phenomenon for a traditional seed when compared with the modern seeds. The traditional seeds more suits the local conditions of weather, withstanding pest attack, ability of absorb naturally available manures etc. The science led seeds necessitates established conditions to achieve the determined growth or yield of a crop. This

⁵ R. Patel “The long Green Revolution.” *Journal of Peasant Studies* 40(1) 2012, pp. 12-16.

⁶ K. Subramanian. *Revisiting the Green Revolution: Irrigation and Food Production in 20th Century India* (PhD diss., Dept. of History, Kings College London) 2015, pg. 3.

⁷ Knowledge in Civil Society. *Knowledge Swaraj: An Indian Manifesto on Science and Technology*. Secunderabad: KICS, December 2009.

is a common phenomenon anywhere in the world that necessary inputs and agro ecological conditions should favour the success of a crop. If there is less rainfall, scarcity of inputs, drastic change in pest attack etc which are uncertain natural phenomenon it plays a major role in the success of a crop. Given the fact if all the conditions of bringing up a crop is established yield capacity of crop is assured. In the recent times we find the productivity statistics of crops throughout the world is wavering around stagnant yield in most of the crops even after achieving the ideal conditions of production⁸.

In the recent times there have been new scientific reason emerging as a paradigm shift to the science and technology in green revolution. The new science is being propagated for the following reasons.

- a. The area of the world or a particular state cannot be altered one has to produce food and other items in the given territory. The challenge was to increase yield in the given land for the blooming population.
- b. The stagnation in the yield has cropped up due to the imbalanced use of green revolution knowledge by the farmers. This has resulted in infertility of land which is not responding to technologies of green revolution.
- c. The global weather patterns have changed which requires crops to withstand hard natural circumstances of dryness or heavy rains or pest attacks or infertile soil etc.
- d. The technological advancement in seeds and various other important inputs have to be sustainable.
- e. To bring input cost of farmers to increase the profitability to sustain in the volatile global market.

The new science - Biotechnology

The impact of science in agriculture has produced new realities which are combated with new advancement in science. The new science has come in the form of Biotechnology which offers hope of increasing productivity by genetic modification of crops and combating various other natural and man-made phenomena. It is a different paradigmatic approach which rejuvenates the promise to increase yield which have seen stagnation by green revolution. The scientific techniques technologies have improved the yielding capacity of crops and it is strongly believed that biotechnology would further increase the yield. This has evoked enthusiasm and aspirations among the progressive farmers, scientists, administrators etc as well scepticism in among small farmers, social scientists and pessimist of science and technology⁹.

The main exercise of farming like preserving the seed, selecting good seed for next cultivation, farmers' indigenous way of bringing up a crop, etc is being taken over by the new

⁸Jennifer Clapp. "Review Essay: The Global Food Crisis and International Agricultural Policy: Which Way Forward?." *Global Governance*, Vol. 15, No. 2 (April–June 2009): pg. 300.

⁹ Shiv Visvanathan and Chandrika Parmar. "A Biotechnology Story: Notes from India". *EPW*, Vol. 37, No. 27 (July 6-12, 2002): pp. 2714-2724.

science. The techniques of growing the crop and all necessary information on pesticide, manures, harvesting, storing etc anything on crops are prescribed by the scientist, science and the lab. The farmer with the inputs provided by the science has to cultivate and replicate the knowledge he has gained from the scientific agencies. The deviation in yield would be mismatch of information provided and knowledge practiced in the field. The farms and the farmers are being managed by the knowledge outside of the farm and the rest like failure of a crop, any unnatural threats or risk in the crop are managed by further reliance on the science, scientist and the lab¹⁰. The rationality of farming is to absorb the ideas of growing a crop from the prescription given by the companies which sell seed and offer knowledge from other input components like the fertilizer, pesticide etc which are provided by the company. The deviation from the established norms of prescription would in a strict sense not allow the farmer to reap the full benefits of the crop.

The products of biotechnology and their acceptance is not a settled debate in the world. The developed states like USA, China, Brazil, Canada etc have accepted the advancement of science in agriculture as natural and do not perceive great threats to the environment and human health. The European countries, India, etc do not consider the biotechnological products as extension of nature and perceive threats to the environment and human health. The adoption of genetically modified crop (GM crop) which is one of the main products of biotechnology is uneven based on the political will of the government. The developed states adopt the advancement of this new science and do not want to lag behind. Many states do not want to keep the new science dormant and take possible commercial achievement. The European states have not totally disregarded the advancements of biotechnology, since the environmental and health issues are at stake, the decision have been postponed as wait and watch policy to understand the impacts thoroughly. The Americans perceive the unacceptance of GM crops by the Europeans as political and deliberate attempt to bring in trade imbalances¹¹.

The Indian experience does match with the European opinion on GM crops. The Indian state even though it has allowed one non-food crop, bt cotton, the moratorium on food crops continue since the prospects are not clearly visible. The civil society has been so vibrant in bringing in moratorium on food crops namely Bt brinjal¹² and Bt mustard¹³. The political will is an interesting phenomenon to be understood in India. The BJP government which came to power in 2014 promised to ban GM crops but in the recent times it has shown lot of pro-active role in releasing GM crops¹⁴. The confusing state of affairs was also noticed during two regimes of UPA government which at times show pro-active role in releasing GM

¹⁰ Rajashree Chandra. *Knowledge as Property: Issues in the Moral Grounding of Intellectual Property Rights*. New Delhi: Oxford University Press, 2010. pp. 140-178.

¹¹ Michael Antoniou, Claire Robinson and John Fagan. *GMO Myths and Truths*. Kolkata: Earth Open Source. June 2012, pp. 23-36.

¹² Jairam Ramesh. Ministry of Environment and Forest. *Decision on Commercialization of Bt Brinjal*. 2010.

¹³ Supreme Court of India. Interim Report by the Technical Expert Committee Accessed January 10, 2017

¹⁴ BJP Election Manifesto 2014.

crops and continue the moratorium when the civil society opinion became oppose the move¹⁵. The same dual approach can be witnessed in many of the states where they initially promise to ban GM crops during the times of election and once they are in power taking pro-active role and supporting GM crops in alleviating hunger and poverty¹⁶.

The rationale behind increasing the production each and every year is to fulfil the needs of the growing population this rationale is being applied for both the food crops as well as the non-food crops. The biotechnology also has favoured more research on the cash crops rather than the food crops. In India the first GM crop released was Bt cotton, and there are now attempts by the government to release Bt mustard and Bt brinjal which does not contribute the food security of the people. The GM rice which assures to ensure the micro-nutrients have not seen the light, which every now and then miss the release for commercial cultivation. The motive of biotechnology is shaped by the private companies which want to bring in their seed and establish permanent markets. The debates on food security is only discussed and debated in their program of GM research but does not have made serious attempts to bring invention in this lines. The government has absolved its duties of promoting new science since its exercise has been actively taken by the private.

The genetic modification of crops is an attempt to engineer the nature and bring in desired changes in the name of science. The private companies do assure that the science would help poor states to achieve food security and save environment. But the projection of this new science overthrows the alternative methods of agriculture and knowledge available with people. The new science has created a favourable environment with the policy circles to project biotechnology as superior over other forms of knowledge¹⁷. The driving force behind the private knowledge has hegemonized the local knowledge of the people and monetizes every aspect of farming. The new technology has assured to break the stagnating yield of crops and reduce the input cost of farming.

Yield vs Genetically Modified (GM) Crops

The Genetically Modified (GM) crops considered to be the major breakthrough in Biotechnology. This technique of transferring the desired gene from any organism to any germplasm of a seed results in achieving the desired motive. Bt cotton was the first GM crop introduced in India for commercial cultivation in India. In this crop *Bacillus thuringensis* (Bt) is a soil bacteria introduced into cotton which will act as pesticide when the crop is attacked by the pests. If the pests eat any part of the crop, the pest will die due to the poison produced by the bacteria into the gut of the pest. Thus Bt acts as a natural pesticide since it is

¹⁵ Your Voice Your Pledge. Lok Sabha Election Manifesto 2014.

¹⁶ Press Trust of India. "Nitish writes to Centre against approval to GM Mustard crop." *Indiatoday*. May 18, 2017.

Mayank Aggarwal. "Chandrababu Naidu against commercial cultivation of GM Mustard." *Livemint*. September 5, 2017.

¹⁷ Sambit Mallick. "The Political Economy of Agricultural Biotechnology in India." *Social Scientist*. Vol. 37. No. 03-04(March – April, 2009): pg. 56.

inbuilt into the crop. The major benefit expected by the technology is that it will decrease the use of pesticide and it will pave the way to increase the yield of the crop.

The promoters of the crop claimed that Bt cotton will prove to reduce the pesticide usage and increase the yield. It is understood that since Bt is injected into the crop it will reduce the pesticide usage, but the indirect benefit of increasing the yield was also promoted by the developers of the seed¹⁸. This is a common phenomenon being claimed in all the GM crops being developed in India and elsewhere in the world. The indirect benefit of increasing the yield is blown out of proportion that the real purpose of the plant for which it is being known got side-lined and the phenomenon of yield has taken over.

The yield of Bt cotton is statistically proved that its yield has consistently increased from 2002 onwards. There are multiple factors which have contributed to the yield increase in Bt Cotton. One of the major factor is about the shift in cultivation of Bt Cotton from rainfed to irrigated lands¹⁹. It is also been generally agreed in the scientific establishments that Bt cotton cannot perform the same in all types of land. The Bt cotton when introduced in India showed a dramatic result in the yield but it was not able to fulfil the promise in the rainfed regions of the state. The crop is to be provided with secured irrigation, manure and vigilant pesticide spray which would give the required yield. But the Bt cotton crop when promoted was not differentiated where and how it has to be planted. There are at places the farmers have spent more in pesticides and manure to secure the crop since farmer has bought the seeds with a heavy cost. The Bt cotton failure in Vidharbha region of Maharashtra, Telangana, Andhra Pradesh, Tamilnadu and Karnataka have become an indirect reason for the thousands of farmers' suicide²⁰.

The yield of Bt cotton versus the local hybrid cotton is not so dramatic in the rainfed regions. In countries like China the substantial divide in the yield of Bt cotton was short lived and it is showing downward trends in the yield²¹. The Bt cotton presupposes some established infrastructure which would give the desired yield. This is similar with the green revolution technologies which presupposes established infrastructure which would establish the desired results. The primary need for the Bt cotton crop is good irrigation, the crop cannot perform to the expected levels in the rainfed regions, the information was little known to the farmers and they treated the Bt cotton seed equally with the hybrid seed. The introduction of GM crops has initiated fresh debates in the research establishments and in the global policy promoters.

The Global Perspective

¹⁸ Gopal Naik, Matin Qaim, Arjunan Subramanian and David Zilberman, "Bt Cotton Controversy – Some Paradoxes Explained", *EPW*, April 9, 2005, pg. 1514 -1517

¹⁹ M. Sabesh, M. Ramesh, A. H. Prakash and G. Bhaskaran. "Is There any Shift in Cropping Pattern in Maharashtra after the Introduction of Bt Cotton?" *Cotton Research Journal*. Vol.6, No. 1(January – June 2014): pp. 63-71.

²⁰ Roundtable on "The fabric of Cotton: Seeds, Farmers and Textiles. What should be India's Cotton agenda?." Organised by National Academy of Agricultural Sciences (NASAC), The National Commission on Farmers and the Centre for Science and Environment, July 10, 2006, NASC Campus, New Delhi.

²¹ Kavitha Kuruganti. "Bt Cotton and the Myth of Enhanced Yields". *EPW*, Vol. 44, No.22 (May 30-June 5, 2009): pp. 29-33.

The phenomenon of increased input cost, volatile food market, uneven monsoon conditions, standard yield of crops, reducing fertility of soil etc are prevalent ailing conditions of agriculture throughout the world. These causes have increased the food cost in the global market which forced millions of people to hunger and food insecure. It forced many organisations to review agriculture productions and the reasons for the volatile nature of food security throughout the world. These concerns were defining features in the World Bank's; World Development Report (WDR, 2008) and the United Nations report on International Assessment of Agricultural Knowledge, Science and Technology for Development Report (IAASTD, 2009). The above mentioned reports are worth analysing to understand the global agriculture situation and the various policy options being promoted by these agencies which are readily accepted as solutions to the ailing agriculture in various countries by the policy circles.

The above mentioned reports argue for a variety of solutions to the ailing agriculture in the world. The close examination of the reports reveals the real objectives of the nations involved in the making of the report. There were a total of twenty World Bank economists and an additional of forty experts in various fields was involved in the writing of World Development Report. The report aims to advocate and reinvent policy changes to address poverty and economic growth for the world economies and gave a special focus for the developing worlds. It seeks to place emphasis on the increase of agricultural productivity to foster growth for the economies and increase the global trade to address poverty and development. The IAASTD report is an initiative by the World Bank and the Food and Agriculture Organization of the United Nations in 2002 as a global consultative process to determine whether an international assessment of agriculture knowledge, science and technology was needed. The report is report written by 400 experts, with additional input from 500 individuals across the globe to balance the geography. It is a multi-disciplinary report involving all stakeholders in agriculture, including government representatives, non-governmental representatives, producers, consumers, private groups etc. The report making was so rigorous and similar to the making of the Intergovernmental Panel on Climate Change (IPCC) and the Millennium Ecosystem Assessment.

The WDR places lot of emphasis on the agricultural growth for the agriculture based states where agriculture is done in a way is environmentally sound and less vulnerable to climate change. The report suggests the transition economies i.e economies which are progressing towards industrialization like the regions of Asia, China and Southeast Asia should move into high value agriculture which helps the people to proceed towards non-agricultural sector. The report recommends that the urbanized countries can still assist in reducing the remaining rural poverty. The IAASTD report offers an assessment of the state of knowledge about the role of agriculture knowledge, science and technology in promoting food security and environmental sustainability. The report does not prescribe any policy but it has given lot of policy options for the states which can bring sustainability of agriculture and reduce poverty. The major argument of the IAASTD report is that the present trajectory of growth is un-sustainable and it need to look for lot of policy options. It strongly argues that the smallholder farmers, rural livelihoods, the environment and culture are all at risk with the current system of growth. The

report argues that the most affected section of the society would be small farmers and their environment and culture. Thus the report argues for a reconsideration of the objectives of the scientific progress which is shaping the agricultural activities in the world.

Farmers' knowledge over agriculture

The human civilizations thrived with the advancement of human knowledge in cultivating and produce food for his needs. The knowledge acquired over generations on cultivating has been passed on which plays an important role in the affairs of agriculture. The development of modern science enhanced the knowledge over plants and various other activities related to farming. The rationality of science and farmers knowledge have annihilated human civilizations from hunger and poverty.

In the present times we are witnessing a trend of science and technology completely withholding the knowledge of farmers and considered it as obsolete²². The farmers have to play the second fiddle while the science dictates the affairs of farming and agriculture. The farmer sovereignty over seeds has been completely taken by the research labs and the scientific agencies. The seeds provided by the private companies are being cultivated by the farmers. The farmers have lost the culture of preserving seeds and cultivation of only the seeds available in the market have resulted in the loss of bio-diversity. The lab designed seeds seeks to assure good yield and various other benefits which has taken away the farmers knowledge to preserve seed. The price of seed supplied by the private companies increase each year by justifying the claims of newly incorporated science into it. The price of Bt cotton seed bought by the Indian farmers was once equal to the price of Bt cotton seed bought by the farmers in USA.

The seed industry has steadily prospered with the advent of TRIPs. The private and public scientific research is also moving with the aspiration of more patents rather than addressing the vital problems of agriculture. The seeds propagated under the lab condition give the desired yield but when they are transferred to the fields the experience is mismatching. The seeds propagated necessitate artificial conditions which are not effectively achieved in developing states. The farmer does not have any role in the preparation of the seed except simply cultivating what is being provided to him/her. If the seed fails the company reassures the farmer that it would reinvent and incorporate what is being overlooked to suit the local conditions. The seeds which are claimed to have been tested for all its features when it fails in the field, the farmers knowledge over cultivation practices is being questioned and they are labelled as unscientific and traditional farmer. The seeds which are promoted by the MNCs even though claimed to adopt local conditions does not suit for industrial agriculture. In India where more than 80% of the farmers are small farmers it is very tough to adopt and bring the crop accordingly.

²² C. Shambhu Prasad. "A Green Economy of Permanence: Innovation Insights from Grassroots Knowledge". *The International Journal on Green Growth and Development*, Volume 1, Issue 1, (January-June 2015): pg.54.

The world agriculture policy and knowledge promoted by the developed countries and the scientific research agencies lack multi-dimensional perspective. It does not recognize the plurality of knowledge prevailing in the developing societies and does not acknowledge that it would be very essential for the sustainable agricultural practices. The other forms of knowledge are labelled as non-scientific and do not figure in the policy as well as in the products of science and technology offered to the farmers in the present times. There is being a mistrust developed in the solutions offered by the modern science since it does not solve the societal and economic problems of the agricultural community. Also many a times the commercial interest becomes naked in the promotions of the solutions offered to the agricultural problems.

There is a consensus among the scientist that the farmers cannot take part in the science and technology offered to them. It can be accepted that in labs farmers cannot contribute but the experience learned over centuries can play a vital role in the formation of a technology. The expertise of the farmers is so diverse in a state like India where technologies behave differently according to the topography could be very useful in developing technologies. The society is so hierarchical that every spectrum of the society needs to be involved in the solutions offered to agricultural problems. The technology offered to the farmers needs to incorporate the perspectives of the labourers who work in the field. The technologies propagated in the market also should match the convenience and comfortability of farmers as well as the labourers who largely employ the technology.

In the view of scientist most of the problems can be solved through emerging science and technology. The scientist resist to accept the problems are multi-dimensional and it needs expertise from different section of population. Most of the problems which need societal participation can be recommended by the scientist which might be cost free and a chance to involve the local expertise. The technology offered by the scientist also should take care of diverse social population as well the different topographical nature of a state. The technology cannot be one for a single problem, it has to possess the necessary capacities to adopt and clone according to the local conditions. In the history of science and technology policy formation in the independent India over 2000 scientists were consulted in fifth five year plan(1974-79) which was short-lived and not completely seen through.

The scientists have developed superior hierarchy attitude over the expertise and the knowledge of farmers. The scientists need to accept the parity of famers for their contribution towards the growth of agricultural knowledge. Scientists also have to accept that their solution is a temporary phenomenon and the knowledge of the farmers play an important role in promotion of new science and techniques in the society. There are so many examples where farmers have become more perfect than the scientist. The dominant ideas are witnessing setbacks which are forcing the scientists to co-opt knowledge from various other sources like the agro-ecological farming. The agro-ecological farming concentrates on enriching the soil more than the yield of the crop. It believes that if the soil is rich, the crop over the land would yield better. Rather the scientific approach concentrates on how to increase the yield by chemical manures which fail to enrich the soil and the yield is short

lived. The number of dams built in the independent India considered to industrialize agriculture has seen a setback. The soils have become so porous, lost the water retention capacity, have become so alkaline, the storage levels of water in the dams have decreased due to deposition of water sediments etc. Ideas once considered to be breakthrough and vital have become burden on development.

The contributions of the social scientists are also being overlooked in policy options and their views on ethics over a technology. The perspectives of the social scientist are treated as un-scientific and claimed that science is beyond the comprehension of social science. The scientists fail to comprehend that the technology has to operate in the society and it is capable of emanating repercussions which are beyond the comprehension of the scientists. The scientist who is an careful social observer might comprehend what would the new technology impact the society. The stakes with the technology and the professional ethics of the scientist suppress him to express or to reveal anything about the technology when it is introduced in the society. There is a need emerged in the society that scientist must understand the impacts of the technology before it is introduced in the society and co-opt diverse knowledge available in the public to construct a technology.

Diversity of knowledge

The farmers around the world have developed varieties of farming practices which fits to their geographical conditions. One of the more common practices which is followed throughout the world can be labelled as agroecology. Agroecology — the science and practice of sustainable agriculture — creates highly productive farming systems by tapping farmers' knowledge and integrating agricultural innovations developed over millennia with emerging scientific research. Agroecological farming methods include intercropping, cover cropping, crop rotation, conservation tillage, composting, managed livestock grazing and combined animal and plant production²³. The agroecological farming is a broad category of environmental sustainable techniques which does not have any defined set of techniques. Organic farming can be considered a subset of the agroecological farming systems that exist around the world and practised by many.

Agroecological farming systems can generate many environmental benefits, including water conservation, decreased soil erosion, reduced use of synthetic chemicals and greater biodiversity in the soil and on the farm. They can also help to mitigate and boost resilience to climate change. They strengthen resilience to drought and floods by improving soil structure and water-holding capacity and can decrease agriculture's unsustainable energy use and greenhouse gas emissions. By sequestering more carbon in the soil than conventional practices, these methods can be an important part of climate change mitigation strategies.

Agroecology is not only about farming practices, it is a holistic approach that includes cultural diversity and social justice as important aims of our food and farming systems²⁴.

²³ Friends of the Earth. *Farming For The Future: Organic and Agroecological Solutions to Feed the World* by D. Cook, Christopher, Kari Hamerschlag, and Kendra Klein. June 2016. pg. 6.

²⁴ International Panel of Experts on Sustainable Food systems. *From uniformity to diversity: A paradigm shift from industrial agriculture to diversified agroecological systems*. 2016, pg. 9.

Agroecology is a central pillar of food sovereignty, a global grassroots movement working to combat poverty, inequality and hunger by promoting democratically-controlled food production and challenging corporate power in our food system²⁵. The agroecological movement declares that world hunger is caused primarily by poverty, lack of democracy and unequal access to land, water and other resources and infrastructure, especially among women. The movement insists that simply producing more food under unequal conditions, the solution to hunger hinges on creating more democratic and fair political and economic systems that expand access to resources. Agroecology movement challenges unjust power and inequality in society and promotes policies and practices that make farmers, fisherman, shepherds, indigenous people, workers, consumers and citizens the primary decision makers about food and farming.

Agroecological ideas are prevalent in most part of the World. These ideas in the modern times were in the contour due to the extra hard work required in implementing the techniques as well the uneconomic prospects involved in the cultivation. It has gained its importance over the years due to the fallouts of the green revolution technologies and its impact on environment, health, social, economic, cultural and political on people. The agroecological techniques have not thoroughly seen its implementation due to the stagnant developmental ideas considered to be fit for ages. The agroecological techniques are very much prevalent in the subsistence agriculture followed by the people for centuries. The techniques are very much documented in the ancient scripts and also recorded by the English in various agricultural surveys. The organic farming can be considered as a subset of agroecological ideas. The major thrust of organic farming is self-sustaining techniques which is established by bringing in traditional knowledge and experience of a farmer in bringing up a crop.

Conclusion

The idea of organic or agro-ecological agriculture is the only practice in the pre-modern times of the world which was based on subsistence and practices according to the wisdom of farmers. With the advent of modern science and technology the traditional practices were labelled as unscientific and new scientific methods were promoted as the only way of conducting agriculture. The unsustainable nature of this model of agricultural production and management has now necessitated the promoters to look for various other options to establish sustainability in agriculture. As discussed earlier in the article, the diversity of knowledge is seen as the only saviour to the present problems ailing agriculture. The knowledge available with the farmers across the world has a lot of potential in bringing back sustainability in agriculture.

²⁵ Friends of the Earth. *Farming For The Future: Organic and Agroecological Solutions to Feed the World* by D. Cook, Christopher, Kari Hamerschlag, and Kendra Klein. June 2016. pg. 16.

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