



E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP3: 99-104

Mukhtyar Ahmed
Research Scholar, Bhagwant
University, Sikar Road, Ajmer,
Rajasthan, India

(Special Issue- 3)
National Conference
**“Sustainable Agriculture and Recent Trends in Science &
Technology”**
(February 22nd & 23rd, 2019)

Sustainable agriculture and recent trends in science and technology

Mukhtyar Ahmed

Abstract

Agriculture is one of the important economic activities practiced in the country since antiquity. But still India is a home of 15% of the world's undernourished population. More than half of the workforce is still dependent on it, directly or indirectly for their livelihood and employment. In India, agriculture is considered as the largest economic activity and contributes to the declining share of its GDP (17% in 2013-14). However with the advancement in science and technology and the use in Agriculture, it undoubtedly revolutionized the agriculture on the one hand but on the other hand it degrades food quality as well as the farm lands for long time. Despite of these challenges, there is vast potential for India to enhance its agricultural productivity to meet the food requirements of its growing population. Sustainable agriculture and organic farming is the key way to improve the soil health, productivity and the longevity of arable land. This study attempts identify the changing strands on Agriculture with two reasons; first. To analyze the changing trends of technology in agriculture. And second its repercussions on production and productivity. The study is based on the following objectives;

- To highlight the significances of sustainable agriculture in the country.
- To study the emerging trends of scientific techniques in the promotion of sustainable agriculture.
- To analyze the role of sustainable agriculture in India.

Keywords: farm land, productivity, sustainable agriculture, advancement, technology, arable land, organic farming.

Introduction

Indian subcontinent is one of the 2nd most populace countries in the world. It occupies 2.4% of total geographical area to supports over 17.5% of world's population. India is also the 2nd largest country in terms of arable land after United States and has more water area than any country after Canada and United States Agriculture is the mainstay of economy. Most of the people in India are dependent on agriculture and allied sector for food and employment opportunities. The matter of concern is that instead of large share of population engaged with this sector it still shows the declining trend of growth towards the GDP. After independence the country faced sever shortage of food and abject poverty. This was responded with new inputs mechanism in agriculture, and the development termed as 'green revolution'. In 1960s the inputs methods resulted high yields per hectare production and productivity in most of the agriculturally rich states like Punjab, Haryana and utter Pradesh. In short span of time the production of grains especially Rice and wheat doubled. In later stages of history these areas faces the harmful consequences of land degradation, soil health problem, declining of ground water level and reduction in food quality.

At present the time has come to focus more on Sustainable agriculture. India is facing two critical situations; first to increase food production to meet the needs of increasing country's population and second, without irreversible and undesirable ecological consequences, environmental degradation. The emphasis on sustainable agriculture that would enhance food production without destroying the environment has been made by various reports. Although there is no consensus on what exactly is meant by sustainable agriculture.

Sustainable agriculture techniques make possible in the advancement in resource efficiency.

Correspondence
Mukhtyar Ahmed
Research Scholar, Bhagwant
University, Sikar Road, Ajmer,
Rajasthan, India

They help to produce better agricultural output while using lesser land, water and energy, ensuring benefit for the farmers. This basically includes methods that, among other things, protect and enhance the crops and the soil, improve water absorption and use efficient seed treatments. While Indian farmers have traditionally followed these principles, new technology now makes them more effective. U.S. Public Law 101-624) defines sustainable agriculture as: “An integrated system of plant and animal production practices that enhances environmental quality and the natural resource base upon which the agricultural economy depends; makes the most efficient use of nonrenewable resources and on-farm resources; integrates, where appropriate, natural biological cycles and controls; sustains the economic viability of farm operations; and enhances the quality of life for farmers and society as a whole”. The main aims of the Sustainable agriculture is to integrate the three main aspects these are environmental health, economic prosperity, social and economic fairness and it include the concept of minimizing the distance that food must be transported to the consumer.

Benefits of sustainable agriculture

Sustainable agriculture offers many benefits. In particular, the food can be healthier because smaller amount of pesticides and fertilizers are used, no hormones are used to raise the animals, and, since the food is grown in the vicinity, it can be delivered to the end user fresher. Sustainable agriculture can also help to save from harm and preserve the environment by helping to conserve topsoil, improve water quality, protect local biodiversity, and trim down waste. Last but not least, sustainable agriculture can potentially help enhance quality of life as it provides customers wider access to better turn out, and can help to make possible the economic viability of family farms.

There are many practices generally used by people functioning in sustainable agriculture and sustainable food systems. Cultivators may use methods to n the nearby financial system. And researchers in sustainable agriculture frequently cross punitive lines with their work: combining biology, economics, engineering, chemistry, community development, and many others. On the other hand, sustainable agriculture is more than a collection of practices. It is also process of cooperation: a push and pull between the challenging interests of an individual farmer or of people in a community as they work to solve complex problems about how we grow our food and fiber.

Methodology

Methodology plays a vital role in the representation and expression of factual knowledge in a systematic and synthesized manner. Discipline is synthesis not by its subject matter but by its methodology is a key to re presentation, expression and analysis of the field work. The data for this study is based on secondary sources. The data has been collected from books, both published and unpublished research article, journals. The present study is analytical and empirical in nature. The data has been analyzed and interpreted through tabulation and percentage methods in a way to suit the study.

Role of science and technology for agricultural development in India

The visions and ideas of sustainable development often remains the unanswered question. What activities engaged the present generation that will guarantee the future generation to meet their economic as well environmental requirements? In this background, we try to assess the task of technology in directing agriculture along the measures of sustainable path.

From the agricultural sector’s view, this necessitates an ideal investment plan for a nation’s standards of environmental possessions that accounts for an intergenerational contentment of sustainability’s dual goals; First, the satisfying food and fiber requirements at reasonable costs to consumers; and Second, providing environmental service flows in sustained manner. In appraising agrarian indicators to evaluate the nation’s performance in meeting these goals, we find productivity growth has improved while rates of soil erosion, wetland conversion, and pesticide application have declined. The capability of the agricultural sector to meet the food, fiber and environmental service demands, partly depends on the accessibility, availability, adaptation and implementation of new technology. Several market obstacles explain the undersupply of sustainable technologies; the main factors include, First, firms cannot fully appropriate the rents from technology growth and development, Second, the varying rate of success with farm structure, third, the heterogeneity of the available resource base impacts adoption; and last but not the least, farmers and farm sector cannot capture the benefits of environmental services.

It was the time when there was need to increase food production in order to meet the growing desires of nutrition of increasing country’s population for this it was necessary to raise the agricultural production and productivity. In order to tackle these obstacles the Government of India invited a team of experts sponsored by the Ford Foundation. The team submitted its report entitled “India’s Food Crisis and Steps to Meet It”. In April 1959. This report suggested the means of improving production and productivity of the country with stress on modern inputs, especially fertilizers, credit, marketing facilities etc. This new ‘agriculture strategy’ was adopted for the first time in India during the Kharif season of 1966 and was termed as high-yielding varieties program (HYVP). This plan was introduced in the form of a package program since it depended significantly on regular and adequate irrigation, fertilizers, and high yielding varieties of seeds, pesticides and insecticides.

Impacts of green revolution

The green revolution influenced the country’s economy and living standards of the people to a large extent. Its Impacts are reflected from the following point’s like-

▪ Increase in production and productivity

Green revolution has marked the phenomenal increase in the production of food grains that is why it is also known as grain revolution. Among the food grains it was wheat which drew the maximum benefits. Its production increasing from 11.1 million tons in 1966 to 71.3 million tons in 2002 the overall contribution of wheat to total food grains has increased from 13 per cent in 1950 – 51 to 34 per cent in 2003-04.

Table 1: Crop Yield per hectare in kgs from 1950-51 to 1999-2000.

Year	Rice	Wheat	Pulses
1950-51	668	663	441
1960-61	1.013	851	539
1970-71	1.123	1.307	524
1980-81	1.336	1.630	433
1990-91	1.740	2.281	578
1992-93	1.744	2.327	573
1995-96	1.855	2.493	552
1999-2000	1.986	2.778	635

Source: Central statistics office

This Table shows that except pulses, average yield (mostly rice and wheat) per hectare has improved significantly due to new technology.

▪ Prosperity of farmers

With the increase in agricultural production the farms the income of the farmers also increased due to this they become prosperous. Mostly big farmers who were have lands more than 10 hectare. The government comes up with the different flagship schemes with significant welfare potential in order to ease out the farmer's distress.

▪ Scientific Cultivation:

This was one of the most important aspects which affect the Green Revolution. Due to this the traditional agricultural inputs and practices have given way to new and scientific practices. Instead of farm seeds, farmers are now using HYV seeds. Traditional fertilizers are replaced by chemical fertilizers. Consequently under HYV seeds increased sharply from 1.66 million hectares in 1966-67 to about 78.4 million hectares in 1998-99.

▪ Capitalistic farming

Large scale of production offers greed to the big farmers and tends to get more benefits by investing large amount of capital in various inputs like HYV seeds, fertilizers, machines etc. this has led to the growth of capitalistic farming in the country.

▪ Change in cropping pattern

Two changes are significant. First, the proportion of cereals in the food grains output has increased and the proportion of pulses has declined. Second, the proportion of wheat cereals has increased while that of coarse grains has declined.

▪ Industrial growth

Green revolution has brought large scale of farm mechanization which created demands of various types of machines like tractors, harvesters, thresher, diesel engine, electric motors and pumping sets etc. besides, demand chemical fertilizers, pesticides, insecticides etc., have come up to meet the growing demand for these commodities.

▪ Change in attitudes:

The Indian farmers were illiterate, backwards and they were using the traditional methods of cultivation from early times. The healthy contribution of green revolution helps in change in the attitudes of farmers. Our farmers have now begun to think that they can change their misfortunes by adopting new technology. Unlike past, they are now giving up traditional agricultural practices for scientific practices.

Importance of technology in agriculture

Technology has played an important role in developing the agriculture, particularly the agricultural biotechnology. This technology helps the plants and other crops to survive even in drought condition. GEM crops are the best examples. Following are the importance of technology in context to the advancement of Indian agriculture:-

- 1. Application of global positioning system:** it is well defined systems to capture, store, check and display data related to positions on earth's surface. Some of the important use of GPS in agriculture is use of GPS in soil sampling, weed location, accurate planting, harvesting, farm planning, field mapping, assessment for the availability of water in an area, identifications of swamps and water logged area, river mapping and contour mapping. The most important use of this technique is applying pesticides based on the capacity of each square meter reduce the application amount of pesticides being used. This shows the soil to absorb all the pesticides hence reducing the chance of runoff. It also helps in giving quick responds related to crop stress conditions and natural calamities.
- 2. Use of information technology:** information technology plays an important role not only in the forming techniques but other means of technology too. That is advancement of information technology, has also come into view as an significant field in building a fine set of connections for the farmers to connect with the other parts of the state. Due to mobile phones, use of computers, Internet, etc. is serving in an accurate decision making for the workers who work for the welfare of the farmers. Thus, we see that Information Technology (IT) has a major role to play in making possible for farmers in improving the efficiency and productivity of agriculture and allied activities, and the potential of IT lies in fetching about an overall qualitative improvement in life by providing timely and quality information inputs for decision making.
- 3. Increase in employment opportunities:** With the advancement of technology, the old-fashioned and old techniques of farming can now be replacing by the farmers. Due to the allusion of Green Revolution, government is focusing on the comprehensive growth pattern in agriculture sector too, so that bulky mass of unemployed labors can be given wages. Techniques like crop diversification, double cropping, proper irrigation facilities, High Yielding Verity seeds will help the farmers to stand on their feats and contribute in the growth of Indian Economy

4. **Use of modern inputs:** Before the 1970s, Indian agricultural output did not raise much to meet the country's needs. The mid-1960s was a disaster as far as India's agricultural sector was concerned. The country witnessed a huge loss in agricultural production due to consistent droughts from 1965-66 to 1967-68. When the vast number of people faced the twin blows of hunger and malnutrition. This was the time when there was an urgent need of new innovation to get rid this massive obstacle from the country. This led to the introduction of green revolution as a package program modern inputs like irrigation, high yielding variety seeds, and fertilizers etc. The green revolution is determined by the technology revolution: seed-fertilizer-water and modern technology.
5. **Commercialisation of agriculture:** with the advancement in new and improved technology there has been a change of agriculture from subsistence to commercial proposition was result of series of developments which took place in the later part of 19th century. Which resulted in the massive yield production and surplus were exports from the country have like jute goods, tea, oil, cakes, tobacco, spices, coffee, etc. By exporting them, it has been possible to import in return the much-needed machinery and manufactured goods.
6. **Controlled environment agriculture:** This technique can be used to grow literally any crop fully 100% environmentally controlled enclosed closed loop system. Invention like poly houses has given the opportunity to the farmers to grow vegetables under the technically build poly houses which provide proper temperature to the vegetables which were unable to grow in that regions climate. For example in the regions of Rajasthan, farmers are making use of poly houses to grow tomato, potato, green vegetables which were once not possible for them.
7. **New research institutes:** The governments of India come up with number of institute to boost the agriculture with new innovative techniques, these institutes are Indian council of agriculture and research (ICAR). It is India's national institute for agricultural research education and extension. Indian agricultural research institute (IARI), Agricultural and technology management agency (ATMA) at district level and there are number of private as well as government institute at state level established for the purpose of education research and development of agriculture in the country.
8. **Development of modern labs:** New testing laboratories like seed testing laboratory, national seed corporation, states seed corporations, regional seed testing laboratory and indo American hybrid seeds etc are being opened, at present there are 107 seed testing laboratories in all states of the country. New research centers are also have been opened up to carry forward different type's agriculture related research. These national level centers like Krishi Vigyan Kendra are helping farmers with the new farming techniques and new variety of seeds for better level of production. And to do the research new and modern technologies are being used by the agro scientists and researchers.
9. **Global market platform:** India's signing of the general agreement on tariff and trade (GATT) agreement in 1994 and her union the world trade organization as a organizer member have put Indian agriculture in to the framework of global competition and rule of the global market. After the period of reforms in LPG in 1990s the Indian economy was opened which resulted in the competition on agricultural inputs. Considering other countries progress Indian agriculture was also given a boost with the help of technology due to which finished and good variety of food grains can be produced and that can compete in the global market. With the proper irrigation system, good fertilizers, pesticides and HYV seeds Indian agriculture saw a boost in the level of production, which ultimately created a demand in the global market. For example Indian spices, jute, tea, cotton, silk, has a place in global market.

Impact of science and technology on agriculture

Three major revolutions in science and technology as have been rightly observed by M.S. Swaminathan (2010) that "As we approach the new millennium we are experiencing three major revolutions in science and technology, which will influence agricultural technology in a fundamental manner". These are namely the gene revolution, the information and communication revolution and the eco technology revolution.

- A. **The gene revolution:** There have been quick advances made throughout last one decade in understanding of how biological organisms function at molecular level, as well as in our abilities to analyze, understand and manipulate DNA molecules, the biological materials from which the genes are made in all organisms. The Human Genome Project, an initiative of US Department of Energy has provided a giganticshove to this process by providing huge resources for the development of new technologies for working with human genes. The genetically modified crops can help in increasing yield, reduce vulnerability of crops to environmental stresses, increase nutritional qualities, and improve taste, text and appearance of food. The same technologies are having their application for all other organisms, including plants. This has given rise to a new discipline of genomics, which has promoted the biotechnology industry. In Europe and USA, many corporations have invested huge funds for adapting these technologies to produce new plant varieties of agricultural importance for large-scale commercial farming. These technologies can be very useful for developing countries for making them food secure. Genetic engineering can play a crucial role in modification of the genetic compositions of plants, animals and microorganisms. However, like other products, genetically engineered products undergo a period of R&D before they are ready for commercial use .Every farmer uses this technology in their own way. Some use it to create fertilizers, others use it to market their products, and others use it in production. So as a farmer, you have to specify what you need.
- B. **Use of machines on farms:** Mechanical devices such as tractors and equipment, used in farming to save labor. Farm machines including a large multiplicity of devices with a wide range of complexity. Now a farmer can cultivate on more than 2 acres of land with less labor, and

can cut expenses even more when they are looking for a used tractor and other harvesting technology, versus new equipment. The use of planters and harvesters makes the process so easy. In agriculture, time and production are so important; you have to plant in time, harvest in time and deliver to stores in time. Modern agricultural technology allows a small number of people to grow vast quantities of food and fiber in a shortest period of time.

C. Development of animal feed: The basic reason for the poor performances of livestock in developing countries is the seasonal inadequacy of feed, both in quantity and quality. These deficiencies are due to lack of infrastructure, technological know-how and poor management etc. This has solved the difficulty of hunting for grass to feed animals, now these feeds can be manufactured and consumed by animals. The price of these feed is fair so that a low income farmer can manage to pay for them. The majority of these manufactured animal feeds have additional nutrition which improves the animal's health and the yield of these animals will also increase. In agriculture, the health of an animal will determine its output. Poorly feed animals are always unhealthy and they produce very little results in form of milk, meat, or fur.

D. Modern transportation

It has been recognized that transport cost has critical role in recognizing the link between the accessibility and agricultural development. Good transport system is important for distribution of agricultural produce. Road transport has a vital role because it is major means of transporting agricultural produce from farm to the market as well as to various urban communities. There are number of modern ways of transportation that is roads, railways, air ways, and water ways. All the transport systems have its own advantages depending up on the distance from the farm land. road transport is suitable for short distance while rail transport is better for long distance because it is a cheap source and less dependent on weather conditions such as heavy rain, snow and fog, water transport is relatively cheap and efficient way of transporting goods for long as well as for short distance. The finest way of transportation of farm produce is air ways its very quick transport and is suitable for long but is costly.

E. Internet facility: the use of internet to support the transmission of localized information and services working towards making farming socially, economically and environmentally sustainable while contributing to the delivery of nutrition and food for all this comprises digital agriculture. Recently the government and other private companies have launched number of applications for the farmers where they can keep up with the latest commodity and mandi prices, precise usage of pesticides and fertilizers farm and farmers related news. These are Kisansuvidha launched by prime minister modi in 016 to work and empowerment of farmers. IFFCO kisan, RML Krishimitr, pusaKrishi, agri app, kheti-badi, Krishigayan, crop insurance, Agri market, provides low-cost access to information and highly interactive distance learning. The researchers can interact among themselves through the internet and can also

communicate effectively with the potential users of their research knowledge. These applications have revolutionized the agriculture e.g., crop Doc helps the farmer in identifying the problem that affects their crops at the right time it suggests corrective actions.

F. The eco technology revolution: Blending of traditional knowledge with frontier technologies is termed as eco technology. For example, in Rajasthan, drinking water is available even in areas receiving 100mm rainfall, because women continue to harvest water in simple structures called kunds. Similarly, biogas plants in every farm will help to improve the productivity and profitability of dry land farming: The decision of the World Intellectual Property Organization (WIPO) to explore the intellectual property needs, rights and expectations of holders of traditional knowledge, innovations and culture is hence an important step in widening the concept of intellectual property. Sustainable agriculture in the 21st century will be based on the appropriate use of biotechnology, information technology and ecotechnology. Practical achievements in bringing about the desired paradigm shift will depend upon public policy support and political action, regulation through legislation, social mobilization through local level community organizations and education through the mass media and information shops will be needed to meet the dual demands for food and ecological security.

G. Cooling facilities: These are used by farmers to deliver tomatoes and other perishable crops to keep them fresh as they transport them to the market. These cooling facilities are installed in food transportation trucks, so crops like tomatoes will stay fresh upon delivery. This is a win-win situation for both the consumers of these agricultural products and the farmers. How? The consumer's gets these products while still fresh and the farmer will sell all their products because the demand will be high.

H. Fast-tracking adoption of new agricultural technologies: The adoption of digital technologies in agriculture has been increasing at a rapid pace. The inclusion of technology brings tremendous value for business and individuals. In the agricultural industry there are many technologies that fall under the category of "precision agriculture" this technology are changing the ways that farmers manage their crops and is being adopted and growing rates. Although still on hold in India, Btbrinjal has been released in Bangladesh. Interestingly, Bangladesh approved Btbrinjal based on the data generated here in India, which illustrates a concept that I would like to promote further. Many countries, like India, already have rigorous approval processes for genetically-engineered products, crops, food, etc. Countries in South Asia, for example, could mutually recognize those approval processes much as they recognize the food standards in the Codex Alimentarius² rather than insisting that each test be repeated locally. This would be a responsible way to accelerate the adoption of high science and biotechnology — including crop varieties. Bangladesh's release of Btbrinjal is one excellent example. Perhaps an even better proof of concept is when, last October, the secretaries of agriculture of India, Bangladesh, and Nepal signed an

agreement to fast-track the release of any rice variety undergoing proper evaluation protocols in any one of their countries. Acting rapidly on this revolutionary and courageous agreement, India has already directly released four rice varieties from Bangladesh and two from Nepal for Indian farmers growing rice in similar agro-ecologies. This historic agreement will not only fast-track varietal releases, but will also bring huge savings of time and resources to the three countries.

Conclusion

The country is competing with the number of issues associated to agriculture like declining production, productivity and low credit flow, cost-effectiveness, irrigation facilities, falling water tables/lack of difficulties of agriculture marketing, lack of adequate storage for food grains, crumpling agricultural extension, climate change its connected problem and food security. The paper highlighted the need and importance, role of science and technology in agricultural revitalization. The three categories of revolution perceived in the present century as has been discussed by M.S. Swaminathan. These are: the gene revolution, eco technology revolution, the information and communication revolution and the. He held that the “Sustainable agriculture in the 21st century will be based on the appropriate use of biotechnology; information technology and eco technology”. To sum up, it is the application of science and technologies that makes agriculture logically stimulating and economically rewarding. All these steps put together will certainly make India’s rural parts as favorable destinations to investors as its cities are. Then, rural regions will also be creating an urban-style work- culture and help in checking the migration flow from rural to urban. India too will be able to hitch the demographic dividend from side to side revival of agriculture by using multi-pronged tactics.

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