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# Utilizing Science and Technology in Agriculture to Ensure the Enhancement of Quality of Life Through Food Security, Improved Nutrition and Sustainable Livelihoods.

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Ensuring food, nutrition, and income security is of paramount importance for India, a country where over 50 percent of the workforce is employed in agriculture, contributing approximately 17 percent to the GDP. Food security encompasses more than just production availability; it encompasses ensuring nutritional well-being for the populace and financial stability for farmers. Throughout history, agricultural advancements driven by science and technology have significantly influenced India's agricultural landscape, spanning various revolutions such as the green, white, blue, rainbow, and golden revolutions. India has achieved notable progress in terms of agricultural production, productivity, and availability of essential commodities like food grains, horticultural produce, milk, meat, and fish, largely owing to technology-driven development and governmental initiatives. The Ministry of Agriculture and Farmers Welfare has spearheaded flagship programs and production-oriented schemes like the National Food Security Mission and the National Mission on Oilseeds, aimed at promoting technology adoption and bridging yield gaps. However, amidst a scenario of increasing population and diminishing land and water resources due to climate change, the challenges are growing. Climate change is expected to exacerbate issues such as high temperatures, unpredictable weather patterns, the emergence of new pests and diseases, and threats such as rising sea levels and glacier melt. Addressing these challenges requires robust support for research and development to deliver science-based solutions that enhance the quality of life for all, including farmers who not only produce food but also rely on it for their livelihoods.

**Present Scenario food production :**

Out of total geographical area of 328.7 million hectares (as per the land use statistics 2015-16) of which about 140 million hectares is reported as net sown area and about 195 million hectares is the gross cropped area with a cropping intensity of 139%. The net irrigated area is 68 million hectares. The total food grains production increased from 218.11 million tonne in 2009-10 to 284.8 million tonne during 2017-18 and touched all times high food grain production. This accomplishment was a result of the determined efforts of all stakeholders in making latest crop production & protection technologies available to farmers and providing postharvest marketing support. The total area coverage of food grain crops during kharif 2018 (as on 12.10.2018) is 107.2million ha, which is 105% of normal area sown. However, the total production is expected to be higher because of better science based production technologies and spread of high yielding varieties. Although area continue to be the same to 140 ± 2 million hectare for the last 40 years, but production has increased apparently. It gives a lot of satisfaction that production of food crops has increased 5.5 times, horticulture 11.5 times since 1950-51. Many of the crops which were not known before have emerged as important crop and India has become a leader. But the challenges ahead are much greater than before. Shortage of oilseeds and rising price of food is cause of concern. The impact of climate change is likely to increase in terms of high temperature, uncertainty of weather, emergence of new pests and diseases. How we can address the increasing food needs of the increasing population and reducing highly unequal social satisfaction. But there is a need to address new challenges that transcend the traditional decision making horizons of producers, consumers and policy-makers.

**Quality of life is linked with food, nutritional and income security :**

The quality of life and health of any nation is directly linked to food and nutritional security, which is the back bone of national prosperity and well-being of the people. There is direct relationship between food consumption levels and poverty. In rural context, agriculture development for small and marginal farmer is the most important dimension of livelihood. The diversification of agriculture for food e.g., cereals, pulses, edible oil yielding, fruits, vegetables, medicinal and fodder crops are necessary to meet the food& nutritional requirements and augment income to farmers to meet the income security. According to some projections, the demand for fruits and vegetables would increase from 265 million tonnes to 300 million tonnes. Given the shifts in consumption patterns, towards non-cereal food, and even to non-food, it is felt that the demand projections of the Ministry of Agriculture on food grains of around 350 million tonne for 2030 are reasonable. The food security of the country has to be aimed through increased and stabilized food production on an economically and environmentally sustainable technologies/ methods.

**Agricultural Research System:**

The Indian National Agricultural Research System is one of the largest systems in the world in respect of human source engagement and infrastructure, and the Indian Council of Agricultural Research (ICAR) is an apex body of this system. The ICAR coordinates guides and manages research, education and extension services in agriculture, including crops, horticulture, agroforestry, fisheries and animal sciences. It has a vast network of 102 ICAR institutes, 78 All India Coordinated Projects/Networks, four deemed to be universities, three Central Agricultural Universities and 695 Krishi Vigyan Kendras (KVKs) spread across the country. In addition, there are 64 state Agricultural/

Veterinary/Horticultural/Fishery universities and 4 general universities with agricultural faculty, as part of the NARES. Extensive research infrastructure representing many agro-ecosystems and highly prized genetic resource apart, there is a critical mass of highly accomplished scientists with multidisciplinary knowledge. The science has made significant contributions in production and sustainability of agriculture which is necessary for ensuring better life. New technology has boosted food production and has dramatically changed the scenario. Advancements in agriculture science and technology has taken place and has provided science based practical solutions to farmers and agriculture industry.

**1. Advancement in breeding approaches**

The application of genetics in crop improvement has yielded many successes leading to unprecedented growth in agricultural productivity. In the past, the Green Revolution (particularly of rice and wheat) was initiated by the development and large-scale adoption of dwarf and semi-dwarf, lodging-resistant, fertilizer- and water-responsive, photoperiod-insensitive, widely-adaptable and disease- and pest-resistant cultivars (the highyielding varieties HYVs).Strong agriculture research system helped in development of 543 new varieties of food grains and oil seed crops and 234 varieties of horticultural crops in last five years. Molecular breeding (the molecular-marker-assisted selection and marker-based genetic-distance analysis) is widely used for gene pyramiding. These approaches help to accelerate back-crossing procedures and to predict the performance of progeny. These techniques and the products derived from them do not suffer from the biosafety concerns associated with GMOs, and hence are becoming more popular. The biotechnological and information revolutions have hastened the pace and precision of development of new super ideotypes, hybrids, and new life forms characterized by greatly enhanced yield, productivity, and adaptability. But yield of major crops in the country is much lower than that in the rest of the world.

Considering that the expansion of cultivated area are almost closed in the country, the future increase in food production to meet the continuing high demand is to come from increase in yield. Ample scope exists for increasing genetic yield potential of a large number of vegetables, fruits as well as other food crops. Besides maintenance breeding, greater effort needed towards developing hybrid varieties as well as varieties suitable for export. Hybrid rice, single cross hybrids of maize, sorghum and pearl millet offer new opportunities. Soybean, sunflower, mustard and oil palm will help in meeting future oil demands successfully. Biofortification is also the mean of breeding crops to increase their nutritional value either through conventional selective breeding, or through genetic engineering. Few of recent achievements in this context are Rice CR Dhan 310 (protein rich variety), DRR Dhan 45 (zinc rich variety); Wheat WB 02 (zinc & iron rich variety), HPBW 01 (iron & zinc rich variety); Maize Pusa Vivek QPM9 Improved (provitamin-A, lysine & tryptophan rich hybrid), Pusa HM4 Improved (lysine & tryptophan rich hybrid), Pusa HM8 Improved (lysine & tryptophan rich hybrid), Pusa HM9 Improved (lysine & tryptophan rich hybrid); Pearl millet HHB 299 (iron & zinc rich hybrid), AHB 1200 (iron rich hybrid); Lentil PusaAgeti Masoor (iron rich variety); Mustard Pusa Mustard 30 (low erucic acid variety),

Pusa Double Zero Mustard 31 (low erucic acid & low glucosinolate variety), Cauliflower Pusa Beta Kesari 1 (â-carotene rich variety); Sweet Potato Bhu Sona (â-carotene rich variety), Bhu Krishna (anthocyanin rich variety); Pomegranate Solapur Lal (iron, zinc & vitamin-C rich variety). But in the present context of meeting the challenge of climate change, emphasis is needed in breeding climate resilient varieties suitable for mitigating the effects and ensuring preparedness for sustainable production systems capable of ensuring food security.

**2. Revolution through agriculture mechanization**

Mechanization in agriculture has been well recognized to help not only in improving utilization efficiency of other inputs, safety and comfort of the agricultural worker but also to improve quality and value addition of the produce.

Efficient machinery helps in increasing production and productivity, besides enabling the farmers to raise a second crop or multi crop making the Indian agriculture attractive and a way of life by becoming commercial instead of subsistence. Considering the importance, Government of India promote mechanization through sub mission. A level of 25-50% subsidy on procurement cost is made available under RKVY, NFSM, and NHM & NMOOP schemes also for different categories of equipment. As a result Indian farmers are adapting farm mechanization at a faster rate. Looking at the pattern of land holding in India, large portion of the holdings are below 1 ha. As an individual farmer may not be in a position to purchase high cost equipment on his own. But 'Custom Hiring Centers of Agricultural Machineries' operated by Cooperative Societies, Self Help Groups and private/rural entrepreneur are enabling easy availability of farm machineries to the farmers and bringing about improvement of farm productivity. At present the farm power availability per ha is 1.84kW/ha (2013-14) which is to be increased to 4.0 kW/ha by 2022.It is felt that machines for large-scale precision farming have to be developed. Optimization of production systems and farm work sites with vehicle and machine systems that can sense and control; systems that are capable of collecting, storing, and transferring information about the crop, field, and machine state at the time of field operation are likely to materialize in the country. There is need that farmers improve crop production through the use of global positioning systems (GPS), site specific management through sensor based technologies and drones.

**3. Nutrient management**

Attention should be given to balanced use of nutrients. Phosphorus deficiency is now the most widespread soil fertility problem in both irrigated and un-irrigated areas. There is need to correct the imbalances in the use of primary plant nutrients nitrogen, phosphorus, potash; micronutrients and use of bio-fertilizers. Soil Health Management (SHM) is one of the most important interventions under National Mission for Sustainable Agriculture. SHM aims at promoting Integrated Nutrient Management (INM) through judicious use of chemical fertilisers including secondary and micro nutrients in conjunction with organic manures and bio-fertilisers for improving soil health and its productivity; strengthening of soil and fertiliser testing facilities to provide soil test based recommendations to farmers for improving soil fertility; ensuring quality control requirements of fertilisers, bio-fertilisers and organic fertilisers under Fertiliser Control Order, 1985; upgradation of skill and knowledge of soil testing laboratory staff, extension staff and farmers through training and demonstrations; promoting organic farming practices etc.To improve efficiency of fertilizer use, what is really needed is enhanced location-specific research on efficient fertilizer practices (such as balanced use of nutrients, correct timing and placement of fertilizers, and, wherever necessary, use of micronutrient and soil amendments), improvement in soil testing services, development of improved fertilizer supply and distribution systems, and development of physical and institutional infrastructure.

**4. Biofertilizers and biopesticides**

As an eco-friendly alternate, science of microbiology has given several microorganisms and their association with crop plants which are being exploited in the production of biofertilizers and biopesticides. Biofertilizers based on their nature and function have been grouped in different types N2 fixing, phosphate solubilizing, phosphate mobilizing, biofertilizers for micro nutrients and Plant Growth Promoting Rhizobacteria. Biofertilizers increase certain soil microbial processes which accelerate availability of nutrients in a form easily assimilated by plants. Microbes and their supplements also provide protection against various pests and pathogens. The biopesticides are categorized under microbial pesticides, plant-incorporated-protectants and biochemical pesticides, which are produced through naturally occurring substances that control pests by non-toxic mechanisms. The global market for biofertilizers and biopesticides is expected to be around USD 15 billion. There is need to increasingly popularize them as a component of Integrated Nutrient Management and Integrated Pest Management systems. Efficient biopesticides and biofertilizers are required to be identified for different agroclimatic conditions and crop conditions by using molecular approaches. Owing to its eco-friendly characteristics, the demand for biofertilizers and biopesticides are on the increase but delivery of quality input is needed to be insured through a stringent quality assurance system.

**5. Water saving technologies has impacted**

India will be required to produce more and more from less and less land and water resources. Alarming rates of ground water depletion and serious environmental and social problems of some of the major irrigation projects on one hand, and the multiple benefits of irrigation water in enhancing production and productivity, food security, poverty alleviation, are well known. In India, water availability per capita was over 5000 cubic metres (m3) per annum in 1950. It now stands at around 2000 m3 and is projected to decline to 1500 m3 by 2025. The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) was launched on 1st July, 2015 with the motto of 'Har Khet Ko Paani' for providing end-to end solutions in irrigation supply chain, viz. water sources, distribution network and farm level applications. PMKSY not only focuses on creating sources for assured irrigation, but also creating protective irrigation by harnessing rain water at micro level through 'Jal Sanchay' and 'Jal Sinchan'. Micro irrigation is being popularised to ensure 'Per drop-More crop'. Per Drop More Crop mainly focuses on water use efficiency at farm level through precision/ Micro Irrigation (MI) (Drip and Sprinkler Irrigation). Till today total 11.6 million ha area has been covered under micro irrigation. PMKSY adopts State level planning and projectised execution that allows States to draw up their own irrigation development based on District Irrigation Plans and State Irrigation Plans.

Further, the quality of available water is deteriorating. Also, there are gross inequalities between basins and geographic regions Agriculture is the biggest user of water, accounting for about 80 percent of the water withdrawals. Policy reforms are needed from now to avoid the negative developments in the years to come.

**6. Information technology in agriculture**

The ICAR has been engaged in development of efficient and effective technology transfer systems for shortening the time lag between technology generation and adoption. But, its clientele now extends to industry, business community and the consumers at large. There have been continuing efforts to evolve innovative pathways for disseminating breakthroughs in technology to farmers and the industry such as Agricultural Technology Management Agency (ATMA), Agri-clinics, Agri-business centres, Krishi Vigyan Kendras, E-chaupals, etc. The capacity building of community based organizations and farmers' groups for acquiring knowledge and its transfer is being put in place for a faster dissemination. There is a need to strengthen adaptive research and technology assessment, refinement and transfer capabilities of the country so that the existing wide technology transfer gaps are bridged. For this, an appropriate network of extension service needs to be created to stimulate and encourage both top-down and bottom-up flows of information between farmers, extension workers, and research scientists to promote the generation, adoption, and evaluation of location specific farm technologies.

**7. Managing climate change**

Climate change is a reality and it is now widely accepted that the change is currently taking place at a much faster pace than in the past. An Indian study has shown that a 1 degree Celsius rise in temperature in North India would reduce the duration of the wheat crop by one week, thereby reducing yield by 500 to 600 kg/ha. Anticipatory research, including conservation, characterization and utilization of topical genetic resources and use of biotechnology and other cutting-edge sciences, to meet the challenges of global warming and climate change have been undertaken by various research institutions. The countries likely to be negatively impacted by climate change should collaborate not only in strengthening their relevant research and technology development, but also in their negotiations at various international forums. The National Action Plan on Climate Change (NAPCC) identifies measures that promote India’s development objectives while also yielding co-benefits for address-ing impact of climate change effectively. It outlines a number of steps to advance India’s development and climate change-related objectives of adaptation and mitigation. There are Eight National Missions which form the core of the National Action Plan, representing multi-pronged, long-term and integrated strategies for achieving key goals in the context of climate change. The National Mission for Sustainable Agriculture (NMSA) is one of the eight missions envisaged under the aegis of NAPCC.

## CONCLUSION

Science is an essential contributor to solving the triangle of the global problems of hunger, poverty, and environmental degradation. Without sound scientific input of different kinds, the challenges will not be addressed. Science, including the biological sciences and increasingly the social and physical sciences, must be applied to agriculture, fisheries, and forestry, and to those rural, coastal, and urban ecosystems and human systems within which hunger and poverty persist.Science and technology must address (for crops, livestock, fish, and forests) various issues in order to attain higher productivity and sustainability and thereby help alleviate hunger and poverty. While the established approaches that contributed to the food security through green revolution (viz cultivation of high yielding variety of rice and wheat the expansion of land under production and irrigation, greater use of fertilizers and pesticides and greater availability of credit) are to be harnessed for maximum dividend. It will be worthwhile to examine how scientific advancement can be mobilized for enhancing the horizon of productivity without ecological harm. Maximizing farmer‘s profit, placing into the hands of farmers the largest numbers and higher quality and encouraging reinvestments by spending on technologies designed to boost production such as drip irrigation systems, agriculture education and green houses are economic approaches to food security. There is need and scope of blending of the best in traditional knowledge and technology with frontier technologies such as biotechnology, space and information technologies, renewable energy etc to increase output from current land without further loss of productive land. All attempts should be made to adverse climatic changes; varietal improvement programme should bring out strains capable of withstanding vagaries of climatic change. Closing the yield gap which refers to the difference between realized productivity and the best that can be achieved using current genetic material and available technologies and management is of paramount importance. Increasing production limits and reducing wastage of food are other significant inputs.

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