Mahatma Gandhi's Vision of Agriculture
Achievements of ICAR

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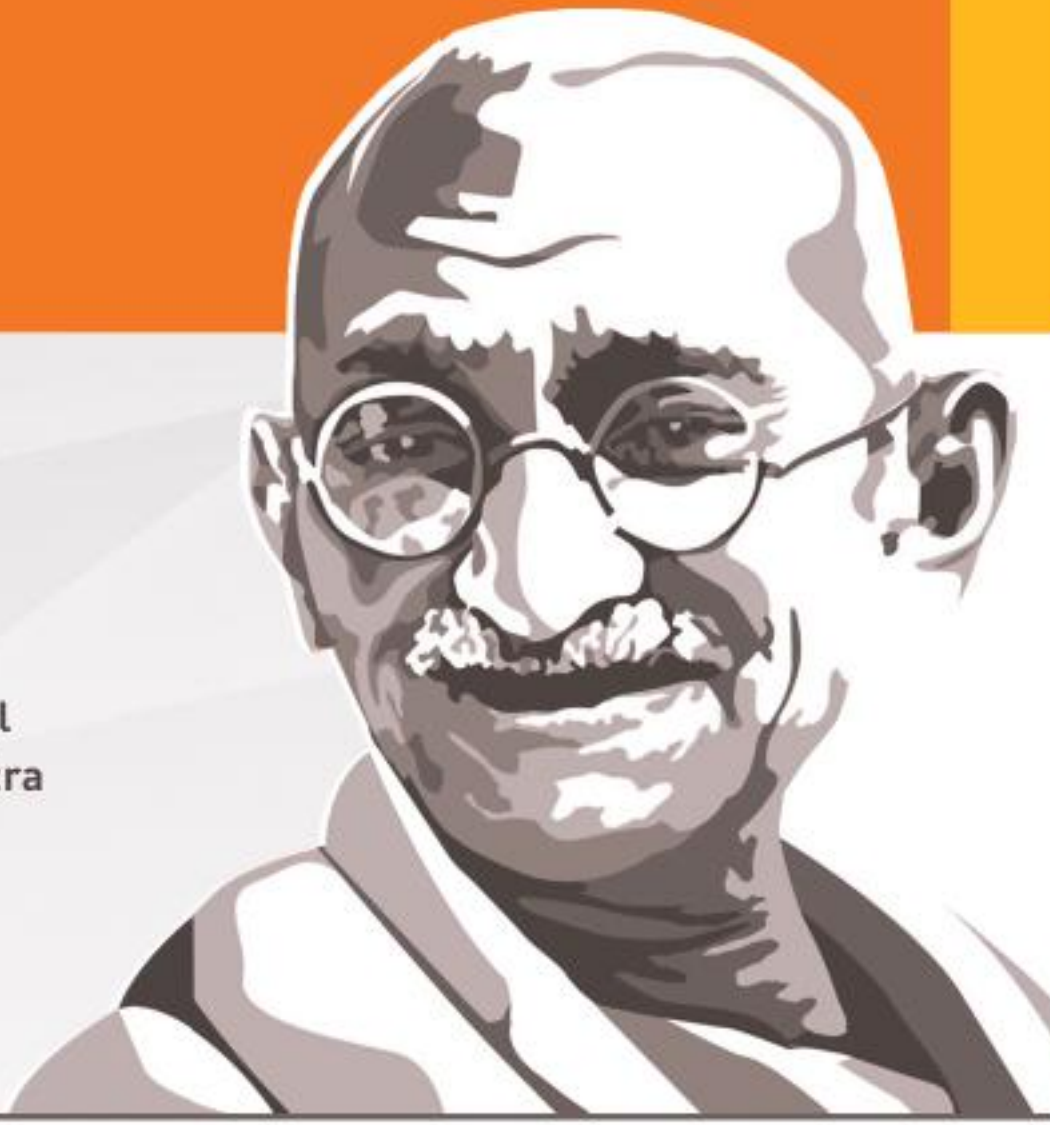

Indian Council of Agricultural Research
New Delhi

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MESSAGE

Mahatma Gandhi has inspired generations to maintain peace and harmony in the world. His vision of agriculture and rural development is globally acclaimed as a strategy for inclusive growth and collective governance. Development of agro-industries in the villages, upscaling of rural innovations and empowerment of people through skill development and education were central to the prosperity of rural areas and poverty reduction. The global experience has shown that the countries following the path of decentralization and rural industrialization have achieved faster economic growth and reduction in poverty. In India, the development of Panchayati Raj Institutions has shown its impact on the strengthening of the third tier of democracy, participatory development and empowerment of women.

Development of agriculture in harmony with nature, sustainable use of resources and protection from market-generated vulnerability have been the main pillars of sustainable development. These fundamentals of agriculture are still relevant when there is so much risk originating from unstable markets. Technological advancements have been useful in the sustainable increase in agricultural productivity and reduction of risk. Indian Council of Agricultural Research (ICAR), an apex organization in the country, has contributed to the innovation-led agricultural growth following the Gandhian principles. Development of favourable production environments, addressing the needs of resource-poor farmers, promoting rural livelihoods, skill development of farmers, including women, have been some of the important benefits.

I compliment ICAR for bringing out this publication "Mahatma's Vision of Agriculture: Achievements of ICAR" highlighting its endeavors to realize the Gandhian vision. This publication will be useful for policymakers and public agencies working for agriculture and rural development to follow the Gandhian way of development.

Narendra Singh Tomar
Minister of Agriculture and Farmers' Welfare,
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MESSAGE

The country is celebrating the 150th birth anniversary of Mahatma Gandhi, 'Father of the Nation'. He was a leader, philosopher, writer, and social reformer who worked with the masses for their welfare. His simple living and high thinking inspired millions of people in India and abroad, including several leaders in the world. Gandhiji devoted his life to the upliftment of the poor, untouchables and the weakest man in the society. Truthfulness and non-violence were the cornerstones of his philosophy and approach to life. He wanted the village to be the central place in the national economic development with strong social, economic and spiritual values. He firmly believed that India lives and will live in her villages, not in towns and the path of development, therefore, goes through rural development.

Indian Council of Agricultural Research (ICAR) has played a pioneering role in ushering the Green Revolution in the country and subsequent developments in other areas of agriculture. The recent experience of COVID-19 has shown that Indian agriculture is resilient to external shocks and can contribute to the inclusiveness of the economy. This is possible through the application of science and technology in agriculture. The Council has played a major role in promoting excellence in education and building human capital for agriculture, as envisaged by Gandhiji. The celebration of the 150th birth anniversary of Gandhiji is the occasion to reaffirm our faith in this development approach and apply to address the challenges in the years to come. The volume on hands is an example of the achievements of ICAR and its approach in addressing the developments like climate resilience, conservation of resources, and inclusiveness. The publication has spelled out the contributions of the Council in improving agricultural productivity, ensuring food, nutritional and livelihood security, protecting the environment, and promoting small agri-enterprises. These contributions also contribute to the development objective of the government of Atma Nirbhar Bharat.

I compliment the Council for bringing out this publication to show its contributions to realize the vision of Gandhiji. I am sure the readers shall find the publication useful and take the task forward for the betterment of the society.

Kailash Choudhary
Minister of State, Agriculture and Farmers' Welfare
Government of India
Krishi Bhawan, New Delhi

FOREWORD

Father of the Nation, Mahatma Gandhi led the freedom struggle against the British empire and emerged as a global leader of masses, disadvantageous and poor people. He has shown the way of social, economic and political transformation with small steps to serve the rural poor. Non-violence, truthfulness, democratic institutions, village industry and people-centric approach were his main principles and teachings. He had led several movements to pursue the cause of Indian farmers, including famous protest of Champaran in 1917. These movements motivated the farmers and rural workers to join the freedom struggle.

Mahatma Gandhi firmly believed that prosperity of agriculture and farmers should pave the way for economic prosperity of the country. This belief has been reaffirmed in the agricultural development process followed in India and other developing countries. Evidences are now available indicating that agricultural growth has significant impacts on reduction of poverty and promotion of social and economic equity. The pandemic of COVID-19 has further established that agriculture is a strong pillar to absorb economic shocks and build resilience to economic growth.

The Indian Council of Agricultural Research (ICAR) has been at the forefront to propel agricultural development through development and dissemination of technology, building human capital and establishing the rural centres to serve the farmers. The Council has developed partnerships with the organizations serving farmers and rural people. One of the important components of ICAR strategy is increasing agricultural productivity in harmony with nature. The needs of unprivileged farmers, marginal production environments, and rural youth have been accorded high priority in research programs of the Council. Similarly, gender mainstreaming, outscaling of farmers' innovations, farmers' participatory approach, and institutional change for higher efficiency has been corner stones of research approach of ICAR. The Council has followed the principles of Mahatma Gandhi to make Indian agriculture prosperous, empower farmers, and strengthen village institutions. The efforts made by the *Krishi Vigyan Kendras* to develop skills of rural women and small farmers, and to provide services at the doorstep of farmers have contributed to the Gandhian vision.

This publication documents the major contributions of ICAR to promote sustainable development, technological empowerment of people in inaccessible areas, enhance value of farm produce, and promote rural livelihood. Conservation of biodiversity, soil and water, yield improvement of millets in hill areas, improvement of indigenous cattle, goat development, support for fishermen and food processing options for households are some of the notable examples.

I compliment the authors for bringing out this publication that shall be useful for policy makers and public agencies to take the task of agriculture and rural development on the Gandhian way. This is the need of the hour when there is weakening of the values of rural communities and rising pressure on natural resources.

Trilochan Mohapatra
Secretary, DARE and DG, ICAR
Government of India
Krishi Bhawan, New Delhi

PREFACE

India is celebrating the 150th birth anniversary of Mohandas Karamchand Gandhi, the 'Mahatma', 'Father of the Nation'. He was a leader, politician, saint, philosopher, thinker, writer, social reformer and educationist who worked for the masses and with the masses. His plain living and high thinking inspired millions of people in India and abroad. Gandhiji devoted his life for upliftment of the poor, downtrodden, untouchables and the last man of the society. With the struggle and efforts of Gandhiji, the "dumb millions" found their voice; the disinherited recovered their heritage and the disarmed won a great battle with moral force. Truthfulness and non-violence were the corner stones of his thinking, philosophy and personality. The whole world celebrates the United Nations International Day of Non-violence on October 2nd each year, the Mahatma's birthday, to pay homage and respect to this great man.

To the Mahatma, true independence meant wiping every tear from the face of every Indian. He wanted the village to be the central place in the national economic development with sound scientific and spiritual values. He firmly believed that "*India lives and will live in her villages, not in towns; in huts, not in palaces. If village perishes, India will perish too*". He asserted that the only way of bringing the progress and prosperity to India is development of rural economy, industry and skills. For Gandhiji, the farmer was the central point for development and sustainable social order. Farmers form the bulk of India's population and are the backbone of the country. Majority of the India's population depend on agriculture and associated occupations such as cattle farming, dairying, poultry and piggery. He observed that a farmer's life is necessarily one of cooperation, not competition. He wanted the state's support to farmers should be directed at transforming them to become a vibrant self-reliant, and not to make them dependent on the state. Gandhiji recommended co-operative farming, which would save labour, capital and tools and provide employment to all adult villagers and increase production. He said, 'we must attempt to prevent further fragmentation of land and encourage people to take to co-operative farming'. According to him, the agriculture of a village should be planned in such a manner that each village shall be self-sufficient in its food requirements. Gandhiji insisted on the social workers to render effective service in the village, for which they must acquire sufficient theoretical as well as practical knowledge about agriculture. The Mahatma had a noble dream of making Indian farming remunerative, self-reliant, sustainable and nature-friendly.

The Indian Council of Agricultural Research (ICAR), since its inception, has been working to realize the dreams of the Mahatma and has made significant contributions in achieving those. It is an autonomous organization under the Department of Agricultural Research and Education (DARE), Ministry of Agriculture and Farmers Welfare, Government of India. Formerly known as Imperial Council of Agricultural Research, it was established on July 16, 1929. The Council is the apex body for coordinating, guiding and managing research and education in agriculture

including horticulture, fisheries and animal sciences in the country. With its headquarters at New Delhi and a network of 101 research institutes and 71 agricultural universities spread across the country, this is one of the largest national agricultural systems in the world.

The Council has played a pioneering role in ushering the Green Revolution and subsequent developments in agriculture in India through its research and technology development that has enabled the country to increase the food production several folds and thus ensuring national food and nutritional security, which the Mahatma dreamed of. The Council has played a major role in promoting excellence in education in agriculture, as envisaged by Gandhiji.

To pay our homage and respect to the Father of the Nation on his 150th birth anniversary, ICAR brought out this publication to present the contributions of ICAR in implementing the Gandhian philosophy for realizing sustainable agriculture and rural development. Detailed assessment has been made in improving crop, horticulture, animal and fish productivity; ensuring food, nutritional and livelihood security; imparting practical and theoretical agricultural education; promoting organic and low-input agriculture; protecting environment, agro-biodiversity and ecology; promoting small agri-enterprises and gender empowerment; encapsulating Gandhian thoughts on new science and technology-led development; upholding ethics in agricultural science; and harnessing local interventions for global gains in natural resources management. It also highlights the future path of ICAR in line of Mahatma's vision of Gram Swaraj and Atma Nirbhar Bharat.

We sincerely hope that the publication will be useful to the policy-makers, planners, administrators, farmers, social workers, students and the followers of Gandhiji in India and abroad. Besides helping the ICAR in reassessing and setting new path of agricultural progress, it shall provide necessary inputs to the other organizations and stakeholders in improving agriculture with the vision of Mahatma Gandhi.

Editors

ACKNOWLEDGEMENTS

Farmers form the bulk of India's population and are the backbone of the country. With about 55% of India's population dependent on agriculture for its livelihood, the welfare of farmers assumes great significance. For Gandhiji, the farmer was the central point for sustainable social order. According to him, the agriculture should be planned in such a manner that each village shall be self-sufficient in its food requirements. He asserted that the only way of bringing the progress and prosperity to India is development of rural economy, industry and skills. He wanted the village to be the central place in the national economic development with sound scientific and spiritual values.

Gandhian vision of rural development is based on *Antyodaya* i.e., *'the upliftment of the last man in the row'*. In principle, he wanted to reconstruct a *'harmonious, poverty-free, non-violent and self-reliant society'* on the basis of ethical principles marked by Hind Swaraj. Gandhiji insisted on the social workers to render effective service in the village. In order to do this, they must acquire sufficient theoretical as well as practical knowledge about agriculture. Though a critic of modernity, Gandhiji was in favour of technology. He opposed the inequalities and hierarchies of power and the blind subjugation of nature to man, resulting from the estrangement of technological development from morality. He wanted a peaceful and sustainable integration of men, modernity and mother-nature.

In spite of tremendous progress in last decades, several challenges are posed to Indian agriculture. It is high time that we learn lessons from the past and plan out strategies, which are relevant to our times following Gandhiji's vision, which gives us a rare insight into the future of mankind.

This publication is about the contribution of Indian Council of Agricultural Research (ICAR) on the upliftment of livelihood and ensuring food and nutritional security of Indian masses. Seventeen chapters of the book capture various aspects of Gandhian philosophy on sustainable agriculture, animal husbandry, fisheries, rural development and agricultural education; his principles of food and nutritional security, environment, natural resource management, agro-biodiversity, ecology, organic farming and integrated farming system; his thoughts on new science and technology-led development and also ethics in agricultural science and future path of ICAR with Mahatma's vision. The success stories of various ICAR institutes in improving productivity and profitability of crop, horticulture, livestock, poultry, fisheries and other commodities; managing natural resources in a sustainable manner; imparting agricultural education; and taking the knowledge and technologies to the farmers using of modern technologies have been documented. The technologies developed by ICAR have contributed to increasing the income, reducing gender divide, and in empowering the villagers to lead a dignified life. The Council is committed to internalize and upkeep the Gandhian philosophies, the relevance of which are more than ever before, in all its research endeavours.

The present publication is an outcome of a detailed exercise by more than 60 leading scientists of ICAR, from a range of disciplines engaged in research on various aspects of agriculture. The scientific information provided in the Chapters is a result of efforts made by the scientists and other associated staff of Institutes and AICRPs under ICAR. The authors gratefully acknowledge their contributions. The compilation gives us hope and confidence that ICAR is on the track to realize the dreams of Mahatma Gandhi about rural livelihood and nutritional security.

In the course of preparing the book, the authors and editors have received help and support from different individuals. We are extremely grateful to each one of them. The editors take this opportunity to express their gratitude to all the authors for developing the chapters in a comprehensive manner. We sincerely thank Hon'ble Minister of Agriculture and Farmers' Welfare, Rural Development and Panchayati Raj; and Hon'ble Minister of State of Agriculture and Farmers' Welfare, Govt. of India for their guidance and support in bringing out this publication. We are thankful to the ICAR-Directorate of Knowledge Management in Agriculture, New Delhi for its kind support and guidance; and Mr. Sunil Kumar Sinha, ICAR-NRRI, Cuttack for formatting and developing cover page of the publication.

We hope that the publication would be useful to the researchers, teachers, policy makers, planners, administrators, farmers and students of agriculture.

Editors

CONTENTS

ABBREVIATION

AI	Artificial Insemination
AI-NPOF	All India Network Programme on Organic Farming
AICRP	All India Coordinated Research Project
AICRPDA	All India Coordinated Research Project for Dryland Agriculture
AIVA	All India Village Industries Association
APCs	Agro-Processing Centres
ART	Assisted Reproductive Technique
ARYA	Attracting and Retaining Youth in Agriculture
ASCI	Agriculture Skill Council of India
ATIC	Agricultural Technology Information Centre
ATMA	Agricultural Technology Management Agency
AUs	Agricultural Universities
BAIF	Bharatiya Agro Industries Foundation
BDA	Biological Diversity Act
BPKP	Bharatiya Prakritik Krishi Paddhati
CAFRI	Central Agroforestry Research Institute
CAZRI	Central Arid Zone Research Institute
CBD	Convention on Biological Diversity
CCBF	Central Cattle Breeding Farms
CFSPTI	Central Frozen Semen Production & Training Institute
CHCs	Custom Hiring Centres
CIAE	Central Institute of Agricultural Engineering
CIAH	Central Institute of Arid Horticulture
CIARI	Central Island Agricultural Research Institute
CICR	Central Institute of Cotton Research
CIRC	Central Institute for Research on Cattle
CIRCOT	Central Institute for Research on Cotton Technology
CIRG	Central Institute for Research on Goats
CISH	Central Institute for Subtropical Horticulture

CITH	Central Institute of Temperate Horticulture
CNG	Compressed Natural Gas
CPCRI	Central Plantation Crops Research Institute
CRIDA	Central Research Institute for Dryland Agriculture
CRM	Crop Residue Management
CRP	Consortia Research Platform
CSA	Climate Smart Agriculture
CTCRI	Central Tuber Crops Research Institute
CVD	Cardiovascular Diseases
DAY-NRLM	Deendayal Antyodaya Yojana – National Rural Livelihoods Mission
DDU-GKY	Deen Dayal Upadhyay Gramin Kaushalya Yojana
DFA	Desired Fatty Acids
DFI	Doubling of Farmers Income
EL	Experiential Learning
EMF	Environment Management Framework
ET	Embryo Transfer
FFP	Farmer FIRST Program
FIG	Farmer Interest Group
FIRST	Farm, Innovations, Resources, Science and Technology
FLD	Front Line Demonstration
FMD	Foot and Mouth Disease
FPARP	Farmers' Participatory Action Research Program
FPCs	Farmer Producer Companies
FPOs	Farmer Producer Organizations
FPT	Field Progeny Testing
GABA	G-Amino Butyric Acid
GADVASU	Guru Angad Dev Veterinary and Animal Sciences University
GBPUAT	Govind Ballabh Pant University of Agriculture & Technology
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEM	Government E-Marketplace
GHG	Greenhouse Gases
GOI	Government of India
HLS	Home Lighting System

HYVP	High Yielding Varieties Program
IAAP	Intensive Agricultural Area Programme
IADP	Intensive Agricultural District Programme
IBP	Indigenous Breeds Project
ICAR	Indian Council of Agricultural Research
ICDP	Intensive Cattle Development Projects
ICMR	Indian Council of Medical Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information Communication Technology
IDDP	Intensive Dairy Development Programme
IDF	Insoluble Dietary Fibre
IEC	Information, Education and Communication
IFS	Integrated Farming Systems
IGFRI	Indian Grassland and Fodder Research Institute
IIHR	Indian Institute of Horticultural Research
IIMR	Indian Institute of Millets Research
IISR	Indian Institute of Spices Research
IIVR	Indian Institute of Vegetable Research
INM	Integrated Nutrient Management
IOFS	Integrated Organic Farming Systems
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
ITK	Indigenous Technical Knowledge
IVAG	In Vitro Active Genebank
IVBG	In Vitro Base Genebank
IVEP	In Vitro Embryo Production
IVF	In Vitro Production
IVLP	Institute Village Linkage Programme
IVRI	Indian Veterinary Research Institute
IWMP	Integrated Watershed Management Program
KF	Karan Fries
KKA	Krishi Kalyan Abhiyan
KSHAMTA	Knowledge Systems and Homestead Agriculture Management in Tribal Areas
KUSUM	Kisan Urja Suraksha Evam Utthaan Mahaabhiyan

KVASU	Kerala Veterinary and Animal Sciences University
KVK	Krishi Vigyan Kendra
KVS	Key Village Scheme
LLP	Lab-to-Land Program
LUVAS	Lala Lajpat Rai University of Veterinary and Animal Sciences
MANAGE	National Centre for Management of Agricultural Extension
MCP	Multiple Cropping Programme
MCT	Medium Chain Triglycerides
MGMG	Mera Gaon Mera Gaurav
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MIDH	Mission for Integrated Development of Horticulture
MLT	Multi-Locational Trial
MNRE	Ministry of New and Renewable Energy
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MOET	Multiple Ovulation and Embryo Transfer
NABARD	National Bank for Agriculture and Rural Development
NADCP	National Animal Disease Control program
NAEAB	National Agricultural Education Accreditation Board
NAHEP	National Agricultural Higher Education Project
NAIP	National Agricultural Innovation Project
NAP	National Agroforestry Policy
NAPCC	National Action Plan on Climate Change
NARI	Nutri-Sensitive Agri-Resources and Innovations
NARS	National Agricultural Research System
NATP	National Agriculture Technology Project
NBAGR	National Bureau of Animal Genetic Resources
NBAIM	National Bureau of Agriculturally Important Micro-organisms
NBAIR	National Bureau of Agricultural Insect Resources
NBFGR	National Bureau of Fish Genetic Resources
NBPGR	National Bureau of Plant Genetic Resources
NCAP	National Centre for Agricultural Economics and Policy Research
NCOF	National Centre of Organic Farming
NDDB	National Dairy Development Board
NDP	National Dairy Plan
NDRI	National Dairy Research Institute

NEH	North-Eastern Hill
NFDB	National Fisheries Development Board
NFSM	National Food Security Mission
NIAP	National Institute of Agricultural Economics and Policy Research
NICRA	National Innovation on Climate Resilient Agriculture
NIMSME	National Institute for Micro, Small and Medium Enterprises
NIRDPR	National Institute of Rural Development and Panchayati Raj
NLM	National Livestock Mission
NMBP	National Mission on Bovine Productivity
NMOOP	National Mission on Oilseed and Oil Palm
NMSA	National Mission on Sustainable Agriculture
NOFRI	National Organic Farming Research Institute
NPBBDD	National Programme for Bovine Breeding & Dairy Development
NPDD	National Programme for Dairy Development
NPOP	National Programme for Organic production
NRC	National Research Centre
NRRI	National Rice Research Institute
NSAP	National Social Assistance Programme
NSQF	National Skill Qualification Framework
NSSO	National Sample Survey Office
OEI	Other Educational Institutions
OFWM	On-Farm Water Management
OPU	Ovum Pick-Up
OPU-IVF	Ovum Pick-up and In-Vitro Fertilization
ORP	Operational Research Project
PDFSR	Project Directorate for Farming Systems Research
PGR	Plant Genetic Resources
PKVY	Paramparagat Krishi Vikas Yojana
PM-KISAN	Pradhan Mantri Kisan Samman Nidhi
PMAY-G	Pradhan Mantri Awaas Yojana – Gramin
PMFBY	Pradhan Mantri Fasal Bima Yojana
PMGSY	Pradhan Mantri Gram Sadak Yojana
PMKSY	Pradhan Mantri Krishi Sinchai Yojana
PoP	Package of Practices

PPP	Public Private Partnership
PPV&FRA	Protection of Plant Varieties and Farmers' Rights Authority
PRA	Participatory Rural Appraisal
PSU	Public Sector Undertakings
PV	Photo Voltaic
RAD	Rainfed Area Development
RAWE	Rural Awareness Work Experience
RCA	Royal Commission on Agriculture
READY	Rural Entrepreneurship Awareness Development Yojana
RKVY	Rashtriya Krishi Vikas Yojana
RTF	Ready to Fruit
SAPCC	State Action Plan on Climate Change
SC	Scheduled Caste
SCSP	Schedules Caste Sub-Plan
SDF	Soluble Dietary Fibre
SDG	Sustainable Development Goals
SERP	Society of Elimination of Rural Poverty
SFAC	Small Farmers Agri-Business Consortia
SIA	State Implementing Agencies
SIQ&CMP	Strengthening Infrastructure for Quality & Clean Milk Production
SL	Solar Lanterns
SLS	Street Light System
SOC	Soil Organic Carbon
STC	Scheduled Tribe Component
SVVU	Shri Venketeshwara Veterinary University
TDF	Total Dietary Fibre
TSP	Tribal Sub-Plan
UAE	United Arab Emirates
ULDB	Uttarakhand Livestock Development Board
UNEP	United Nations Environment Programme
UNFCCC	UN Framework Convention on Climate Change
UV	Ultraviolet
VCRMC	Village Climate Risk Management Committee
VPKAS	Vivekananda Parvatiya Krishi Anusandhan Sansthan
WFP	World Food Program

Chapter 1

Realizing Gandhiji's Vision for Agriculture and Rural Development: Role of ICAR Innovations

Trilochan Mohapatra, Sanjay Singh and Suresh Pal

"Be the change that you want to see in the world."
MK Gandhi

1. The Gandhian Philosophy and Agriculture

The country is celebrating the 150th birth anniversary of Mahatma Gandhi, Father of the Nation. This is the time to recapitulate his ideas and teachings and imbibe his principles in public life and service. He is revered by the world and influenced world leaders of his time and thereafter. Therefore, India has greater responsibility to uphold his ideas in the present scenario and contribute to the realization of a world without class, conflict and deprivation. Non-violence, peace and truthfulness shall continue to guide world development policy and bringing a change at all levels in the governance and public service.

A large part of Gandhiji's ideas can be used for improving the life and livelihood of rural people in developing countries. Both Asia and Africa, the regions where he spent most of his time, need greater focus as most of the poor people, hungry and disadvantageous people live in these regions. The same also holds true for Latin America for higher economic inequality. The development of rural livelihoods and human capital in these regions is closely linked with agricultural development. This can be well-understood by milestones set for Sustainable Development Goals (SDGs) of the United Nations. Several SDGs, viz. no poverty, zero hunger, reduced inequality, life below water and on land, are directly related to agricultural development. In the Indian context, the Government has also identified the areas for interventions to achieve SDGs, and the concentrated agricultural and institutional development efforts are targeted for the 171 Aspirational Districts (Niti Ayog 2020). This approach in a way reiterates Gandhiji's thought of deliberate attempt in the approach and actions to serve the rural poor. His major *Satyagrah* of Champaran in 1917 after his return to India was to protect the interest of poor peasants. This approach has been followed by important political and social leaders for the welfare of farmers and other rural workers.

Gandhiji had a significant impact on the working of establishment and development institutions. For instance, Gandhiji thought of rural-centric institutions and initial experience of Sriniketan (West Bengal) on community development led to the establishment of agricultural and rural institutions, which were also later developed as agricultural universities on the pattern Land-Grant System of the US. These principles were also adopted by the Indian Council of Agricultural

Research (ICAR). Since ICAR and agricultural universities have greatly contributed to agricultural development through the green and other revolutions, these institutions have emerged as champions of agricultural and rural development.

ICAR has followed the Gandhian principles in its working, research approach and targets. It has a network of research institutions and most of them are located in the production environment close to the mandate. These institutions work in partnerships with clients and farmers. A good number of them are mandated for unfavourable production environment and resource-poor farmers in tribal and hilly areas. The concerns of equity and environment are built into the research priority setting process, and technological developments aim the needs of the majority of smallholder farmers (production by the masses). The concept of development in harmony with nature is followed by the development of technology and practices for the conservation agriculture and natural resources (soil, water and biodiversity) (ICAR 2015). This chapter contains some of these contributions of ICAR towards realizing Gandhiji's dream of inclusive, sustainable and people-çentric agricultural development. There is empirical evidence that ICAR-led efforts have not only contributed to national food security but also helped in reducing poverty in the country (ICAR 2020).

2. Satyagraha: Pursuance for Discovery of Truth

Gandhiji always stood for truth and strived through peaceful means for others to follow the path of truth. Research is primarily an activity to discover the truth and new knowledge and use it for the betterment of the masses. This is particularly true for agricultural research, which has larger applications for addressing the basic needs of people and promoting inclusiveness. This pursuance for truth is centered around an understanding of production systems and inter-relationship between living (plants, animals) and non-living (soil, water) systems. There is so much discovered about these systems but still we need to probe further to exploit synergies and efficiency of these systems. Similarly, there is so much to understand about the biological systems of plants, animals, microbes, fish, etc. Understanding of these functions shall help in the development of new varieties and breeds, which are more responsive to inputs, resilience to stresses and rich in nutrients.

There are newer areas with high potential to make the production systems efficient, sustainable and income-generating. The potential of bio-economy and microbiome has great potential to improve the efficiency and resilience of the living systems. This area has also the potential for application in the food and agro-industry. This area has not been exploited much and ICAR shall continue to make efforts to strengthen research in this area to discover useful microbes.

The advancements in molecular biology are taking place at a much faster rate. This area also offers great potential to address some of the production constraints, e.g. drought tolerance, pest tolerance, which are not addressed by using conventional breeding methods. While some of these applications may require modifications in genetic structure, but this should not alter the basic functions and nature of the plant systems. The bottom line is that all scientific exploration

should discover new knowledge but it should not alter the basic fundaments of nature. ICAR shall continue to strive for this and accelerate the pace of basic and strategic research, which can be applied to address the R&D needs of agriculture and society at large.

3. Gandhiji's Talisman and Priority Setting

> *"Whenever you are in doubt, ... Recall the face of the poorest and the weakest man (or woman)... and ask yourself, if the step you contemplate is going to be of any use to him (or her)... will it lead to swaraj (or freedom) for the hungry and spiritually starving millions..."*
>
> Mahatma Gandhi

Mahatma Gandhi laid great emphasis on reviving the rural economy, preserving the ecosystems and reducing the consumption not to create any stress on the environment. This talisman of Gandhiji champions the cause of '*Sarvodaya through Antyodaya'* implying the welfare of all through the weakest of the society which lies at the core of the Indian Constitution. Gandhiji's talisman is a call to the stakeholder to develop a framework so that they are effectively able to assess the needs of vulnerable sections and work towards their upliftment through agricultural research. The time has come for us to make his thoughts and philosophy a part of our economic policy. This is essential to internalize and embrace the Gandhian way of life and decision-making.

How this Gandhian way of decision-making or setting priorities can be used to improve the effectiveness and efficiency of R&D through rationalization and use of resources with greater objectivity and transparency to address priority research themes. A formal priority setting mechanism was evolved and adapted to incorporate the concerns of equity and ecology. There are visible and perceptible changes in the allocation of research resources and utilization of funds across agro-ecosystems, production systems, and research themes, to address issues and concerns of poverty, marginal areas, gender issues, and institutional developments.

Convergence in priority setting: The elements of objectivity, transparency and ability to make impacts are built into the priority setting approach. The resources are being allocated to a well-prioritized and targeted research agenda. The priority setting exercises focus on the vulnerable sections of farming society particularly smallholders, women in farming and other relevant equity-related indicators. Our marginal areas such as rainfed, arid and hill & mountain regions now account for two-thirds of public expenditure on agricultural research. The resource allocation towards the marginalized areas increased significantly over time. A notable example is the establishment of new institutes in the eastern region that have low productivity and a high incidence of poverty.

ICAR has also made a deliberate attempt to allocate higher resources to R&D for the economic welfare of vulnerable sections have increased considerably. The Tribal Sub-Plan (TSP) aims to bridge the gap between the Schedule Tribes (STs) and the general population concerning

socio-economic development in a time-bound manner. The Schedules Caste Sub-Plan (SCSP) is an umbrella strategy to ensure the flow of targeted financial and physical benefits from all the general sectors of development for the benefit of Scheduled Castes. This plan provides thrust to family-oriented schemes of economic development of SCs below the poverty line and provides the resources for filling the critical gaps and for providing missing vital inputs for effective implementation of the scheme. ICAR has been conducting the capacity building activity under these two special plans and also carrying out many development activities for the overall development of beneficiaries in different regions.

Focus on equity and environment: The new strategy in NARS envisages the rationalization of resource allocation based on prioritized research portfolio and strengthening M&E of research programmes. It is aimed to institutionalize PME process through integration with the research management process at all levels in the NARS. The guiding principle is that PME process should be more objective, transparent and decentralized. The equity criteria represent the distributive effects of research investments. This measure should reflect the share of various sections of society (e.g. poor and non-poor; male and female; or urban and rural) in the total welfare gains. The indicators include the extent of poverty and female illiteracy in the primary domain(s) for which research is targeted.

Environmental sustainability has been given due emphasis in the priority setting approach. The measures on environmental sustainability reflect the extent to which the use of technology affects the natural resource base. The productivity is sustained over time so that welfare gains from research accrue to society are maintained over time. The country's research and education system has witnessed a sea change. The vast network of ICAR institutions has come up in a big way to address the commodity and region-specific research problems and foster linkages. All these institutions consider the status of natural resources like soil and water depletion and degradation, in the finalization of research programs.

Gandhiji left us with his dream of equality. Government policies must necessarily focus on the vulnerable and marginalized sections of the society even if it requires making special provisions for such classes. Gandhiji's philosophy emphasizes a lot on priority setting, based on the potential impact on the rural poor. The agro-ecosystems and production system-level priority setting deals with resource allocation across the systems, programs and projects, and it is best done by a multi-disciplinary team in close interaction with all stakeholders like farmers, NGOs, etc. Ideally, the macro priorities are derived from the micro priorities. ICAR has encouraged this approach of identification of research programs and linking them with funding.

4. Khadi: Production by the Masses for the Masses

India lives in villages, and the father of the nation Mahatma Gandhi advocated for self-reliant village economies where the villages will be independent yet inter-dependent economic units for production, consumption and trade, leading to the maximization of social welfare with every individual in the village having affordable access to the basic minimum needs of food,

shelter and clothing. He believed in mass production by the masses for the masses using the locally available natural resources and human capital with little, if any, external intervention. Gandhiji was not against industrialization, but he was against exploitation of the resources and people for profiteering in the process of mass-scale industrialization by a few industrialists.

Gandhiji was against the concentration of agricultural land in fewer hands and was unequivocal in his ideas in favour of the distribution of land to the tillers, and also the collective farming for improving scale economies. He also advocated the use of agricultural techniques and technologies that do not deteriorate and pollute the soil, water and environment, and cause hazards to human health. Nonetheless, given the predominance of smallholdings and unequal distribution of land he opined that agriculture alone cannot solve the problem of unemployment, indebtedness and rural poverty, and therefore, agricultural development should go hand in hand with the development of rural industries that are based on local resources and family labour and require less of capital investment. Agriculture generates raw materials for rural industries, and their outputs can be targeted for consumption by the local people and sale in local markets. He emphasized on the development of small-scale rural industries to generate employment and income for the rural people in the village itself. Gandhiji used *Khadi* and *Charkha* to symbolize rural prosperity through rural industrialization by rural people. He was convinced that *"Provided this character of the village industry is maintained, there would be no objection to villagers using even the modern machines and tools that they can make and can afford to use."*

Even after decades of Independence, Gandhiji's idea of sustainable development of agriculture and rural industrialization remains as important as it used to be in the pre-Independence period. For example, the large-scale reverse migration of labour from urban areas back to the villages, and the supply chain disruptions in wake of Covid-19 disease pandemic induced lockdown have exposed the weaknesses of urbanization and urban-based industrial employment, hence the need for labour-intensive rural industrialization based on local resources, including the agricultural surpluses, labour, skills and capital. Unfortunately, the country missed this opportunity in the process of economic development, leaving behind the rural areas and leading to an increase in rural-urban disparities in social and economic indicators of welfare. Rural industries help the decentralization of economic activities to the benefit of a large proportion of the population. The government's current emphasis on the development of micro, medium and small scale enterprises that are labour-intensive and require less of capital holds the key to move on the path of rural industrialization.

The other idea of Gandhiji that remains relevant and will remain relevant in the future is the need for collective action in agriculture and agricultural marketing. Since Independence, India has made tremendous progress in agriculture, making the country self-sufficient in food and non-food commodities. However, over time the landholdings have fragmented to the extent that as of now 70% of the landholdings or size less than or equal to one hectare, depriving farmers of the potential scale economies in production and marketing. Probably the inadequate institutions,

policies, and incentives that could have motivated the farming communities to come together for better agricultural outcomes are one of the reasons behind the poor collectivization in farming. The government's recent initiatives on the expansion of rural industries, strengthening of Farmer Producer Organizations, and one- district one-product based clustering farming is likely to enable them to harness the scale economies. The multiplier effects of such efforts are likely to be large to the benefit of millions of small-scale producers, rural artisans, and landless workers.

Finally, the relevance of Gandhiji's advocacy for sustainable development of agriculture cannot be undermined in the context of the on-going agrarian crisis. The need to produce more food for the growing population compelled the policymakers to promote the high-yield crop varieties along with mechanization. The high-yielding crop varieties, developed by the ICAR-SAU system made the country food secure. Recognizing the negative externalities of intensive agriculture based on KVKs, the agricultural research system under the guidance of ICAR has started refining and promoting conservation agricultural practices and evolving climate-smart technologies to enable agriculture to recover from the negative externalities of intensive agriculture, and climatic shocks that have become more frequent in the recent past. In the present context, ICAR has re-oriented its approach to the technological empowerment of small farmers for enhancing agricultural productivity with sustainable use of natural resources.

Realizing Gandhiji's dream of self-reliant village economies is a challenge. However, given the recent advancement in information and communication technologies, geographic information systems, biotechnology, and logistics the challenge is not insurmountable. Such innovations can make a powerful impact on rural economies if the public policymaking builds from the bottom as per the requirements of the rural population.

5. Non-violence: Development in Harmony with Nature

"I need no inspiration other than Nature's. She has never failed me as yet. She mystifies me, bewilders me, sends me to ecstasies."

Mahatma Gandhi

Against the backdrop of environmental deterioration, there is an urgent need to recall and rewind the Mahatma Gandhi's Philosophy towards non-violence and harmony with nature. Mahatma Gandhi's lifestyle was true learning for all generations to have complete harmony with nature. This was not only true for the present generation of that era but also for the future generation. His welfare-oriented approach kindled many enthusiasts and institutions to build a sustainable future. This is truly applicable to address the issue of sustainability and harmony with Nature. Indian Council of Agricultural Research (ICAR) has also practiced many of his valuable messages for creating farmers' welfare and prosperity while reducing the damage to the environment.

Gandhiji has adopted the principle of non-violence in his entire life, which can also be applied to development in harmony with nature. Gandhiji was well aware of the environmental degradation, biodiversity and sustainability issues and found himself the solution to address it, non-violence. He stressed the importance of natural resources and its effective conservation by key stakeholders engaged in the administration and appropriation of these resources. This motive was taken to action by ICAR and in the last few decades, it laid key policy framework and interventions for natural resource conservation and avoided a fair amount of damage to soil, water and atmosphere. The direction of research activities in ICAR institutes encompasses the motive to establish harmony with nature. The Gandhiji concept of "*Sarvodaya*" has a similar meaning to the contemporary word "Sustainable Development" which is closely associated with the research approach of ICAR that covers all the stakeholders engaged in farming irrespective of class and region and is more inclusive in terms of delivery of benefits. The novel approach of Integrated Nutrient Management (INM) and Integrated Pest Management (IPM) and other key practices are directed mainly to augment the harmony with nature and achieve sustainable development. The research system method adopted by ICAR is less exploitative and in sync with the natural endowments. Even the policy advocacy emanating from the studies lays greater trust in building harmony with nature and the use of non-violent force to achieve the ends in it. The clear portray of sustainability in all the aspects ICAR employs to create resources is the hallmark and is carried since its inception. More so the healthy development with nature was always been the prime motive for Gandhiji, in the ICAR system healthy development taking shapes with the development of nutri-rich cereals, conservation of germplasm, indigenous methods, forest species and preserving local food system among others. Emphasizing the development of rural India, where the eyes and ears of Gandhiji live, ICAR system with KVKs, ATARIs, and Regional stations have tried to solve problems, transferring the research benefits and augmenting their resource and knowledge base significantly. There always a cadre of scientific staff to mitigate the adversaries of nature and natural calamities which was evidenced during the recent locust attack in Rajasthan, Gujarat and other parts of northwestern India. This illustrates the Gandhiji's idea of a cadre of frontline workers who try to lessen the adversaries during any calamity.

There is always a set of integrated approaches and ideas put forward by the ICAR system for the conservation of germplasm, soil, water, biosphere and ecosystem, which was highlighted by the Gandhiji time and again. In the direction of achieving economic equality put forward by him, various interventions have been made by *Kisan Melas*, training programmes, mass demonstrations and others to enhance the availability of newly developed and advanced technologies to use in their farm.

Further addressing the climate-related issues, which were highlighted by him at the beginning of the 20th century, the ICAR has actively promoted a set of plant varieties, management practices and technologies to reduce the vulnerability of farmers to climate adversaries. Climate change

shows a clear violation of the Gandhian principle of non-violence and harmony with nature. Indeed Gandhiji had cautioned the world much before any modern-day environmentalist. Climate change is a reality and the approaches to contain are on full swing. In this milieu, ICAR-NIAP carried out righteous researches on mainstreaming climate adaptation into the development agenda and assess the impact of climate change on different crops across different agro-ecoregions in an attempt to build climate-resilient agriculture. To build resilience to the climate erratic's trends both the knowledge and resource endowments are strengthened with the active support of government and civil society organizations. The heart of climate-resilient lies with rural segments where any change can disproportionately affect the people and ICAR has ably demonstrated its AR4D through its climate-smart villages, wherein, technological and institutional options for dealing with climate change in agriculture are showcased in different parts of the country. The past event suggests that agriculture is the most vulnerable sector for the events originating from the climate change. However, one must not forget the fact that the sector is a hotbed to bring lost climate resilience through sustainable practices and production methods. This certainly aligns the sustainable development with social harmony in the coming years as his core ideas largely built on the ecological practices of peasants and the rural populace. This would perhaps bridge the regional inequality, bring overall development and growth amongst the people, class and society. These are the key metrics that define the welfare of people at large in the policy discourses of ICAR-NIAP.

ICAR system has never made greed over its resource endowments while conducting research, taking research it farmer field, by following Ahimsa (Non-violence). By practicing non-violence while enacting harmony with nature the ICAR has necessarily inculcated the essential ingredients of non-violence.

6. Research Policy and Management Reforms

Change is a dynamic process. The speed of change increases with the development process and this is true for the economies in transition. In India, both the economy and agriculture are under transformation that is facilitated by institutional change and policy reforms. ICAR has been at the forefront to pioneer, adopt and facilitate these policy and institutional reforms in the context of agriculture and rural development. A number of these reforms are imbibed and motivated by the Gandhian Philosophy of change in the agricultural development process. This focus is on bringing the research and development organizations closer to the end-users to understand and address their needs and seek their participation in the implementation of the programs (ICAR 2015, Pal 2017).

Farmer participatory research: Participation of farmers in on-farm research has been an important research approach of ICAR institutes. This is done through various programs, beginning from Lab-to-Land, and Institute-Village Linkage programs. These programs were further upscaled through the creation of outreach activities like technology demonstration, farmer participatory seed production, and most recent Mera Gaon, Mera Gaurav for monthly interaction with farmers. A much larger component of research-extension-farmer linkages is

operationalized in the forms of frontline extension by the institutes and *Krishi Vigyan Kendras*. Under this program, special attention is paid to rural women and youth who can be empowered with improved technology, skills and entrepreneurship. Empowerment of rural women is visible through their participation in agriculture activities like Joint Liability Groups of women for access to land (e.g. in Kerala) and credit, conservation of natural resources, and their participation in larger rural development programs.

Transparency and objectivity: Decision-making in public organizations is often described as 'top-down,' lacking grass root realities. The modern management methods have provided tools to make the decision making more objective, i.e., based on information and facts, and transparent. These principles are adopted in resource allocation though the development of decision-making criteria, which are objective and transparent. This process is used at all levels i.e., ICAR, institutes and programs. An outcome framework linking resources with goals, activities and expected outcomes was adopted for research planning.

Transparency and objectivity are also adopted for evaluation of research programs, and scientists' performance, which are linked with an incentive in the form of career advancement. The scientists are evaluated against their traits and contributions using a quantitative assessment framework. A similar objective framework is used for the recruitment of scientists and management personnel. This framework has been adopted by other scientific and academic organizations in the country. More recently, a transparent system of transfer of scientists has been adopted by ICAR.

Empowerment of researchers: Research is a highly specialized and creative activity with uncertain outcomes and therefore it requires different working rules and flexibility in management. Thus, autonomy and decentralization have been encouraged since the re-organization of ICAR in 1973 with a focus on flexibility in the governance and management functions such as human resource development, finance, administrative procedures and international collaboration. ICAR's vision documents also envisage for business-oriented rules and greater independence for better governance. The decentralization of responsibility to the institutes and program levels has helped in a reduction in the transaction cost and improvement in research efficiency. The decentralization of the responsibility and financial management down to the project level has been done successfully with compliance with the government's financial rules. This is a major change to innovate in project implementation and bring research closer to farmers' needs.

Tracking the targets: Research monitoring or concurrent evaluation is an important process to ensure implementation of the prioritized programmes, evaluation of the progress, and direct resources to social needs and weaker sections. A mechanism for monitoring and evaluation was adopted by ICAR and its institutes. This was later adopted by state agricultural universities. Some factors are responsible for the success of the monitoring mechanism. First, it is important how the monitoring process is taken in the system and ICAR has adopted this as a learning tool. Second, the monitoring indicators were simple, objective and verifiable. These indicators were

often suggested by the researchers. The successful programs were rewarded with adequate funding and their upscaling system-wide. A computer-based information system for project monitoring was developed.

Funding for priorities and performance: ICAR has adopted competitive funding for research, seeking the participation of a larger number of institutions and researchers. Under this mode of funding, researchers compete for the dedicated funds for specific research to address high priority R&D needs. Competitive funding is a powerful mechanism to bring institutional reforms in the research system to improve relevance, cost-effectiveness and accountability of research. Often the perception of 'good science' may overshadow need-based research, and the competitors' credentials may dominate the relevance of proposal in terms of clients' needs and objectives of the fund. The competitive funding adopted by ICAR has addressed these concerns and attracted the participation of other scientific organizations, including private R&D, addressing research needs in partnership modes. This mode was later adopted by other scientific organizations in the country and developing world.

Information System: Addressing specific goals, particularly the welfare of weaker sections of the society, there is a need for information on their regional concentration, needs, and resources directed for their welfare. This information is often missing. ICAR made special efforts to develop an information system for resources and their allocation for different institutes and target beneficiaries. The information on resources allocated to the institutions working in different production environments, and community-specific programs like tribal sub-plans, gender etc. are compiled in an information system and reviewed periodically. Also, there is an information system for personnel, financial management, project management and e-office management. Timely availability of information has improved the quality of research planning, enabled judicious use of resources, and directed programs to target groups. These efforts have paid dividends in terms of better access to disadvantageous groups to improved technology, quality input like seed and planting material. The use of information communication technology (ICT) has facilitated such an improved information system in ICAR that has been adopted by other research organizations like state agricultural universities. Efforts are being made to develop the information system for research outputs, technology, and their dissemination, outcomes and impacts.

7. Swaraj through Village Institutions

Gandhiji always believed in strong village institutions for the overall development of the society in the rural areas as the concentration of economic or political power would violate the principles of participatory democracy and thereby of Swaraj. To promote decentralization, Gandhii suggested the institutions of villages as units of economic autonomy. He started *Sevagram yojana* in Wardha district of Maharashtra in 1934 to make villages self-sufficient and self-contained. His ideas and perspectives in terms of rural reconstruction were adopted officially and resulted in the Panchayati Raj movement. The village is the lowest unit of a

decentralized system, politically a village has to be small enough to permit everyone to participate directly in the decision-making process. It is the basic institution of participatory democracy. Agricultural development activities got a push under this system especially when MNREGA activities were converged with agricultural development activities like creating bunds for soil and water conservation, rejuvenation of common water resources, pasture land development activities for enhanced availability of forage for animals etc. ICAR institutes especially working under Natural Resource Management and Crop Science Divisions are working for the development of watersheds with the active involvement of gram panchayats in different states of the country. Besides this, ICAR in partnership with ICRISAT, State development department and Panchayats has also developed watersheds in different parts of the country. Successful adoption and replication of these water conservation techniques and agroforestry were useful in addressing the problems of soil erosion and water crisis for drinking as well as for irrigation. For efficient utilization of water, user associations were created at different project sites. All these watersheds developed by ICAR institutes have empowered poor rural communities residing in those areas by creating better access to quality drinking water and higher income from agriculture and livestock activities. It has also helped in reverse migration in some areas from towns to villages and fulfilling the Gandhiji dream of Swaraj. ICAR-IGFRI and CAZRI have played a role in the rejuvenation of community pasturelands in Rajasthan, Madhya Pradesh, Tamil Nadu, Himachal Pradesh and Uttar Pradesh where MNREGA funds were utilized and all the gram panchayats in the project areas were actively involved in the development of grasslands for better availability of quality fodder and improved livestock productivity.

Cooperatives: The secret of successful co-operative effort is that the members must believe in co-operation, which should have a definite progressive goal. Cooperation according to Gandhiji was necessary for the creation of a socialistic society and complete decentralization of power. He believed that cooperation was one of the important means to empower people. Any industry based on agricultural produce should be on a cooperative basis so that the producers could secure the best value for their output. India has seen a lot of success stories of cooperatives, particularly in milk, sugarcane, fruits and vegetables, crops. Some of the successful cases are AMUL, fruits and sugarcane cooperatives in Maharashtra. The dairy cooperative movement in India could grow due to an increase in milk production. ICAR institutes are playing a great role in technological backstopping to cooperatives. ICAR-NDRI has helped milk cooperatives in producing various kinds of milk products with enhanced shelf life. Due to changing consumer behaviour and rising per capita income, demand for processed milk products is rising and NDRI has transferred these technologies and trained manpower through producing thousands of students who are managing dairy plant operations in various state dairy cooperatives in the country. ICAR-IVRI by its vaccine and other livestock technologies has helped millions of farmers through milk cooperatives. Similarly, ICAR institutes working in horticulture crops have helped fruit crops based cooperatives working in different states by enhancing not only their farm productivity but in post-harvest operations to improve the keeping quality.

The formation of farmers groups for seed production, forage seed, and minor forest produce collection and processing are other notable examples to build village society.

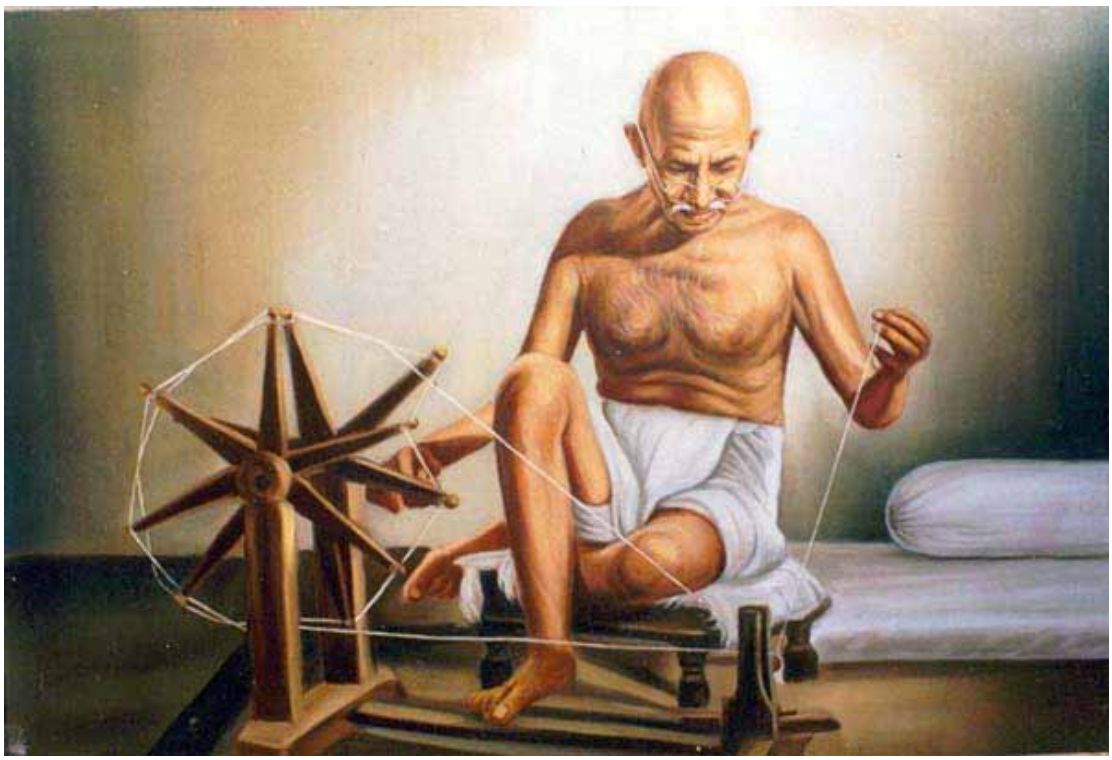
Human resource development by KVKs*:* For agricultural development skilled manpower is vital. ICAR strongly address this issue by helping the KVKs operating under SAUs and through its own KVKs network. KVKs are directly working for rural development at the grass-root level for the transfer of agricultural technologies. Nowadays agriculture is not only a farmers' job; it is growing as agri-business for both rural as well as urban areas. In the present scenario, farmers are educated, intelligent, attentive, skilled and eager to learn new things that may help in their work. They are using most modern technologies for better production and marketing of their produce. Hence, agriculture is flourishing as agribusiness and it has a better potential to uplift the socio-economic status of the rural community. KVKs are working with a vision of Science and technology-led growth leading to enhanced productivity, profitability and sustainability of agriculture. KVKs have the mission of Farmer-centric growth in agriculture and allied sectors. Capacity building of the farmers about the adoption of new technologies is done through ICAR and SAUs, which are eventually supported by ICAR. The KVKs are not only supporting agriculture but also the allied and non-farm activities through various capacity building programmes. The capacity building of members of self-help groups, commodity interest groups, FPOs is done by KVKs, so that all these groups can work professionally with greater efficiency. The recent human capital development initiatives of ICAR through KVKs included ARYA (Attracting and Retaining Youth in Agriculture), Farmers FIRST programme, skill development of farmers and youths through the Agriculture Skill Council of India (ASCI). KVK also focuses on women-centric capacity building programmes, especially on primary processing of agriculture, horticulture and dairy products through the formation of women self-help groups. All these programmes are developing the man resources for participation and management of village-level institutions and thus helping in fulfilling Gandhiji dream of Swaraj.

8. Way Forward

"The future depends on what you do today."
Mahatma Gandhi

It is clear from the foregoing discussion that ICAR has made significant contributions to agricultural and rural development with a focus on the needs of disadvantaged regions and sections of the society. Several institutional reforms involving stakeholders' participation and transparent decision-making have helped in targeting these special groups. Improvement in agricultural productivity and farm income has empowered the farmers that contributed to the empowerment of rural institutions, a major pillar of the Gandhian thoughts. The 150th birth anniversary of Mahatma Gandhi is an occasion to reaffirm the commitment of ICAR to his vision of agriculture and rural development. ICAR shall continue to make deliberate attempts to improve rural livelihoods and income through technological interventions. Small farmers,

women and rural workers shall be the main clients of ICAR, besides addressing the R&D needs of other farmers and agricultural workers. National food security, environmental sustainability, and equity shall continue to guide priority-setting efforts of ICAR. Empowerment of women and small farmers through technological and skill empowerment shall be the main goal. This is turn shall contribute to the economic and social empowerment of rural people and strengthening democratic principles of village institutions. ICAR has an advantage of its linkages with the villages and resource-poor farmers and therefore to contributes to the vision of Mahatma Gandhi. ICAR shall accelerate these efforts in the years to come.



Chapter 2

Horticulture for Rural Livelihood and Nutritional Security

AK Singh, S Sriram, ES Rao, Santosh J Eapen and MR Dinesh

"An ounce of practice is worth a thousand words."
MK Gandhi

1. Introduction

Mahatma Gandhi said, '*The progress of the country lies in the development of its rural villages, the rural economy, and rural skills*'. Without contribution from agriculture, the economy of the country will collapse. This was irrevocably proved during the present COVID19 pandemic, wherein agriculture was the only sector that showed positive growth among the several contributors to India's GDP. This further proved that the Mahatma was correct in his wisdom of rural economy. Agriculture provides the largest source of livelihood in India and remains a key driver of national economic growth and our country has substantially progressed in improving the food as well as nutritional security in the past few decades. Horticulture has been a major contributor surpassing the agriculture production since 2012. This sector is considered as a key driver of economic growth as it is gradually taking shape of an organized industry with key linkages to seed business, value addition and export, leading to Job-Full growth. Horticulture provides not only diversification but also contributes towards food, nutrition and economic security. Rise in production of horticultural crops both by small and marginal farmers who constitute up to 85% of farming population, has brought prosperity especially in rural India.

ICAR has contributed immensely over the last five decades towards developing varieties and technologies to boost incomes of horticultural farmers throughout the country. The main research agenda of horticultural crop institutes has been to enhance the productivity of horticultural crops by developing high yielding varieties of fruit, vegetables, spices, ornamentals and medicinal and aromatic plants along with state-of-the-art production technologies. To combat the emerging challenges in horticulture sector, the emphasis was laid on breeding varieties for biotic and abiotic stresses, breeding F_1 hybrids, integrated modules for pest, nutrient and water management, improved post-harvest management practices and developing value added products. Emphasis was laid on frontier research areas like hi-tech horticulture, precision farming, information technology, biotechnological interventions to increase yields, protect crops from insect pests, diseases and viruses, and extension of shelf life of crop produce. Many institutes dealing with horticultural crops viz. IIHR, CISH, CITH, CIAH, IIVR, CTCRI, CPCRI, IISR and NRCs working on various horticultural crops like banana, grapes, pomegranate,

onion, garlic, ginger, turmeric, cardamom, black pepper etc. have contributed immensely in their respective domains.

All horticultural crop institutes have also been involved in linking their research outputs with the upliftment of rural livelihoods and providing nutritional security. Few significant accomplishments and success stories of horticultural crops that help to realize the dreams of Mahatma Gandhi on rural livelihood and nutritional security are described in this chapter.

2. Gandhiji's Ideas about Rural Livelihood and Nutritional Security

2.1. Gandhiji's Vision on Rural Economy

Mahatma Gandhi was vocal about the rural economy and rural industries. He advocated that the India's progress was dependent on rural economy (Pandey 2008). Presently about 65% of our population still lives in rural areas, most of who live in poverty, while the rest of the country has shown exceptional progress. The Mahatma gave importance to self-sufficiency (Atma Nirbharatha) and felt that rural under-development is the cause for poverty. He used to quote *"life should not be a pyramid with apex sustained by the bottom"* in his speeches. He emphasized that life is an oceanic circle with individuals as center. Everyone should be ready to sacrifice for the whole unit. His concept was entirely based on sacrifice. From its inception, ICAR has always worked with commitment for the rural development and many horticultural technologies have helped the farmers to find livelihood and promote employment in rural parts of the country. Generating employment opportunities in different sectors by collectively identifying the areas and planning accordingly to materialize the concept of Atma Nirbhar Bharat is one of the major focuses of ICAR.

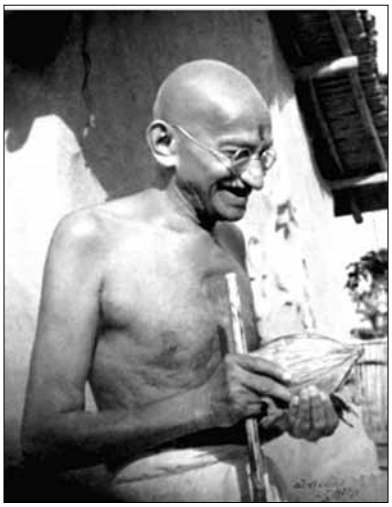
2.2. Gandhiji's Experiments with Nutrition and Diet

He laid serious emphasis on the quality of food taken by an individual and he conducted diet-related experiments either on himself or tested at his ashram. His experimentation with diet began early. At the age of 18, he began eating only unfired (uncooked) foods (Rivets 1959). The range of Gandhi's experiments in the arena of diets varied. His interest in the use of orange peels for preparing jams and murabbas are similar to that of present-day dieticians. His strict regimen of two meals a day mostly comprised of fruits and vegetables.

Gandhiji with Sardar Vallabhai Patel. His intake of food was mainly comprised of fruits and fresh vegetables.

The story of Mahatma nursing his wife Kasturba with dal, milk and green vegetables has been mentioned by various authors. In his book, Key to Health, he wrote, "*Whilst it is true that man cannot live without air and water, the thing that nourishes the body is food. Hence*

the saying, food is life" (Gandhi, 1948). His preference was vegetarian food. Gandhi's diet mainly comprised of salads,curd, fresh fruits, unpolished rice, millets, pulses, jaggery and dry fruits.



Mahatma receiving a coconut before going for Bhajan Session in Sevagram Ashram

3. Contributions of ICAR in Rural Livelihood and Nutritional Security

To realize the dreams of the Mahatma in rural development and nutritional security, the horticultural institutes of ICAR have taken proactive measures to ensure food, nutrition and livelihood security in the nation and have contributed significantly to enhancing the availability of nutritious food and providing employment opportunities to the rural population. These institutes train farmers in sustainable farming, enhancing profitability, water resource management and farming techniques. One of the major thrusts of ICAR is to increase the availability, affordability and consumption of nutrients-rich fruits, vegetables, and spices to reverse malnutrition. This will aid in seamlessly blending the rich Indian culture and applying science-based methodologies for keeping the rural population fit and healthy.

3.1. Linking Biodiversity to Livelihood Security

3.1.1. Empowering the custodian farmer who preserved jack fruit with coppery red flakes

Jackfruit (*Artocarpus heterophyllus* Lam) is native to India. The trees grow wildly in the Western Ghat regions of India up to an elevation of 2,400 MSL. Further, these trees are also grown as homestead or as a mixed crop in the states of Kerala, Karnataka, Tamil Nadu, Bihar, West Bengal, Uttar Pradesh, Assam and Orissa. It is a multi-purpose crop used for food, traditional medicine, timber, fuel and as fodder. The primary economic product is the tender fruit that is used as vegetable and the ripe fruit for table purpose. In addition, several value-added products from both immature fruits as well as seeds are being prepared throughout the country.

It is a cross-pollinated crop and propagated through seeds. The natural populations are highly heterogeneous in nature. Considerable variation is observed in the form of fruit shape, size, density of tubercles and other fruit characters like colour of rind and flakes, thickness, fiber content, fruit quality and maturity. Because of this diversity, it is possible to select promising strains satisfying different purposes. Already, several locally adopted genotypes of jackfruit are available in India, which originated through clonal selection by the farmers. ICAR-Indian Institute of Horticulture Research, undertook a survey to identify superior Jackfruit genotypes during the period 2016-2020 in the traditional Jackfruit growing tracts of Southern Karnataka. These regions are generally dominated by seedling progenies and offer considerable variability for tree morphology and fruit quality parameters. During the survey, 125 plus trees were

identified based on different horticultural traits including colour of flakes and organoleptic values. In this effort, a novel jackfruit tree was identified from field of Mr. S.S. Paramesha, Tumkur district, Karnataka, which fruits during May-July with average fruit weight of 2.44 kg per fruit. Flakes are attractive and coppery red in colour with sweet and firm weighing 24.5 geach and TSS of 30.0 ^{0}B. Phytochemical analysis revealed high carotenoids (4.43 mg per 100g) and lycopene content (1.12 mg/100g). Total Flavonoids and phenols, antioxidant activity was also more compared to yellow and white coloured flakes indicating its potential as health promoting and functional food. This variety was named as Siddu Jack.

This variety identified by ICAR-Indian Institute of Horticultural Research, was given wide publicity through mass media, research journals, official web sites and by organising jackfruit diversity fairs. A model for commercialization in 2017 was created, after recognizing and honouring the farmer for conserving this variety as a custodian of Genetic Diversity. The farmer was also trained in propagation techniques for mass propagation of quality plants. Revenue generation is shared between the Licensor (jackfruit farmer) in such a way that 75% of the earning would go to the farmer and 25% would go to the Institute. He is currently producing the Siddu jackfruit plants and has distributed more than 25000 saplings to the farmers and earned a gross income of Rupees twenty-five lakhs, within two-year period because of the handholding by ICAR.

Similarly, this participatory breeding research approach along with local farmers resulted in identification of another elite 12-year-old seedling jack tree from Shri Ravindra's field in Tumkur district of Karnataka with attractive deep coppery red coloured flakes possessing high carotenoid content. In recent years, several entrepreneurs have come forward to commercialize jackfruit products. Hence, identification of such locally adapted types would increase the area and production considerably. Further, it provides farmers a chance of additional livelihood opportunity.

3.1.2. Tamarind for improving rural livelihood

Tamarind is another important crop like jack and has adapted itself in India over several centuries. Tamarind is widely adaptable and suitable for marginal lands due to its large tap root system, which protects it from strong winds and cyclones. It is also considered to be a suitable tree for inter-planting with other commercial forest species. The tree starts bearing from 6-8 years and its productive life can last for 50-70 years, though the full life span is about 150 years. A healthy tree yields about 50-100 kg of fruits. The fruits are harvested in multiple pickings over an 8-10-week period between February and April. Tamarind pulp is the economic part but other by-products such as seed, shell, fiber are also useful for various purposes. Considering its nutritional and adaptive features, this hitherto neglected and underutilized crop needs attention to tackle malnutrition and climate change adaptation and for providing an important means of livelihood for rural India.

In this context, a survey was undertaken in Tumkur district of Karnataka to characterize the local variability of tamarind for identifying superior trees based on morpho-physiological

analysis of pod and tree characters. During this survey, an accession named L1 was identified in Nandihalli village growing in field of Shri Laxmannappa to be superior in several yield and quality traits. The whole family of Shri Laxmannappa who owns L1 gets involved during harvesting period for processing. The employment is created for six months from February to June. One person can process 15-20 kg pods per day and earn around Rs 400 day^{-1}. After the shell is removed, the pulp is inverted to discard the seeds and the pulp is stacked in ring shape in bamboo basket with capacity of 50kg. Each basket fetches Rs. 1500. The seed is also sold at rate of Rs 17 kg^{-1} and the shell chips at Rs 2.50 kg^{-1}. The seeds of L1 tamarind are bold type and each quintal of pulp produces approximately 40 kg seeds. Thus, primary processing and value addition activities have potential of improving livelihood. Collective marketing and meager primary processing provides the livelihood and regular income. This innovative model of linking biodiversity with livelihood security will help us to double the income of marginal farmers in rural India.

3.2. Connecting rural livelihood to export business

Gandhiji believed in improving rural economy. Farmers' income if enhanced it will improve the whole country. Banana is important horticultural crop. The farmers face problem during periods of high production, in marketing and storage due to its quick perishability. If there is an opportunity to export, then the marketing of produce will happen seamless. For the first time, shipment of Nendran Bananas to West Asia was made possible by the efforts of NRC for Banana along with APEDA and Fair Exports Pvt. Ltd. based at Kochi. This has made the export more remunerative and has can improve the rural economy.

3.3.Promoting rural economy by facilitating better marketing

Marketing is important aspect in doubling the farmers in come. For example, mango production has increased over the years. Mahihabadi Dusseri mango is very popular. But to obtain premium price marketing with Geographical Indicator can help. Due to intervention of ICAR-CISH through farmers first project, GI tag (G-125) for Malihabadi Dusseri was obtained in collaboration with Avadh Mango Grower Society and an FPO 'Farmer Interest Group (FIG) which facilitated the farmers to sell their produce at a premium price of Rs. 60 kg^{-1} (DARE/ ICAR 2019)

3.4. Contribution to ecosystem services

Any benefit accrued to the environment and in turn to humankind from any component of an ecosystem, either plant or animal or landscape is referred to as ecosystem service and of late this concept has become popular an indicator of the health of a given natural entity. For instance, natural ecosystems act as water filters. They are habitat for diverse flora and fauna including the wild bees and natural enemies, which are important as pollinators and biocontrol agents. In addition, people may even find an aesthetic pleasure, inspiration and recreation.

Horticultural ecosystems encompassing perennial trees, herbs and associated flora and fauna have a great potential to contribute to the environment beyond regular crop yields. Systematic

studies were undertaken by Indian Institute of Horticultural Research to understand and assess the extent of ecosystem services provided by multi-varietal mango orchards. It was established that the multi-varietal mango orchards comprising trees of different morphology and phenology provide an array of benefits compared to a mono-varietal orchard. The pollinator fauna in multi-varietal orchard was denser and diverse because of the availability of floral resources for longer periods due to differential flowering periods of different varieties. The species composition and abundance of wild pollinators including honeybees, flies, butterflies and wasps was 2-3 times higher in multi-varietal orchards. Besides pollinators, the beneficial arthropods like predatory beetles and spiders were significantly high in multi-varietal mango orchards. They also contributed in terms of adding organic matter to the soil, and carbon sequestration. It was evident that the multi-varietal orchards offered several non-marketable ecosystem services besides providing farmer with a variety of fruits with uniqueness.

Honeybees are an integral part of any agro-ecosystem as they provide the most essential ecosystem service i.e., pollination. Hence honeybees should not be treated as mere honey producers but as the most valuable partners of the ecosystem and their contributions to the rural livelihood as well as sustaining the crop biodiversity should be appreciated. The enhancement in yield of horticultural crops like mango, guava, citrus, cucurbits and onion due to bee pollination both in terms of quantitative and qualitative parameters has been quantified. Honeybees and horticulture could complement each other and add to the income of farmers as well as the health of environment.

3.5. Beekeeping and rural economy enhancement

Besides the horticultural crops, bee keeping also plays a major role in rural economy. There is need for capacity building in conserving and popularizing bee keeping among farmers creating awareness about the importance of honeybees for value addition and diversification. Under Tribal Sub Plan every year beehives have been provided to beneficiaries. In 2018, Bee colonies were given to beneficiaries in BR Hills and Kollegal areas of Karnataka while in 2019 it was given in Rayagada and Gajapati districts of Odisha. Besides providing the bee colonies, a technical session on bee keeping with basics and benefits of bee keeping was also conducted to spread awareness.

3.6. Nutritional security through new improved vegetables and fruits

Gandhiji emphasized for fruits and vegetables as a major part of his diet. He believed in the curative value of indigenous fruits. In this line, at ICAR-CISH, a new line of high yielding aonla (CISH-A—33) with large fruits rice in ascorbic acid, polyphenolshas been identified. Solapur Lal was developed at ICAR-NRCP. This hybrid is rich in vitamin C and anthocyanin content (DARE/ICAR 2018). The iron content is also high compared to ruling varieties of pomegranate. Though considered as poor man's crop earlier, sweet potato has gain popularity because of its nutritive value. A new variety, Bhu Sona that is rich in carotene besides tolerance to salinity, suitable for cultivation in eastern states, has been identified by CTCRI. Another variety, Bhu Krishna that is rich in anthocyanin, has been identified. IIHR has developed

several nutritionally superior varieties of fruits and vegetables. Lycopene rich guava and tomato; carotenoid rich mango, pumpkin; vit C rich guava, chilli and antioxidant rich leafy vegetables are few popular ones. Recently, a new drumstick line IIHR-D-16 has been identified that recorded 135 fruits per plant compared to PKM-1 (105 fruits/ plant) with good nutritional profile. Among the leafy vegetables *Enhydra fluctuans* (locally called HilMilchi) contained higher phenolics and antioxidant potential. They can supplement the nutritional requirement in the rural areas. Minor fruits viz., *Careya arborea*, *salacia chinensis*, Peanut butter fruit, Canito, Surinam cherry, *Citrus hindsi*, Ugrassa, Chalmogra, *Garcinia mundro*, *Crateagus* sp. *Azimatetra cantha* were characterized and mineral nutritional analysis of these fruits have been carried out. They can help in achieving nutritional requirements of rural and tribal population.

3.7. Improved livelihood with introduction of tuber crops in Tuhet Garden System in Andaman and Nicobar Islands

Gandhiji's concern for the tribal and socially under-privileged people is well known from his days spent in South Africa. The main source of livelihood of tribal population Nicobarese, a dominant tribe in Andaman and Nicobar Island is based on plantation crops especially coconut and fishing. ICAR-CIARI in collaboration with ICAR-CTCRI has made interventions without affecting their ecosystem by introducing tuber crops in their Tuhet Garden System (a joint family farming system). Farmers were trained in growing improved varieties of elephant foot yam and Colocasia. The employment generation in the tuber crops-based farming system was estimated at 510-man days ha^{-1} as compared to 295-man days ha^{-1} in their traditional system showing marked increase in the employment generation. After this success story, younger generation has taken up cultivation of tuber crops in their farms that has ensured livelihood for them.

3.8. Nutritional security through kitchen gardens in rural areas

Growing nutritious vegetables in kitchen garden ensures nutritional security in rural areas. In Rayagada and Gajapati districts of Orissa, 400 adopted households in 25 villages were provided with Arka vegetable seed kits for kitchen garden. Training programmes were also given on various horticultural operations for these tribal beneficiaries. The new crops introduced in these areas were teasel gourd, ivy gourd and pointed gourd.

3.9. Ensuring nutritional security and livelihood through mushroom cultivation in rural areas

The forest areas of Western Ghats of Karnataka, Andaman Islands, Gujarat, Rajasthan, Madhya Pradesh, Sikkim and Manipur have been explored and to document 392 species were documented. Germplasm of 90 species of edible, medicinal and ornamental mushrooms are being maintained at Indian Institute of Horticultural Research. Twelve indigenous species of culinary mushrooms have been domesticated and commercialized.

Cultivation technology of edible species like *Agaricus bisporus* (Button mushroom), *Pleurotus* species (oyster mushroom), *Hypsizygus ulmarius* (Elm oyster), *P. eryngi* (king oyster), *Calocybe*

indica (Milky mushroom), *Macrocybe gigantea, P. tuber-regium, Hericium erinaceus* (Lion's mane mushroom), *Lentinula edodes* (Shiitake mushroom) and *Ganoderma lucidum* (Reishi mushroom) has been developed on locally available substrates.

Genetic improvement of mushroom also has been carried out. Country's first sporeless and low-spored mutants of *Pleurotus* were developed by mutation using UV irradiation to avoid the Farmers' lung disease (related to respiratory problems) and hay fever.

Development of indigenous machinery for mushroom spawn production and cultivation was taken up that comprised of Grain cleaner, Grain boiler, Boiled grain and chalk powder mixer, Bag filler, Inoculator and Paddy straw pasteurizer. Solar energy was integrated in mushroom spawn production and mushroom production processes to save upto 40% of electrical energy used in mushroom production. Solar energy integrated vertical autoclave was designed for efficient energy, water and space management during spawn sterilization. These technologies have been transferred to rural youth and woman entrepreneurs and have resulted in the upliftment of their economy.

To ensure that the availability of benefits of nutrition through mushroom various value-added products viz. Mushroom fortified 'Arka Rasam powder', seven variants of Arka mushroom chutney powders with high nutrition were developed and licensed to 5 entrepreneurs. The production technology of iron-fortified mushroom was developed (patent pending) and the iron bioavailability from the product was studied in animal model system. The iron content of iron fortified increased by 150% (33.8 mg/100 dry wt.) over control. Its bioavailability was 21.68%, which can play a very pivotal role in mitigating iron malnutrition. The delivery system for the iron-fortified mushroom has also been developed. Consuming 10 g of iron-fortified oyster mushroom powder may provide 36-76% bioavailable iron depending the age and sex of the person.

The ready to fruit (RTF) bag technology was developed to help women and SHGs to cultivate mushrooms for household consumption and as a skill for additional income. A multifuel boiler was also designed and developed for substrate sterilization suitable for rural areas. An outdoor mushroom growing chamber was designed and developed to help rural farmers with space and resource constraints to grow mushroom. The unit was also integrated with solar energy.

The use of paddy stray in mushroom production indirectly reduces the straw burning. Twenty-six mechanized spawn production labs have been established in public and private sector in 14 states to alleviate the problem of availability of quality spawn, which is the primary requirement of mushroom cultivation. The transfer of technology activities to rural and socially deprived population was carried out through Tribal Sub Plan and NEH funds of ICAR. Spawn production laboratories were established at Saregachi (West Bengal), KVK (Nellore, Andhra Pradesh) and KVK (Mudigere, Karnataka). Training of rural woman and youth in mushroom cultivation, spawn production and value-added products were provided at Tripura and Arunachal Pradesh in 2018.

Besides, due to the efforts of ICAR-CIARI, Port Blair, Dr. Nitu Sindhu a woman entrepreneur has not only started mushroom cultivation but has turned spawn producer to cater the need of the 30 mushroom growers in Andaman and Nicobar Islands. Through AICRP- Mushroom project, ICAR-CIARI imparted trainings on mushroom spawn production to the interested progressive farmers for mushroom spawn production to meet out the growing demand of mushroom spawn all over the islands

3.10. Seed villages

To be self-reliant, ICAR institutes need to make arrangements for the availability of seeds or planting material of improved varieties by themselves. It may be difficult to cater to the diverse and vast country of ours. In such situation, Seed Village concept of ICAR has really provided us to make the Mahatma's dream come true by empowering the farmers to produce the seeds of improved varieties where by they not only get employment but get the profitable returns also as the produce are bought back by the institute. This 'Seed Village Concept' has helped in spreading of varieties and hybrids of onion, chilli and tomato developed under ICAR.

3.11. Strengthening farmer collectives

The increasing role of farmer collectives is recognized by ICAR in mainstreaming the need for integrating commercially viable value addition opportunities. This is attempted through increasingly participatory approaches with FPO's as a key partner in designing crop value chain solutions. In this connection, the participatory development of FPO's involved in turmeric farming and value addition in Andhra Pradesh by ICAR IISR is noteworthy. Demonstration of Turmeric boiler (Improved TNAU Model of 250 kg capacity) was undertaken at several locations along with massive training programmes focused on value addition and quality improvement. Four such units along with four turmeric polishers were distributed to four trained turmeric FPOs identified by the Society of Elimination of Rural Poverty (SERP) a government of AP tribal rehabilitation initiative. This helped to produce polished dried turmeric of t quality and higher prices in market.

3.12. Bio-encapsulation to promote use of bio-inputs

The development of microbial encapsulation has paved the way for greater and convenient use of beneficial microorganisms in agricultural production process. The use of such microorganisms will reduce the dependence on chemical inputs, while ensuring a cleaner production environment. This will definitely enhance the sustainability of the productions as a whole.

3.13. Tribal Sub-plan

Under Tribal Sub-plan ICAR has contributed for the livelihood and nutritional security of rural areas from 2013. In 2018-19 alone ICAR has supported all institutes and 11 SAUs to carry out activities in this line. Many demonstrations on livelihood security have been conducted in Mysuru and Tumkuru districts of Karnataka. At Karnataka, trials/demonstrations were

conducted in BR hills and in Tumkuru district. CHES, Bhubaneswar conducted trials on demonstration trials for the benefit of rural population on vegetables, flower crops and other horticultural technologies in Odisha, West Bengal and North-Eastern Hilly (NEH) region. In Odisha, the demonstrations were conducted at 28 villages belonging to Kashipur and Mohana blocks of Rayagada and Gajapati districts. In 2019, technologies distributed to rural areas in eastern India include 25 beehives, seeds of eight vegetable crops and three flower crops, mushroom spawn, kits of kitchen garden vegetables. Microbial formulations for the soil and plant health promotion viz., Arka Microbial Consortium and Arka Actino Plus were also distributed and their efficacy has been demonstrated in these areas.

Production of planting materials of high value underutilized cucurbit crops and other seasonal crops in tribal areas through establishment of commercial nursery has been successfully carried out which helps to cater the planting material requirement of adjoining regions and other nearby blocks of the district. Horizontal expansion through promotion of commercial vegetables like ivy gourd, teasel gourd in Gajapati increased the seasonal income of the farmers. Besides distribution of seeds and technologies, awareness programmes were also conducted in these places in collaboration with State Governments of Karnataka, Odisha and Northern Eastern States (ICAR-IIHR 2018, 2019).

Under the tribal sub-pan activities of ICAR Indian Institute of Spices Research, several training programmes were conducted in selected tribal areas across the country. The focus on value chain approach for creating sustainable livelihood activities is one of the focus areas of the activities under tribal sub-plan. The turmeric value chain initiative in ITDA, Paderu, Andhra Pradesh and the interventions in Attapady, Kerala are designed to provide sustained support for spices development in the region. For example, a master black pepper nursery was established at the Horticulture Nursery and Training Institute under the Integrated Tribal Development Agency, Paderu Tribal agency area, in Visakhapatnam District, AP in 2018. About five thousand rooted black pepper cuttings of improved varieties of black pepper were distributed to the tribal framers.

Training on mushroom cultivation, utilization and value addition were conducted at BR Hills in collaboration with NGO Vivekananda Girijana Kalyana Kendra (VGKK) woman participants were imparted training in mushroom cultivation and every month 10 ready to fruit (RTF) bags were given to them for six months. One RTF bag production unit (Mutli-fuel Solar integrated vertical autoclave with boiler and Chaff cutter) was established at People trust, NGO, Srirmanahalli, Bengaluru rural district, College of Agriculture Limbuchera Agartala (Tripura), KVK, Roing, Lower Debang District (Arunachal Pradesh) and College of Horticulture & Forestry, Pasighot (Arunachal Pradesh) to create awareness among rural population and to conduct training in sustainable way. Number of beneficiaries during 2018 -19 was over 1000 families. During the National Horticultural Fair conducted during 2018-2020, the progressive farmers from rural areas belonging to tribal community, socially deprived societies were honoured every year as a token of encouragement. Central Tuber Crops Research Institute distributed Distribution

Training of rural woman in tribal areas (BR Hills) of Karnataka to empower them and have livelihood with production of Ready to Fruit mushroom

Demonstration of improved varieties of (a) elephant foot yam and (b) Colocasia in TSP programme of ICAR-CTCRI

of planting material of improved varieties of cassava (86500 stems), sweet potatoes (920000 vines), greater yam (26500 kg), taro (21750 kg), elephant foot yam (29500 kg) and yam bean (572.5 kg) were distributed to the tribal farmers covering 1464 beneficiaries in three states viz. Chhattisgarh, Jharkhand and Odisha under TSP programme. A total of 1814 tribal farmers were selected for conducting demonstrations on tuber crops technologies.

3.14. North Eastern Hilly Region Plan

In 2019 alone, 1160 demonstrations with an area of 344.65 acres were undertaken in 21 crops and 42 varieties/ hybrids of the institute involving 41 KVK's in NEH states (Mizoram, Nagaland, Meghalaya, Tripura, Sikkim and Arunachal Pradesh). Every year, efforts are made to transfer the technologies to farmers in NEH region. In 2019-20 alone, the number of technologies in various crops were 29 (16 crops), 13 (10), 23 (14 crops), 13 (9 crops), 20 (15 crops) 21, (12 crops), 13 (9 crops) and 10 (8 crops) in Assam, Mizoram, Nagaland, Manipur, Meghalaya, Tripura, Sikkim and Arunachal Pradesh respectively. Demonstration of 24 Arka series varieties were taken up in an area of 113.5 acres in 2018-19 alone in Assam. The crops included tomato, French bean, chilli, brinjal, cowpea, okra, Dolichos, palak and ridge gourd. Area covered in

other states viz. Mizoram, Nagaland, Manipur, Meghalaya, Tripura, Sikkim and Arunachal Pradesh respectively, 26.95 acres, 68.75 acres, 23.25 acre, 39.25 acres, 35.04 acres, 18.65 acres and 13.7 acres. Arka Vegetable Special (250 kg) and Arka Neem soap (200 kg) were distributed to 10 KVKS in NEH region to facilitate the organic pest management.

Demonstration of improved varieties of yard long bean in North Eastern States by ICAR-IIHR to enhance the productivity and income of rural farmers

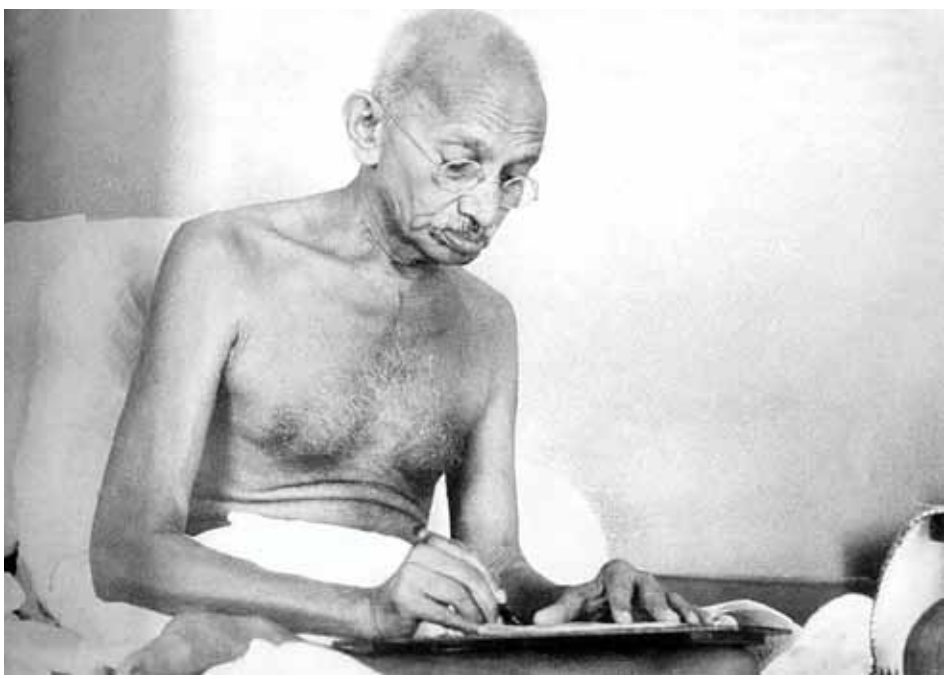
Demonstration of tomato hybrid (Arka Samrat) at Champai, Mizoram

Master black pepper nursery established by ICAR IISR at Paderu, Andhra Pradesh.

5. Conclusion

Demonstration of mulching in pineapple at Nolvom in Nagaland

It is important to visualize that doubling farmers' income and achieving a 5 trillion US$ economy are interdependent, and these will be possible only if rural areas become centers of prosperity and growth. There are more than 700 districts and 6.4 lakh villages in the country. If we empower the rural people through improved livelihood with horticultural technologies, we can not only provide employment and income but can ensure the nutritional security. Now India needs nutritional security more than self-sufficiency in food production. ICAR and its institutes dealing with horticultural commodities are committed to achieve Mahatmas vision for a prosperous rural India through sustainable research-led innovations in horticulture. The recent pandemic incidence also has re-emphasized the Mahatma's principles of rural economy and has taught us how innovatively horticultural produce can be marketed and play a major role in improving the economy of farmers.



Chapter 3

Improvement of Indigenous Cattle: Gandhian Perspectives

BN Tripathi, MS Chauhan, A Mukherjee,VK Saxena and V Bhasin

"Humans need cows more than cows need humans. Cows need to be protected for humans to survive."
MK Gandhi

1. Introduction

The indigenous cattle are the part of our tradition and culture since ages. Cows are considered as a part of family accorded with motherly status as "Gaumata" in Indian tradition. The *'Lord Krishna'* was named as Gopal, which means one who protects cows. Ten important properties of cow milk have been stated in Charaka Samhita *viz.*"Svadu (sweet), sheetal (cool), mridu (soft), snigdha (unctuous), bahula (dense), shlakshna (smooth), pichcchil (viscous), guru (heavy), manda (low) and prasanna (pleasing). Several health benefits of cow milk such as enhancing tissue regeneration, and immune response for disease resistance and considered as a good food during convalescent period have been described in Ayurveda.

India possesses large repository of cattle genetic resource diversity with a population of 193.46 million as per 20th Livestock census, which is 2nd highest in the world and showing an increase of 1.34% over previous Census. Cattle is the most prominent species of Indian Livestock with 36.04% share in Indian Livestock population. Crossbred / exotic purebred cattle constitute around 51.36 million showing an increase of 29.3% over the previous census, while the indigenous/non-descript constitute around 142.11 million showing a decrease of 6%. Out of total 74.59 million breedable cows, exotic/crossbred cows are 26.08 million and indigenous cows are 48.51 million. Presently, country has 50 registered cattle breeds distributed in their respective breeding tracts and can be classified according to their utility as milch (4), dual (10) and draft (36) and rest are non-descript desi cattle i.e., those which do not have definite or uniform characteristics like well-defined breeds. Theannual milk yield in India in 2018-19 was 187.75 million tonnes (Mt), of which 48% is contributed by the cattle (21% by the Indigenous cattle). Annual yield per cow in India is 1642.9 kg against the global average of 2430.2 kg (FAO 2017). The per capita availability of milk is 394 g day^{-1} and Punjab is at the top with an average availability of more than 1100 g. Apart from milk, Indian cattle also contribute towards draft power (30.77 million bullocks), and production of bio-manure, fuel, medicines and leather.

The Indian cattle have capacity to withstand harsh climatic conditions making them economically suitable and sustainable in their habitats. These unique attributes of some of the Indian breeds have been used in the Latin American countries, Australia and southern parts of United States for crossbreeding with *Bos taurus* for beef and dairy production. Few countries have imported selected indigenous breeds and are maintaining improved zebu breeds, viz. Gir, Kankrej and Sahiwal by Brazil, West Indies, Australia and Kenya, and Ongole breed by Brazil and Indonesia as purebreds for milk and meat. Considering the importance of Indian breeds, continuous efforts are being made by Govt. of India and ICAR for the genetic improvement of Indigenous cattle breeds through various breed improvement programmes. In 2009, cattle genome was fully mapped (Christine et al. 2009).

2. Gandhiji's Views on Cow

For Mahatma Gandhi "Cow" had very high place in life and spirituality as he said, "*The cow* to me means the entire sub-human world *extending man's sympathies beyond his own species*". Another symbol in the Gandhian proto-ecological worldview is the cow. Gandhiji also described "*The cow is a poem of pity; One reads pity in the gentle animal. She is the mother to millions of Indian mankind. Protection of the cow means protection of the whole dumb creation of God*". He further stressed upon the importance of the cow by saying that "*cow in India was the best comparison; she was the giver of plenty. Not only did she give milk, but she also made agriculture possible*". He added that "*Mother Cow is as useful dead as when she is alive. We can make use of every part of her body-her flesh, her bones, her intestines, her horns and her skin. Well, I say this not to disparage the mother who gives us birth, but in order to show you the substantial reasons for my worshipping the cow*". He was staunch supporter of cow protection and Gauseva. He saw the emergence of cow protection in Indian religion as "one of the most wonderful phenomena in human evolution. It takes the human being beyond this species". The protection of cows is a passion with Gandhi as he said, "*I would not kill a human being for the protection of a cow, as I will not kill a cow for saving a human life, be it ever so precious.*" He believed that cow slaughter can never be stopped by law. Knowledge, education, and the spirit of kindliness towards her alone can put an end to it. Mahatma believed that cow can be saved without having to kill her off when she ceases to give the economic quantity of milk or when one becomes otherwise an uneconomic burden in following ways: 1) by the Hindus performing their duty towards the cow and her progeny: If they did so, our cattle would be the pride of India and the world. The contrary is the case today; 2) learning the science of cattle-breeding: Today there is perfect anarchy in this work; 3) replacing the present cruel method of castration by the humane method practiced in the West and 4) by thorough reform of the PINJRAPOLES (institutions for aged cows) of India, which are today, as a rule, managed ignorantly and without any plan by men who do not know their work.

The excerpts from "And Gandhi Came Alive" by Megha Bajaj depict the vision of Gandhi for genetic improvement of cattle as it says, "Gandhi had always believed in scientific practicality.

He had suggested to Manibhai Desai to take up cattle development to ensure a good supply of milk. Although India had the largest cattle population in the world, it had one of the lowest milk yields; from an economic point of view the average Indian cow was a liability to its owner. Good milk-yielding cows, he reasoned, could increase both the nutrition and the income of the local farmers. In 1948, he started a herd using the local Gir breed. The herd made an excellent progress that in 1953; the then Bombay state donated eight top quality heifers, one bull calf and one adult bull for the herd's further improvement. From 1957 through 1962, the Urulikanchan Ashram's cows captured first and second prizes for highest milk yield in the country. Manibhai Desai later founded the Bharatiya Agro-Industries Foundation (BAIF), which was registered as a Public Trust on August 22, 1967.

3. Gandhian Principles for Milk Co-operative

The Gosanwardhan Goras Bhandar, the milk cooperative in Wardha city started by Mahatma Gandhi in 1931, has proved that Gandhiji's guidelines on how to run the operations helped in running the cooperative successfully. The Gosanwardhan Goras Bhandar is still continuing on the principles of Gandhiji. It offers a robust rate of Rs 36 per litre of milk to dairy farmers. The milk cooperative has formed 15 societies comprising about 1,000 farmers who rear cows. On average, 12,000-13,000 litres of cow milk is collected daily from farmers at a procurement price of Rs. 36 L^{-1}. The milk brought by farmers is never rejected and purchase rate is constant. Operations at the dairy are fully manual, with zero use of machinery. The board of directors believes strongly in the Mahatma's idea of production by masses and not production for masses. The cooperative doesn't process milk but provides fresh milk to consumers in Wardha. It prepares goruspak (a sweet cake), ghee, peda, basundi, curd and paneer by order. Here, again, everything is manual, and a furnace, instead of gas stoves, is used for cooking. The cooperative is managed to run based on Gandhiji's principles and no money is taken from any government.

4. Improvement of Indigenous Cattle: Contributions of ICAR

The ICAR-Central Institute for Research on Cattle (CIRC), Meerut erstwhile known as Project Directorate on Cattle has been implementing the Indigenous Breeds Project (IBP) under the All India Coordinated Research Project (AICRP) on Cattle for the conservation and genetic improvement of important indigenous cattle breeds of the country. The project is being operated by establishing germplasm (GP) units and associated herds are data recording units in the native tracts of indigenous breeds are maintained under farm and field conditions in collaboration with the SAUs, State AH Departments and NGO. Under the IBP, initially Hariana and Ongole breeds of cattle were taken up for improvement. The genetic improvement of Ongole cattle was undertaken in collaboration with Livestock Research Station at Lam under Shri Venketeshwara Veterinary University (SVVU), Andhra Pradesh from 1988 to March 2014 and 73 bulls were evaluated through field progeny testing (FPT). A total of 1.85 lakhs of frozen semen doses were supplied to farmers. Draft studies were also undertaken on Ongole animals by using

single harness plough with digital dynamometer. The breed is suitable for draught work and its draught power varied from 0.60 to 0.72 HP among the bull Genetic improvement of Hariana cattle was undertaken in collaboration with the CCS Haryana Agriculture University, Hisar (1989 to 2009). Hariana bullocks had capacity to pull moderate load of 8 quintals for about 2 hours without showing any serious effect on the physiological status.

Since the year 2010, genetic improvements of Gir, Kankrej and Sahiwal breeds in their home tracts have been undertaken by the Indian Council of Agricultural Research (ICAR) in collaboration with State Agricultural/Veterinary Universities and ICAR institutes. The data recording of Gir and Kankrej cows is being done by involving the farmers and registering their animals in the respective home tracts (Gujarat) whereas, the data recording units of Sahiwal breed are located at GADVASU, Ludhiana, LUVAS, Hisar and GBPUA&T, Pantnagar. About13557 Gir, 6200 Kankrej and 813 Sahiwal cows from the farmers/Organized herds were registered. Total 219823 frozen semen doses of Gir, 143482 of Kankrej and 174172 of Sahiwal cattle were produced out of which 62494, 46936 and 106522 semen doses of respective breeds have been utilized/ sold since inception for AI in the farm and the field to augment milk production. A total of 160708, 71436 and 88642 semen doses of Gir, Kankrej and Sahiwal, respectively, are available for future breeding. The improved females calves of Gir (5490), Kankrej (2743) and Sahiwal (1003) breeds were produced. The identified elite females had average lactation yield of 3238 kg in Gir, 3553 kg in Kankrej and 3393 kg in Sahiwal breeds. Similarly, increase in milk production of Frieswal cattle from 3285 in 2014 to 3336 kg in 2019 in a standard lactation of 300 days obtained showing improvement of 1.55%. Overall improvements in milk yields of (305 days) of Gir, Sahiwal and Kankrejbreeds were found to be 36.73, 24.33 and 20.02%, respectively, during a short span of 10 years only (2010 to 2019). Besides this, a few more indigenous cattle breeds namely; Tharparkar and Rathi of Rajasthan, Ladakhi cattle of Ladakh and Khillar from Karnataka state are also being proposed in forthcoming plan (2021-2025).

4.1. Characterization and Conservation of Cattle Genetic Resource

About 73% of Indian cattle population is uncharacterized and regarded as non-descript, which poses major hurdle in conservation and improvement of these animals. Sustained efforts are being made for characterization and conservation of the remaining cattle genetic resources of the country by ICAR-National Bureau of Animal Genetic Resources (NBAGR), Karnal. The non-descript cattle of the country are being studied for their morphological, biochemical and molecular characteristics for their recognition as breeds. As such, till date 50 cattle breeds of the country have been characterized and gazette notified in The Gazette of Govt. of India. NBAGR is also working on the *in-situ* and *ex-situ* conservation of the endangered/critical/ threatened cattle breeds. A national gene bank is also being maintained at NBAGR with semen from large number of indigenous cattle breeds.

Conservation of Punganur cattle was taken up under National Agriculture Technology Project (NATP) by NBAGR, Karnal during the years 2000-2004 in collaboration with SVVU, Tirupati and 2691 semen doses were cryo-preserved, whereas conservation of Ongole cattle was taken

up by the institute during 2012-17 under Network Project on AnGR and 7100 semen doses were cryopreserved. The *ex-situ* conservation of Kangayam, Rathi, Nagori, Ponwar, Kherigarh, Bargur breeds through semen cryopreservation, whereas in- situ conservation in Tharparkar, Krishna Valley and Ongole breeds by producing progenies has been undertaken under Network Project on AnGR by NBAGR, Karnal during the period from1997 to 2017. A total of 133608 semen doses of total 24 indigenous cattle breeds have been cryopreserved at NBAGR gene bank. Most remarkable achievement was revival of Krishna Valley cattle in Maharashtra and Karnataka. The number of this cattle breed was reduced to only 400 when NBAGR initiated an *in situ* conservation program and after 12 years of continuous efforts the number has increased to 10,000.

4.2. Milk Profiling of Indigenous Cattle

Studies conducted on the evaluation of various physico-chemical attributes (α-casein, β-casein, κ-casein, whey-protein fractions-α-lactalbumin, β-lactoglobulin, fat, SNF, protein,) and mineral content in Sahiwal, Tharparkar and Gir breeds and crossbred Karan Fries (KF) at ICAR-NDRI indicated marginally higher contents in indigenous breeds except for the mineral content which was comparable to the values reported for crossbred cattle. Whereas there were no significant differences in various compositional parameters such as fat, SNF, protein, lactose, ash, fat globule size, viscosity, specific Gravity, phospholipids, cholesterol, beta-carotene, conjugated linoleic acids and fat-soluble vitamins (A, D, E), etc. between indigenous breeds (Deoni and Malnad) and the HF crossbreed. Even the ghee prepared showed no apparent difference in physicochemical parameters.

The study on profiling on milk proteome in indigenous Sahiwal cattle resulted in identification of more than 6800 proteins which were found to be related to the host defence systems - immune regulation and host defense (antimicrobial activity, cytokines, chemokines, lactoferrin, complement C3, lactoperxidase, xanthine oxidase, alpha lactalbumin, alpha2macroglobulin, lactadherin, etc.). However, research is continuing for comparative assessment of different indigenous cattle for various bioactive components to assess their potential role in human health.

4.3. Assisted Reproductive Techniques (ARTs) for Faster Genetic Improvement

The ARTs include several advance reproductive technologies such as artificial insemination (AI), multiple ovulation and embryo transfer (ET), in vitro production (IVF) of embryos, sperm sexing and intracytoplasmic sperm injection. Using these technologies, in recent past there have been immense improvements in the genetics and productivity of the animals. However, the application of these technologies in indigenous dairy cows had been slow. In this respect, NDDB established Embryo Transfer (ET) facility at Sabarmati Ashram Gaushala (SAG) at Bidaj in 1987 and started super-ovulation of elite cattle and buffaloes for production of embryos. Since beginning, ET has been extensively used for bull production programmes. Since the inception of the project in 1987, 11584 viable embryos have been produced and 774 male calves were born. Further, to boost the application of ARTs, Government of India

has launched a new initiative Rashtriya Gokul Mission, with an aim to conserve and improve indigenous cattle breeds in a focused and scientific manner since India is blessed with a huge biodiversity. Under this program ETT/IVF labs are being established.

4.4. Artificial Insemination (AI)

The artificial insemination has made tremendous impact on the dairy industry. Intense genetic selection of bulls and use of cryopreserved semen from these selected bulls for Al has brought rapid improvement in dairy industry in the world. The tremendous progress in semen collection, dilution, and cryopreservation techniques now enables a single bull to be used simultaneously in several countries for up to 100,000 inseminations one year. The first successful insemination performed by Spallanzani (1784) in a dog and later pioneering efforts to establish AI as a practical procedure for animal breeding begun in Russia in 1899 by Ivanow. The milestone Danish invention of the straw for packaging of semen came in 1940 by Dr. Sørensen when he saw children at a birthday party of his daughter sipping punch with cellophane straws, and he recognized that he had found the straw that he needed. Since then tremendous work has been carried out on preservation of bovine semen and insemination with frozen bovine semen is commonly used nowadays in almost all the countries. Artificial Insemination programme was first started in India at the Palace Dairy Farm, Mysore in the year 1939. In 1942, a centre to study problems associated with AI was started at IVRI, Izatnagar and later on 4 regional stations were started at Bangalore, Kolkata, Patna and at Montogomery (now in Pakistan). AI on buffalo gained importance in later years and the first buffalo calf was born through AI in 1943 at the Allahabad Agricultural Institute, Allahabad.

Later on, through various cattle development projects and establishment of germplasm production centres, now India's AI industry in cattle and buffaloes has taken a gigantic shape. As per Department of Animal Husbandry and Dairying information, at present India is having nearly 49 recognized germplasm production stations, 71341 AI centres and 752 mobile veterinary clinics (that also provide AI services). According to current NDDB report, a total of 73 million AIs have been carried out to breed the cattle and buffaloes of the country. Presently, 35% of the total breedable cattle population is covered under AI programme. The overall conception rate to Artificial Insemination is hardly approaching 40%.

The indigenous breed improvement programme (IBP) and the field progeny testing programme of crossbred (FPT) taken up by ICAR-Central Institute for Research on Cattle, Meerut under AICRP on Cattle exploited the benefits of AI programme by utilizing semen of young bulls born through nominated mating for the genetic improvement of Indigenous cattle population in different agro-climatic conditions. In the year 2019, under IBP, 6715 artificial inseminations were carried out in Sahiwal, 28922 in Gir and 18547 in Kankrej cattle with the conception rates of 38.64, 47.98 and 47.45 per cent, respectively. In the Field Progeny Testing programme, a total of 6225, 5569, 5837 and 4303 inseminations were carried out in GADVASU, Punjab, KVASU, Kerala, BAIF, Maharashtra and GBPUAT, Uttarakhand yielding conception rates of 48.5, 43.9, 45.0 and 59.8%, respectively. The limited conception rate indicates that there is ample scope

of improvement and still many areas *viz.* the significant differences in physiological behavior of spermatozoa among males during cryopreservation, lack of sufficient knowledge regarding nature and magnitude of cryo-injuries during cooling the semen to sub-zero temperature, etc., need more intensified R&D efforts for improving and optimizing the semen freezing protocols for achieving further improvement in conception rate with frozen.

4.5. Multiple Ovulation and Embryo Transfer (MOET)

The MOET technology has emerged as an important tool to bring genetic improvement in livestock at faster rate. In this technique, genetic contributions of both the male and female are utilized simultaneously. The first embryo transfer calf in India was born in 1987 at National Institute of Immunology, New Delhi. Problems associated with embryo transfer in indigenous cows involve those associated with embryo transfer in general and those specific to the breed for example the problems of cervical hypertrophy and fibrosis in Rathi cows limiting the passage of catheter for embryo recovery or transfer. During 2017 as per DAHD official data 277 and as per JK Tryst data ~4000 embryos were transferred.

ICAR-CIRC, Meerut, in a pilot study on MOET in cattle, initiated the embryo transfer technology at Military dairy farm, Meerut for conservation and multiplication of Sahiwal cattle. Four Sahiwal cows were super-ovulated and used as donors. All the animals responded well and yielded an average of 6.25 c*orpus luteum* (CL) per animal and 2.25 anovulatory follicles. Three animals yielded 10 embryos and nine embryos were transferred to 8 recipients of which one calf were reported to be produced.

ICAR-NDRI Karnal, and some state government institutions such as Uttarakhand Livestock Development Board (ULDB) are working on augmenting production of indigenous livestock. Animal Breeding Farm of Kalsi under ULDB provides pure Red Sindhi, and crossbreed Jersy x Red Sindhi males for genetic improvement of hill cattle of the region. The farm produces Red Sindhi calves through embryo transfer. Red Sindhi cows at this farm have milk production of more than 4200 kg per lactation. Around 141 pure Red Sindhi ETT calves are reported from the centre. Red Sindhi cows developed at this farm have milk production of more than 4200 kg per lactation (https://rkvy.nic.in/Uploads/Success Story/ UTTARAKHAND/2017).

4.6. Ovum Pick-up and *in-vitro* Fertilization (OPU-IVF) Technology

A technique for *in-vitro* embryo production (IVEP) has been made available as a tool for utilization of the indigenous cow oocyte / gamete pool for enhancing the maternal contribution to genetic improvement. Ovum Pick-Up (OPU) is the only

OPU-IVF Sahiwal calf 'Holi' produced at the ICAR-NDRI, Karnal

means for collecting oocytes from live animals of known pedigree; further this technique also enables repeated collection of oocytes from live animals on a weekly or biweekly basis over a long period of time. When using in-vitro procedures, average rate of blastocyst formation is around 30-40% and calf production is 10-15%. The indigenous cattle of high genetic merit available in GAUSHALA which are clinically sub-fertile or aged or those which do not respond to conventional ETT procedures, this is the only technology which may help in obtaining high value oocytes for using in IVF and embryo production. The embryos generated through OPU-IVF are to be transferred to surrogate mother and elite calf can be produced. At NDRI, Karnal out of the 73 oocytes collected by OPU from Indian cattle breeds subjected to IVM and IVF, 24 reached to 2-4 cell stage at day 2 post-fertilization, with a cleavage rate of 33%. The study demonstrated the use of OPU as a means of obtaining developmentally competent oocytes from an Indian breed of cattle (Manik et al. 2003). The OPU-IVF technology was successfully established and demonstrated by the birth to India's first female Sahiwal calf named 'Holi' from an aged animal in 2007 at ICAR-NDRI, Karnal.

The OPU derived Sahiwal oocytes were matured *in-vitro* to yield blastocysts in a study at G.B. Pant University of Agriculture & Technology, Pantnagar in 2005. A recent report of JK Bovagenix (JK Trust), an NGO working in the field of animal husbandry, established 94 IVF pregnancies from a Gir Donor cow 'GAURI' in a span of 16 months (https://timesofindia.indiatimes.com/india/moo-over-nature-gauri-donor-mothers-better-cows/articleshow/72990160.cms). A collaborative research program of NDDB with Central Cattle Breeding & Research Farm has reported birth of Sahiwal calf from transfer of Sahiwal embryo to crossbred Jersy(https://www.indiatoday.in/education-today/gk-current-affairs/story/india-calf-jammu-and-kashmir-embryo-transplanted).

4.7. Semen Sexing

A total of 12 semen stations in different states *viz.* Gujarat, Haryana, Kerala, Karnataka, Madhya Pradesh, Maharashtra Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand, Punjab and Himachal Pradesh have been established. The use of sex-sorted semen will not only enhance milk production but also crucial in limiting population of male cattle/ stray cattle. At parallel, ABS Technology (website genusabsindia.com) claims to make available sexed semen of Sahiwal, Gir and Red Sindhi bulls in India. The sperm cell sorters have employed at Bengal, Kerala, Maharashtra and Uttarakhand, which are producing sexed semen for use of AI. Also, the use of sexed semen of exotic breeds is becoming popular in some Indian states like Punjab, Haryana, Kerala and West Bengal. However, the high cost and poor pregnancy rates are the limiting factors that have prevented the wider use of sexed semen.

5. Cattle Breeding Initiatives by Govt. of India

5.1. Pre-independence scenario

During this period many committees having experts from agriculture and animal science were constituted by the Government of India for suggesting means and ways for bringing

improvement in livestock sector. Imperial Institute of Animal Husbandry and Dairying was established at Bangalore in 1923, which was subsequently shifted to Karnal and renamed as National Dairy Research Institute (NDRI). Royal Commission on Agriculture (RCA) in 1926, suggested that the type of cow most suitable for the farmers in the villages would be the one which would produce a strong calf (future bullock) and yield around 1000 to 1500 pounds (450 to 680 kg) of milk per lactation for each household. For cities, the aim was to produce a high yielding cow with a production level of 8000 pounds (3600 kg) of milk per annum but not the dual-purpose animal. RCA anticipated that commercial dairy farms were likely to resort to crossbreeding in future, and therefore, advised that government agricultural department should not take up experiments on crossbreeding and should aim to improve the milking qualities of indigenous breeds like Sahiwal, Red Sindhi and other breeds. Later, the two animal husbandry experts Norman Wright (1937) and Oliver (1938), who were invited by the Government, also opposed adoption of crossbreeding and strongly recommended improvement of indigenous stock by means of selective breeding, better feeding and improved management.

In 1944, the Government invited another expert, Mr. Pepperall to advice dairy development in India. He recommended improvement of indigenous cattle breeds and indigenous buffalo to accelerate milk production. He emphasized that production of indigenous breeds of cattle should be improved rather than attempting large scale crossbreeding with imported bulls. The Indian Council of Agricultural Research (ICAR) on recommendations of *Go-seva Sangh* of 1949 laid down systematic steps for improvement of cattle in the country.

5.2. Post-Independence scenario

5.2.1. Key village scheme

Planned development of livestock sub-sector in the country started with the launch of the first five-year Plan in 1951(1951-1956). A program called Key Village Scheme (KVS) was launched in 1952 with the basic objective of multiplication of superior germplasm from the established farms in selected areas in the breeding tracts of the breeds. The scheme emphasized on controlled breeding, better management, improved feeding, disease control and adoption of improved animal husbandry practices. Initially, the scheme covered 146 Key Village Blocks with more than 10,000 breedable cows and buffaloes during 1st Five Year Plan and subsequently expanded to 197 blocks and 64 urban AI centers in the second five year plan. Natural service was practiced initially, but later Artificial Insemination (AI) was introduced at most of the centers. *Gosadans* and *Gaushalas* were encouraged during this period.

5.2.2. Intensive Cattle Development Projects (ICDP)

Since KVS could not make significant impact on the milk production, ICDP was conceived during second five year plan (1956-1961) with the main objective to increase the production of milk to feed public sector dairy plants in the urban areas. Consequently they placed great emphasis on cross-breeding of indigenous cows with exotic dairy breeds and tended to be concentrated in milk shed areas of large cities and towns. The project was expected to cover

1,00,000 breedable cows and buffaloes to achieve a breeding coverage of about 70% of the bovine population and an increase by about 30% in milk production over a period of five years. There were 31 ICDP's at the beginning of the fourth five-year Plan (1969-74), which increased to 126 by the end of 1991-92. The ICDPs failed to make any significant impact, however, two targets were fully achieved *viz*. stationing of bulls and posting of staff, but both remained underutilized. Initially, an experimental breeding program was recommended for crossbreeding of local animals in the high altitude and heavy rainfall areas with Jersey bulls imported from Australia and USA. Momentum to crossbreeding was also provided through various other programs like cattle development scheme for hill and heavy rainfall areas in 1955, Indo-Swiss project at Mattupatty, Kerala in 1963 and Indo-German projects at Palampur and Mandi in Himachal Pradesh. The hill cattle development cross-breeding project was sponsored by ICAR to find out the optimum proportion of exotic inheritance in crossbreds. Other cross-breeding projects consisted of Indo-Danish Project (1967) at Hessarghatta, PL-480 Project at Haringhatta (West Bengal), Indo-Swiss Project (1971) at Patiala, using Brown Swiss and Sahiwal/Hariana, AICRP at five Institutions, NDRI Karnal, and Frieswal Project (HF x Sahiwal) at Project Directorate on Cattle (Now Central Institute for Research on Cattle), Meerut in collaboration with Military Farms. A pioneering work on large scale crossbreeding in different parts of the country was also in vogue by Bhartiya Agro-Industries Foundation (BAIF). Many of these projects used elite indigenous breeds.

5.2.3. Operation Flood

During 1970, a very ambitious program named Operation Flood based on Amul model of dairy development, was undertaken by the National Dairy Development Board (NDDB) with funding from the World Food Program (WFP). Operation Flood I (1970-81), Operation Flood II (1981-85) and Operation Flood III (1985-94) made the small-holder milk producers the kingpin of India's dairying through milk producer's cooperative societies. The AI network of the state/central Government were linked to the cooperatives and bull mother farms were established for production of exotic and crossbred bulls.

5.2.4. National Livestock Mission

Commenced in 2014-15, this centrally sponsored scheme under the Department of Animal Husbandry Dairying and Fisheries (Ministry of Agriculture) has four sub-missions, out of which 3 are related to cattle. The mission is designed to cover all the activities required to ensure quantitative and qualitative improvement in livestock production systems and capacity building of all stakeholders. This Mission is formulated with the objective of sustainable development of livestock sector, focusing on improving availability of quality feed and fodder. NLM is implemented in all States including Sikkim.

5.2.5. National Programme for Bovine Breeding & Dairy Development (NPBBDD)

The programme is being implemented since the 12th five-year plan of the country with aims to improve the bovine breeding and dairy services of the country. It is managed by the Department

of Animal Husbandry Dairying and Fisheries. The programme provides funds to farmers through State Livestock Development Board, State Animal Husbandry Departments, State Milk Federations and other supporting NGOs and universities/colleges. This is a restructured Scheme launched by merging four existing schemes i.e., Intensive Dairy Development Programme (IDDP), Strengthening Infrastructure for Quality & Clean Milk Production (SIQ&CMP), Assistant to Cooperatives and National Project for Cattle & Buffalo Breeding with the budget provision of Rs.1800 crores. The Scheme has two component namely (i) The National Programme for bovine breeding (NPBB) and (ii) The National Programme for Dairy Development (NPDD). National Programme for Bovine Breeding was initiated during 12th Plan period (2013 to 2017) with participation of 27 states.

5.2.6. National Dairy Plan Phase I (NDP I)

This is also a centrally sponsored scheme (2011-12 to 2018-19), which aims to provide technical and implementation support to the states through credit-based system through DAHD&F. The NDP 1 is a scientifically planned multi-state initiative with the objectives to help increasing the productivity of milch animals and help to provide rural milk producers with greater access to the organized milk processing sector. NDP 1 focuses on 14 major milk producing states namely Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal which together account 90% of country's milk production.

5.2.7. Rashtriya Gokul Mission

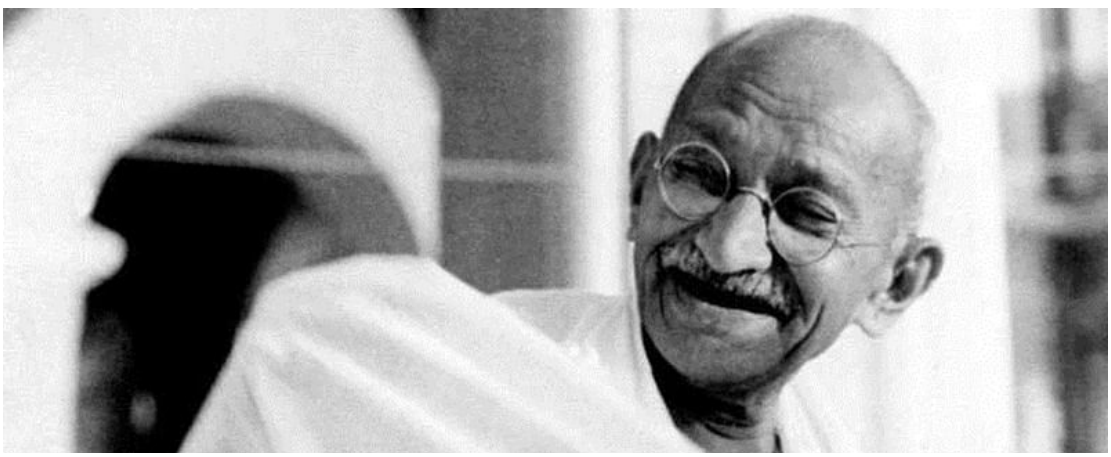
Rashtriya Gokul Mission (RGM) with two components namely; National Programme for Bovine Breeding (NPBB) and National Mission on Bovine Productivity (NMBP) which are being implemented through "State Implementing Agencies" (SIA) *viz.* Livestock Development Boards/ State Goseva Aayogs. All agencies having a role in indigenous cattle development such as Central Frozen Semen Production & Training Institute (CFSPTI), Central Cattle Breeding Farms (CCBFs), ICAR, universities, Colleges, NGO"s, Cooperative Societies, NGOs and *Gaushalas* are also involved. The main objectives of RGM are: 1) to undertake breed improvement programme for indigenous breeds so as to improve the genetic makeup and increase the stock, 2) to enhance milk production and productivity of indigenous bovines, 3) to upgrade nondescript breeds using elite indigenous breeds like Gir, Sahiwal, Rathi, Deoni, Tharparkar, Red Sindhi and 4) to distribute disease free high genetic merit bulls of indigenous breeds for natural service. There is plan to establish National Kamdhenu Breeding Centre in two states.

6. Conclusion

In India, the dynamics of cattle production is evolving at a greater pace to meet the consumers' demands especially the livestock products. Contrarily, the pattern of cattle production in developed countries is directed to build potential production systems that include populations that are efficient in feed conversion and adaptability to new environments, lower demand

Elite Sahiwal and Tharparkar cows

levels for livestock products is the one such reason for this scenario. The genetic improvement programs under AICRP and government run schemes since first five-year plan onwards have brought significant achievement in augmenting milk production in the country. The genetic improvement in indigenous breeds and development of crossbreds using exotic breeds has been the major tools for the increase in production in productivity of cattle populations. The great deal of biodiversity of cattle germplasm is basic and essential resource for sustained growth in dairy sector. ICAR is determined to characterize the remaining 73% of cattle germplasm. Artificial insemination and ETT coupled with genetic selection had improved the productivity of our germplasm. The new emerging technologies like OPU-IVF and cloning will have great impact for enhancement of the indigenous elite cattle population. The high density SNP chip based genomic selection may prove vital tool for achieving the goal of self-sufficiency in the country. Both globally and in Indian scenario, contribution of livestock sector towards economy is significant and provides better opportunities for the livelihood of farmers, rural and vulnerable sections.



Chapter 4

Improvement in Goat Production for Sustainable Rural Livelihood

BN Tripathi, Ashok Kumar, AK Dixit, B Rai and VK Saxena

"The greatness of a nation and its moral progress can be judged by the way in which its animals are treated."
MK Gandhi

1. Introduction

India is blessed with rich animal resources; it is a source of sustainable livelihood and support during the subsistence crisis of farmers. As per National Account Statistics 2019, the value of output from livestock sector was Rs10.44 lakh crores at current prices during 2017-18, which was 33.25% of the value of output from agricultural and allied sector. Livestock, particularly in India is closely interwoven with crop farming. It works as safety valve against income shocks during the subsistence oriented crop farming and natural calamities. Sector generates employment to 164.4 lakh workers as per usual status in the animal husbandry activities. India continues to be the largest producer of milk in the world since 1998.

As per 20th livestock census 2019, goat population in the country has increased from 135.17 to 148.88 million between 2012 and 2019. India ranks first in the world for goat milk production, and second in goat meat and skin production. The growth rate in goat population was about 1.08 % during 2012 to 2019 in spite of higher slaughter rate and annual mortality with an increase in output of goat meat, milk and hide. Annually, goat and its products contribute Rs.38,590 crores to the national economy, which accounts for about 9% to the total value of output (at current prices) from livestock sector in 2010-11. More than 75% goats are reared by the marginal and landless households having less than 2.0 ha of land. It is the main source of income to farmers particularly of the arid and semi-arid regions in the country, where crop failure is the recurring phenomenon. Sheep and goats are basically reared to meet the demand for meat, wool, hides, milk, etc. Globally the demand for livestock products, particularly for chevon and mutton is on rise, due to the increase in per capita income in the developing countries.

Small ruminant sector despite its considerable contribution to livestock economy and potential to enhance household's income of millions of marginal and small farmers, remained underinvested and could not receive financial and institutional support. Its untapped potential and probable economic gains due to technological and marketing intervention will pave ways to country's sustainable goat production and also realize Gandhiji's dream of self-reliant rural India.

2. Sustainable Goat Production: Gandhiji's Vision

Mahatma Gandhi and his vision to create self-sustain and prosperous rural India is still relevant in the twenty first century. Creation of sustainable agriculture, judicious use of local resources strengthen rural economy and overall prosperity of farmers' life are the key attributes of his vision. The Gandhi's economic models are also focused on well-beings of human beings. Mahatma's perception *"The soul of India lives in its villages"* holds very true in the present context since 70% population resides in more than seven and half lakhs of villages. Self-sufficiency of rural India means fulfilling the basic needs- food, clothing and other necessities, and sustainable rural development, wherein goats play a key role. Therefore, among livestock, goat is considered one of the most inclusive species.

India has rich genetic resources with 34 goat breeds distributed in different ecologies and each one of them performing well in their habitats under optimum feeding, bearing natural resistance for diseases and climatic fluctuations. Goats, being primarily owned and reared by the marginal and small farmers are important among resource poor people for their sustainable livelihood and nutritional requirement. Demand for goat meat/mutton has increased with the increase in per capita income and other associated factors. The gap between demand and supply of goat meat/mutton will widen in future as meat demand may grow at faster rate than that of production. Goat milk, which is also known as natural functional food contributes 4% to central milk pool. Majority of goats in the country are reared under extensive production system and highly depend on common resources. Permanent pasture and grazing lands, the most important commons, are gradually shrinking. The improvement in share of goat ownership with marginal category by 2% between 2001 and 2007 has been recorded. Moreover, flock size per goat rearing households has shown increasing trends among all the categories of land holdings. Unit level data from 59th and 70th rounds of National Sample Survey Office (NSSO) (Land and livestock holdings) indicate that overall flock size has marginally increased between 2002 and 2013 and the goat rearing households have increased by 17% during the same period.

Goat, popularly known as poor man's cow, has now becoming a symbol of prosperity in the rural India. Goat has been found to be best alternative for supplementary income and milk for the rural people who are unable to rear cattle or buffaloes. Demographic change in livestock population in the country showed a shift in favour of small ruminant particularly for goat (Dixit et al. 2012). Goat possesses tremendous potential for adapting to different agro-climatic conditions and on wide range of feedings.

2.1. Goat Population Dynamics

There is significant growth in population of goat in India during the last three decades. As per 20th livestock census 2019, goat population in India has increased from 95 to 148.88 million between 1982 and 2019. The highest increase of 16% in goat population was recorded during 1982 to 1987. About 13% increase has been recorded between 2007 and 2013. Similar trends have been noticed between 2012 and 2019, wherein about 10% increment in the goat population was observed. Growth in goat population is demand-driven. In urban areas, demand

for livestock products rises faster than the other food groups when income starts to increase (Gandhi and Zhou 2010).

2.2. Goat Management Systems in India

- *Extensive System:* This system includes free range, transhumance, pasture and range grazing management. The system is based on low resource input and low level of productivity. More than 80% population of goat is reared under extensive system.
- *Semi-Intensive System:* This system is combination of limited free-range grazing and stall-feeding. The optimum level of nutrition, which is better than that under extensive system are observed. The rearing system helps in substantial improvement in body weight gains, milk yield, wool yield and prolificacy. Overall, improvement in quantity and quality of meat production can be achieved by supplementing with concentrate mixtures along with cultivated leguminous fodders and tree leaves.
- *Intensive system:* This system includes grazing on developed pastures and/or complete stall-feeding on cultivated fresh or conserved fodders, crop residues and concentrates. Goats are quite capable of making efficient use of feed and fodder in stall feeding system as well for conversion into meat, milk and fibre.

2.3. Goat Genetic Resources in India

India possesses 34 registered breeds of goats however, population of these breeds comprises <35% of the total goat population of the country. There is intermixing to a larger extent among the breeds in a region where two or more breeds exist. These goat breeds have evolved and developed by the goat farmers for different agro-climatic regions to meet out local demands of the particular region of the country. The goat breeds on the basis of agro-climatic regions are described as follows:

May 1946: Gandhi volunteers tending goats. (Photo by Margaret Bourke-White/The LIFE Picture Collection via Getty Images)

1. Northern Temperate Region: Chegu, Changthangi, and Gaddi. These breeds are medium in size, fiber-producing and also used for transportation of goods. The breeds Chegu and Changthangi produce finest quality of under coat called 'Cashmere' or 'Pashmina' beside meat.
2. North-Western Region: The popular breeds of this region are: Beetal, Jamunapari, Barbari, Sirohi, Marwari, Jakhrana, Surti, Gohilwadi, Kutchi, Zalawadi, Mehsana. Goats of this region are medium to large in size, dual purpose with special attribute of high milk yield. Several lesser known genetic groups/strains/breeds are also found in this region such as Bundelkhandi, Battisi, Totapari, etc.

3. Southern Region: Goats of the Southern and Peninsular part of the country, have dual utility but with low in milk yield as compared to goats of north-western region. Sangamneri, Osmanabadi, Kanna-aidu, Malabari, KonkanKanyal, Berari and Black Attapady are the main breeds of goat of this region.
4. Eastern Region: Black Bengal is main breed of eastern region of India. It is a dwarf size meat goat breed and is widely recognized for prolificacy, skin, and carcass qualities however, has low milk yield. Ganjam is another local breed of this region particularly belonging to coastal areas of Odisha.

Indian breeds of goat according to their major functions are classified as (1) High milk producing breeds: Beetal, Jamunapari, Jakharana and Surti; (2) Dual purpose-a (meat and milk): Sirohi, Kutchi, Malabari, Marwari, Mehsana, Zalawadi, Gohilwadi, Sangamneri, Barbari, Dual Purpose-b (meat and fibre): Changthangi, Chegu and Gaddi; and (3) Meat producing breeds: Black Bengal, Osmanabadi, Kannai-adu, KonkanKanyal, Berari Black, Attapady and Ganjam.

Chandar Bali and his uncle, a practicing doctor in London, arranged goat milk for Gandhiji in London from November to January 1931
Source: https://indusscrolls.com/the-expensive-poverty-of-mk-gandhi/

A continuous growth in milk production has been registered in the country. Goat milk production increased by 14% between 2012-13 and 2017-18. Similarly, goat meat production in the country has also shown increasing trends. Goat meat production increased from 0.94 to 1.08 million tons between 2012-13 and 2018-19. There are virtually no religious or cultural taboos associated with the goat meat consumption. Moreover, the country is largest exporter of sheep and goat meat. The country exported 14,128.85 tonnes of sheep & goat meat worth Rs. 646.69 Crores during the year 2019-20. The country's export of sheep and goat meat has shown declining trends during last three years (2017-20). The export declined by about 8 thousand tonnes between the same periods. Similar trends were observed in value term. The major export destinations during 2019-20 were United Arab Emirates (UAE), Qatar, Kuwait, Saudi Arab, Oman, Maldives and Baharain. The UAE alone receives 70% of total export followed by Qatar, Kuwait and Saudi Arabia.

3. ICAR's Initiatives for Augmenting Goat Production

3.1. Genetic improvement under AICRP on Goat

The All India Coordinated Research Project (AICRP) on Goat Improvement is a major long-term programme focused to bring upon genetic improvement to conserve goat genetic resources in their native tract. The AICRP on Goat aims to enhance genetic improvement utilizing the genetic

variations in native breeds, which are evaluated through structured and systematic pedigree and performance recording of goats in the farmers flock as well in the organized farms. The major mandate of the project is to build up long-term capacity of goat keepers through technology demonstration, capacity building, application of health management practices and introduction of genetically superior goats germplasm for enhancing the production and reproduction potential on sustainable basis. Presently, a total of fifteen breeds and three local genotypes are covered through 21 centres across the country, coordinated by the Central Institute for Research on Goats (CIRG). The project has significantly contributed in increasing goat population, body growth and milk production of goat populations. Preventive health care measures with farmer's support have reduced morbidity and mortality in field flock. The project has brought significant increase in the income of goat farmers besides enhancing the food security in the country.

This project developed a model to implement genetic improvement programme in goat in different agro-climatic zones. Subsequently the project design is being used to develop national breeding plan for goats all over the country. A total of 461 villages with 2277 farmers were covered under AICRP on goat improvement and the performance recording was carried out on 62784 animals during 2014-20. For genetic evaluations, pedigrees of adequate number of goats of 15 breeds (ranging between 1000-6000) were identified by each collaborating unit and their performance recorded under field conditions. Production performance data from farmers flock are being recorded on 15 breeds distributed over 4-5 village clusters to ascertain genetic variability amongst them. The farm based units namely Jamunapari, Barbari and Sirohi are working as best models for *in- situ* conservation in the natural home tract of the breed. Institute based farm units are supplying 354-665 superior male germplasm per years in the field for breed improvement. Farm units have produced and distributed improved animals to different agencies for improvement of breed as also for up-gradation of local germplasm. A total of 6030 elite germplasm of Barbari, Jamunapari, Sirohi and Jakharana goat breeds were distributed during last 10 years to the farmers of the 15 States (UP, MP, Chhattisgarh, Haryana, Punjab, Rajasthan, Bihar , Jharkhand, Gujarat, Maharashtra, Odisha, Hyderabad, Kerala, Tamil Nadu, Uttrakhand) directly or through governmental departments for upgradation/multiplication/ conservation of local animals and for productivity enhancement (through meat and milk production) along with literatures on scientific rearing practices. This has impact in terms of direct income to the farmers and about 30-40 % income has been increased. Use of selected bucks showed improvement in production and lactation traits (2-3%). but also increased true to breed type goats in adopted villages. Significant improvement (5-20%) in average body weight gain and milk production (15-30%) in farmer's flocks have been recorded. The AICRP project facilitated *in situ and ex-situ* conservation of Barbari, Jamunapari, Sangamneri and Surti threatened goat breeds of the country. BLUP estimates of breeding values observed for most goats facilitating genetic selection. Grading up of local breeds through use of superior germplasm (>4500 elite animals introduced by farm unit to the field). Goat keepers from AICRP adopted villages won the Breed Saviour Awards sponsored by the National Biodiversity Authority for Osmanabadi

and Malabari Goats. The technological interventions significantly improved survival rates with significant reduction in morbidity and restricting mortality below 10%.

The AICRP units have created Awareness among goat keepers about how to increase their incomes from goat rearing by improving management at low cost, knowing weights of sale kids and using this knowledge to bargain with traders purchasing kids. The Socio-economic studies revealed that in the Ganjam district of Odisha, the goat is a primary source of income of tribes (Gola). The goat rearing contributed 61.5% of their annual income.

3.2. ICAR Technologies for Profitable Goat-based Enterprise

Goat husbandry in India is recognized as an instrument for social and economic transformation of rural India and has developed into a vibrant sustainable eco-friendly enterprise from resource poor occupation. The CIRG has developed a number of pro farmer's packages of practices and commercially viable technologies for goat improvement in the country. The institute has provided a platform for the enterprisers in different areas by developing commercial valued technologies such as- Diagnostic kits (Brucellosis, Johne's disease, Parasitic diseases); herbal products suiting to the organic farming (antistress formulation, anthelminitic bolus, immunomodulatory bolus, acaricidal liquid/spray); goat production technologies (artificial insemination techniques, area specific mineral mixture, economical feed formulation, intra vaginal pessaries for oestrus synchronization in goats, Pelleted complete feed, specialized goat feeder and waterer); and goat value added products (Goat meat Pickle, Goat meat Nuggets, Herbal Goat meat Nuggets, Goat meat Sausage, Goat meat Patties, Meat Shami Kebab, Meat Murukku, Meat Nimkee, Meat/Milk Biscuits).

3.3. Constitution of Goat Milk and Meat

Goat milk has better digestibility, better nutrition as it contains more whey proteins. It has better amino acid profile (essential amino acids: higher in threonine, isoleucine, lysine, cysteine, tyrosine, valine). Goat milk is rich in fats: high in C4, C6, C8, C10, C12, C14 (MCT) and 62% higher CLA than cow milk. Smaller fat globule size of goat milk results in higher absorption. Moreover, it is useful in mal-absorption syndromes, hyperlipoproteinemia, intestinal resection, infant malnutrition, premature infant feeding because of their ability to provide instant energy. It has about 4-5 times higher oligosaccharide content than cow's milk and has prebiotic and anti-infective properties. It has higher Ca, P, Mg, Fe and Cu than cow's milk; bioavailability is better and adequate, vitamin A, niacin, pantothenic acid, riboflavin indicate its better nutritive value.

Goat meat has higher thiamine (Vitamin B1) and riboflavin (Vitamin B2) as compared to meats from other food animals. Goat meat cuts have fat content 50-65% lower than similarly prepared beef, between 42-59% less fat than lamb (sheep meat) and about 25% fat lower than veal. The percentage of saturated fat in goat meat is 40% less than chicken (without skin) and is far below than beef, pork and lamb i.e., by 850, 1100, and 900%, respectively. The protein contents of mutton and beef are almost similar. Goat fat has ample amount of medium chain triglycerides

(MCT), which can be directly absorbed via intestine to serve as an energy source and do not require emulsification and digestion thus could be helpful in case of jaundice. Goat meat has healthful fatty acid profile; containing 60-80% desired fatty acids (DFA), which is ideal for health conscious consumers.

3.4. Capacity Building Programme

ICAR-Central Institute for Research on Goats (CIRG) organises 6 national training programmes annually (once in a two months) for 8 days duration on commercial/scientific goat farming for goat farmers and other stakeholders to enables them to add their knowledge and skills. These programmes are designed with focus on goat breeding, feeding, health, housing, reproduction, value addition, economics and marketing as per the requirements of trainees. The tranings helped in improving the goat rearing skills of trainees and they were able to take initiatives to start goat farming at commercial level. Apart from national programmes, Institute also organizes 8-10 sponsored training programmes annually. About 700 farmers are being trained on different aspects of scientific goat farming under both the training programmes. Some specialised training programmes on artificial insemination (AI) in goat, value addition of goat milk and meat products are also organised for entrepreneurs, government employees and other stakeholders.

4. Interventions for Sustainable Goat Production

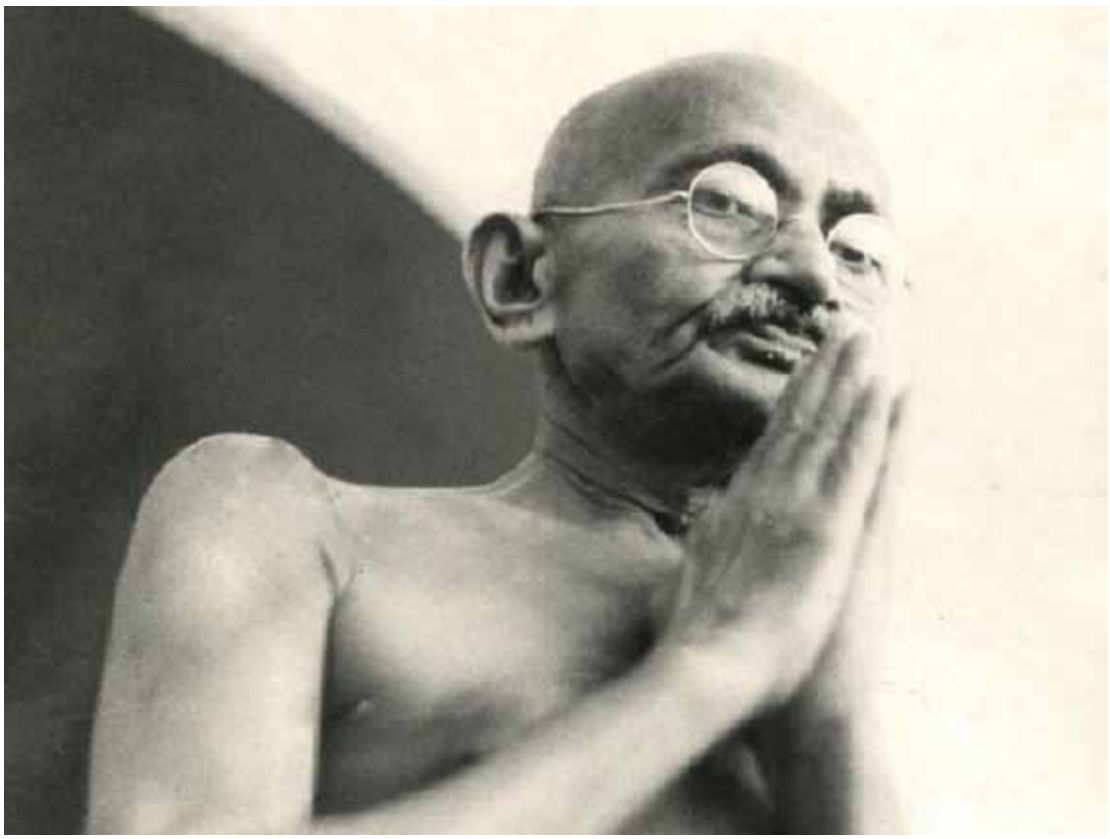
- **Promoting semi-intensive or strategic management system through field demonstrations:** Mostly the goat keepers (>95%) rear their goat on zero input system and earn average profit of Rs. 12500/year from a unit of five adult females. Shifting to goat management to semi- intensive or intensive management may yield the double or more dividends compared to extensive system. Farmers may be charged the cost that is incurred on vaccination, deworming, feed-mineral mixture and service from high potential buck. Profit per goat under extensive management from one adult Barbari goat has been found to be Rs. 3280, whereas with strategic feeding support it could increase to Rs. 6493. The profit increased with strategic inputs support on account of increase in body weight (>40%), milk yield (80%), survivability (50%), multiple birth (50%) and increase in premium value/ breed purity (20%).
- **Development of improved stock by using high quality pure-bred bucks**: The breed adapted to the existing agro-climatic conditions and can thrive well on un-conventional feed and fodder resources should be given priority in goat-based breeding programme. Upgrading of goats through elite purebred bucks needs to be implemented along with prophylactic support. Kids nursery may be established for regular supply of breeding bucks to goat keepers for improvement in genetic potential of goats particularly in rural areas. The progenies born from superior bucks yielded 40-75% more production and fetched 25-40% higher market price.

- **Promotion of prophylactics:** Infectious diseases such as *Peste des petits ruminants* (PPR), enterotoxaemia, goatpox and foot and mouth disease (FMD) are responsible for high economic losses (30-60% goat mortality) in goat farming. In a case study it was reported that vaccination and deworming of goats have reduced the mortality (<10%) thus increased the survival of goat and net income of Rs. 3500-4500/year with a unit of five goats with the expenditure requirement of only Rs. 300/year on five units of goats.
- **Development of feeding resources at village level:** Fodder supplies in villages can be improved substantially by increasing the productivity of traditional feed and fodder crops. Inter-cropping may be adopted with twin objective, using seed/roots/tubers for human and leaves and shrubs for goats. Short duration and quick growing leguminous forage crops should be promoted. Farmers are trained for processing and storage of fodder resources available during monsoon for meeting demand during the lean period as well as their nutritive/value addition. The degraded grazing lands and Common Property Resources (CPR) near villages should be converted into productive system like silvi-pasture. Agro-forestry and good grazing practices need to be popularized among farmers.
- **Strengthening support services and extension network:** Credit is one of the important aspects for goat keepers for accessing technological interventions such as improved housing, feed concentrate, quality germplasm, value added products, etc. It will help and encourage goat keepers to switch their goat management system from extensive (zero-input) to semi-intensive management and up-scaling the production.
- **Popularization of package of improved management practices**: The awareness may be created among goat keepers for improved management practices such as breeding calendar (optimum age and weight of breeding at first time, season/months of breeding) to obtain maximum, production and profit from goats, health calendar, strategic feeding (colostrum feeding, supplementary concentrate feeding at advance pregnancy, efficient use of feed and fodder as per age, sex, productivity), smart marketing and value addition. The other good practices to be followed are avoiding over-crowding, maintaining hygiene and biosecurity, and adequate exposure to sun light. Goat sheds should have a provision of open as well as covered space. The area of open space is normally double of the covered area. A case study conducted in draught prone Bundelkhand region in 2012-13 revealed that farmers earned an additional income of Rs. 18348/year with a 5 unit of goat by proper adoption of improved management practices.
- **Development of low cost goat houses:** Adequate goat housing due to scarcity of space and high inputs/items cost is major constraints for majority of goat keepers, therefore, there is urgent need to conduct research to build multi-layered and low cost out houses.
- **Value addition of goat products to increase income and nutritional value:** Processing of goat meat, milk and skin for producing value added products can contribute to sustained demand for meat and milk and efficient marketing of these products to earn reasonable returns.. Added value can be obtained in terms of shelf stability, better sensory quality,

improved technological functions as well as more convenience. The consumers today are looking forward for variety, nutrients and convenient ready-to-eat products. These convenient items are economical, cost-effective and provide options than traditional products. Value addition may help farmers to increase their net return.

5. Conclusion

Goat is one of the most inclusively distributed species of livestock, providing nutrition in terms of meat and milk to millions of landless, marginal and small farm families. The growth in goat meat production mainly comes from increasing number of animal slaughter rather than yield. Technologies and resource inputs pertaining to healthcare, nutrition, breeding and marketing will improve the productivity of goats resulting into more availability of milk and meat and making goat farming more remunerative. There is a need for concerted efforts on intensification of transfer of technologies through extension services for improved goat production and management practices, with a convenient access to the resources, technologies and markets.



Chapter 5

Local Self-Reliance in Aquaculture and Fisheries: Gandhian Models

JK Jena, PC Das and A Panigrahi

"India lives in villages. If the village perishes, India will perish too. It will be no more India. Her own mission in the world will get lost."
MK Gandhi

1. Introduction

The views and principles of Gandhiji on Indian villages and agriculture including aquaculture are relevant even in modern-day India. He believed that every Indian should possess a piece of land, where he can grow his own food and be independent and self-sustained, and live with dignity. Every individual in a society has an equal right to basic life needs. Gandhiji's economic model is based on the village. According to him, India's heart lies in villages rather than the big cities. Based on these models, Gandhiji dreamed about 'Grama Swaraj'- a human centered village which is a non-exploiting and decentralized economy. Under this village concept, every individual needs to have equal opportunities that employ each of its citizens through voluntary cooperation. This will lead to achieving self-sufficiency in the necessities of life, such as food, clothing and other basic requirements.

Integrated rural development by incorporating agriculture, industry and other economic activities, merging the principles of decentralized democracy and social justice, was a component of Gandhiji's Self-Reliance Model. According to him, villages are multi-purpose cooperatives. Such rural economic models cover all the productive sectors ranging from agriculture industries (Sushila 1979). Even though the recent economic reforms brought significant growth in the economy, unemployment, poverty and economic disparity are alarmingly high in the society (Mahra et al. 2015). Under these circumstances tapping rural knowledge and potential workforce through local management and implementing a Gandhian self-reliance model is the need of the hour.

Aquaculture and fisheries activities have immense potential to strengthen the rural economy as envisaged in Gandhiji's model of self-reliance. India is blessed with 8,118 km long coastline and 2.02 million sq km of vast Exclusive Economic Zone (EEZ). In the inland sector, the country has huge freshwater resources in the form of 2.42 million ha of ponds and tanks, 0.2 million km rivers and canals, 3.12 million ha reservoirs, and the 0.8 million ha of floodplain lakes and derelict waters. It has 1.1 million ha of brackishwater area beside the 7.0 million ha

of inland saline water resources. The country is one of the most important fish faunal hotspots of the world with more than 3300 recorded fish species.

The capture fisheries from marine and inland open-water systems although remained as a major contributor to the fish basket of the country over several decades, the developments made in aquaculture, both in freshwater and brackishwater sectors, in the last four decades have been phenomenal. The aquaculture is not only contributing significantly to the country's fish production and catering to the burgeoning domestic demand, but also sharing about 19% (Rs. 47,000 crores) of the total agricultural export of the country. The fisheries sector has been integrated with agriculture, industry and other economic allied activities, thus providing an opportunity to adopt a self-reliant village model for the economic and social upliftment of the society. Such a model has been able to provide protection and elevate the position of the fisherman communities, which otherwise is loosely organized and represent marginalized and backward classes of the society (Bavinck and Vivekanandan 2017).

Aquaculture is considered as an economic activity, which could aid in poverty eradication and livelihood improvement among the rural population (Kumaran et al. 2020). Considering the availability of widely distributed water resources, both natural and also man-made, aquaculture has been playing a major role in fulfilling Gandhi's dreams. The implementation of various social welfare programmes by the central and state governments over the years aiming for a 'Blue Revolution' has succeeded to bring remarkable changes in this direction. The Indian Council of Agricultural Research (ICAR) has initiated several programmes to develop the village economy, employ the rural youth and provide a dignified living with self-sustenance through Attracting and Retaining Youth in Agriculture (ARYA) and Tribal Sub-Plan (TSP) to safeguard the food security of rural India.

In Gandhiji's opinion, any development scheme should be centered on the man and the man has the responsibility to make judicious use of natural resources and to maintain the ecological balance. While 'Sarvodaya', the welfare of all, was the basis of his thinking, his view on community-centered approach towards sustainability and agricultural development emphasized on 'betterment of human life' by avoiding all sorts of exploitations and establishment of human dignity. He believed in the development but opposed the ruthless drive for economic growth, severe competition, unbridled consumerism and concentration of wealth and power.

2. ICAR's Activities in Realizing Gandhian Principles

The Indian Council of Agricultural Research is the apex research organization of the country spearheading the research, education and extension fronts to enhance the productivity and diversify the Indian agriculture and allied sectors. During the last 90 years of the journey, ICAR as an agrarian organization has heavily relied on the Gandhian principle of rural development and has recognized the farmers as the centre of development. The whole world, and India in particular, have been experiencing several transformative changes with regard to population

growth, changes in lifestyles, urbanization and accelerated climate change, which are creating new challenges. Unlike the focus in past to supply basic needs such as adequate food, the challenges have now shifted to provide adequate nutrients to promote health. However, the ICAR research institutes have stood strong to overcome these challenges and greatly supported to tackle them with new technologies and innovations. The breakthrough made in different R&D activities and large-scale adoption of these technologies could not only feed the burgeoning population of the country but also excelled in the production of many food crops, cash crops, livestock, fisheries and other agriculture produce to a surplus level.

At the beginning of the 20th Century, India was heavily relying on the marine catch to cater to the fish demand. Over the years, the country has not only been able to tap a significant share of the marine potential yield of 5.31 million tonnes, the fish production in the inland sector has also significantly increased. The total fish production has achieved an almost 18-folds increase in the last 70 years, from 0.75 million tonnes in 1950 to 13.76 million tonnes at present. The country has become the second-largest aquaculture producer of the globe and also occupies 3rd position in the total fish production. In the last four decades, aquaculture in India has made a paradigm shift from the homestead activity of 1970's to the technology-driven commercial enterprise today and has been the forefront of developmental avenues in the country. The sector is poised to shoulder the responsibility of catering to the increased protein hunger of the future. Hunt for increasing fish production has led to a marked increase in aquaculture activities in all the three sectors, i.e., freshwater, brackishwater and marine, although the last one is a late entrant. Ponds and tanks, which form the basis of aquaculture development, are the rural resources and as such contribute to improving the rural economy, a concept supporting the Gandhian principle. Aquaculture itself embodies a wide range of activities in the entire value chain, starting from seed production through farming to the marketing of the products and their post-harvest value addition. In every point, it involves sub-sectors which provide scope for farmers and entrepreneurial development. The ICAR, with its series of timely technological interventions and with due support of the State line departments has significantly contributed to all such development. Discussed in the following pages, some of the epoch-making technologies of ICAR related to fisheries and aquaculture that have been developed, time tested and demonstrated to transform the fishery sector over the years taking the fish farmers and entrepreneurs on board.

2.1. Technology Development in Freshwater Aquaculture

2.1.1. Induced breeding and quality seed production

Successful induced breeding of the Indian major carps in 1957 developed by the erstwhile Pond Culture Division of ICAR-Central Inland Fisheries Research Institute (CIFRI), presently ICAR-Central Institute of Freshwater Aquaculture (CIFA), is considered as a revolutionary technology that has transformed the entire aquaculture sector to a vibrant enterprise. It was followed by the development of a sequel of activities and packages of practices over the last five decades. These include the development of different hatchery technologies and models,

beginning from earthen pits to the latest circular eco-hatchery model, ampouleing of pituitary extract, refinement of breeding protocol, use of synthetic inducing agents, better broodstock management techniques, etc. The easy availability of synthetic hormone formulations like Ovaprim, Ovatide, WOVA-FH, etc. in the 1990s has revolutionized seed production and made the country self-sufficient in seed production, and pushed the riverine seed collection to oblivion. Today, the life cycle of more than 30 important freshwater cultivable species have been closed in confinement. With recent trends of species diversification and introduction of new species into the culture system, more specialized hatchery systems have been developed for seed production on a commercial-scale for different species of minor carps & barbs, catfishes (magur, striped catfish, pabda), freshwater prawn, murrels, climbing perch, etc. Standardization of breeding protocols for different ornamental fishes, both indigenous and exotic, has created an important avenue of income for the rural poor as backyard cottage enterprise and contributed to boosting the ornamental trade.

Production of quality seed for the sector has been given importance to harness the productive potential of different species through the adoption of selective breeding and milt cryopreservation technologies. The technologies developed by ICAR-CIFA in achieving higher growth performance of selective-bred rohu '*Jayanti'* by over 50%, catla by 30% and giant freshwater prawn by 30% are testimonies of breakthroughs in ensuring quality seed production. The use of specialized broodstock diets like CIFABROOD™ is bringing early maturity in carps. The technology of multiple breeding has made it possible for the same carp brood fish to breed 2-3 times) through stretching the breeding season using improved broodstock maintenance protocol. The technology could demonstrate 2-3 folds higher spawn recovery over conventional single breeding during a season. Significant efforts of the ICAR-Directorate of Coldwater Fisheries Research (DCFR) have led to developing breeding and seed production technologies for several coldwater fish species including rainbow trout, mahseers and snow trout.

The erstwhile Pond Culture Division of ICAR-CIFRI at Cuttack had been instrumental in developing most of the basic technologies of seed rearing in carp followed during the 1980s. Thereafter, a lot of efforts have gone to improvise the rearing method with the judicious use of resources with the production of quality seeds of important freshwater cultured species. The present-day packages of practices of nursery and rearing with simpler pond maintenance, efficient input use and high seed survival have helped in increasing the survival levels of 50-60% in the nursery and 60-80% in the fingerlings rearing phase, thereby making the seed rearing quite farmers-friendly as well as an economically viable activity. The possibility of achieving 4-6 times higher fry yield per unit area with the use of large-concrete tanks has been demonstrated and following the practice, the farmers have been taking at least three crops in such a system during a season. The concept of the 'cluster approach' of farming is increasingly popularised now-a-days that involves a group of farmers in a locality practicing a similar type of activity (seed rearing). Such a concept has increased technology infiltration and effective adoption of scientific practices in farming, resulting in higher production, and more knowledge and economic empowerment of the farmers. "Cluster seed village' is a typical successful model

working in several places, viz., Naihati in West Bengal for production and supply of fish seed to different parts of the country.

The popularity of fingerlings and larger seed for grow-out stocking has increased among the farmers and is being promoted with special emphasis through many schemes and promotional policies. Protocols are available for the production of stunted fingerlings and yearlings to ensure round the year seed availability which has enabled the farmers to practice fish fattening through short-duration culture rather than long-term farming. Unlike the traditional concept of raising only table fish in ponds irrespective of the pond size, the farmers now-a-days are going for customized use of the ponds depending on the market demand of the different life-stages of carps and other fish species. Such a trend has improved the linkage among the small, marginal and large farmers in the sector.

2.1.2. Grow-out farming

The development of the technology of 'Composite fish culture' is considered as another important breakthrough which virtually has laid the foundation of commercial freshwater fish culture in India. Over the years, ICAR through its research institutes and collaborations with other organizations has implemented several schemes to popularize this technology. The National Demonstration Project (NDP) launched in 1965 was a megaproject undertaken for technology demonstration in farmers' fields at that juncture. The extended version of NDP launched as the Operational Research Project (ORP) in 1974-75 undertook large-scale demonstration of composite fish farming and integrated farming. During 1975-79, the CIFRI-IDRC Project on Rural Aquaculture undertook massive technology transfer programmes in the states of West Bengal and Odisha to demonstrate 4-6 tonnes/ha/year production level in private ponds through composite carp farming technology. The All India Coordinated Research Projects (AICRPs) on 'Spawn Prospecting', 'Composite Fish Culture' (both later merged to one AICRP), 'Air-breathing Fish Culture' and 'Brackishwater Fish Culture' were launched by ICAR-CIFRI in 1970s and operated till 1984. These AICRPs, operated from Haryana through Assam to Tamil Nadu with the demonstration of high yield rates of 8-10 t/ha/yr, actually laid the foundation of the 'Blue Revolution' in the country. By the time the need for HRD in the sector was realized; the Krishi Vigyan Kendras (KVKs) and Trainers' Training Centers (TTCs) were established for capacity building of the farmers. The establishment of the 'Fish Farmers' Development Agencies (FFDAs)' scheme by the Union Government during the 1980s further helped in popularising the aquaculture in the country.

The composite fish culture technique has been refined to make it more productive and farmers-friendly during the transitional phase of aquaculture development. At present, production levels of 3-5 tonnes/ha and 8-10 tonnes/ha/year of carps under modified extensive and semi-intensive polyculture systems, respectively have become common in the farmers' fields. Similarly, production over 20 tonnes/ha/year with exotic pangas catfish *Pangasionodon hypophthalmus* under monoculture with the provision of floating pellet feed has become very common all over the country. Unlike the traditional single-stocking and single-harvest method, carp production

through single-stock multi-harvest and multi-stock-multi harvest methods are becoming more popular among the fish farmers because of the 10-15% yield improvement, reduced feed utilization, lower investment, lower risk and interim flow of income. Popular minor carps, barbs, and other high values species such as pabda, magur, murrels and freshwater prawn are increasingly being introduced in major carp-based systems to expand the species spectrum, improve productivity and increase the farmers' income. The concept of carp farming has shifted towards fish fattening with the use of larger seed stocking size to shorten the crop period. Monoculture of some of the high-valued species has created an opportunity for the farmers to increase their profit margin to several folds. The easy surgical procedure developed for the production of both image and round pearls from common freshwater mussels, *Lamellidens marginalis* has attracted the attention of many fish farmers and posed to create an important avenue for the rural economy.

Due to rain-fed nature, most of the homestead ponds in the eastern and north eastern states and the ponds in hilly terrain hold water for a limited period of the year, which limits productivity and restricts their effective utilization. But these seasonal ponds contribute significantly to rural livelihood and nutritional security. Grow-out technologies have been developed for several indigenous minor carps and barbs which adapt well to such shallow ponds and grow better in high density. The smaller market size and higher consumer preference of these species yield farmer better revenue compared to the short-term major carp farming in these ponds. The Institutes are also working to promote fish seed rearing activities in these ponds for earning more revenue during the short period.

The technology of integrated fish farming has been important advocacy of ICAR which is in line with the Gandhian principle of sustainable agriculture development. The ICAR through its Institutes spread across the country has developed several models of such integrated farming after screening compatible and suitable components and examining their production efficiency. Such a farming system helps in better resource use efficiency through energy recycling, reduces risk through crop diversification and maximizes production. Integrated models of farming fish with varieties of compatible components such as livestock (poultry, dairy, piggery) and high-valued horticulture crops have been developed, extensively demonstrated in the farmers' fields and popularized in almost all the states. Low land and deep-water rice ecology form important resources particularly in the north-eastern states for fish production. The rice-fish farming technology developed for such an ecosystem not only ensures higher rice production from the unit area but also yields fish up to 1.0 t/ha along with a sizeable amount of seasonal vegetables for home consumption.

The development of feed technology over the years has complemented the growth of the aquaculture sector in the county. Research Institutes of ICAR have worked for the screening of the various locally-available feed ingredients and the development of balanced feed for the livestock and fish. While the concept of using feed for higher fish growth has been increasingly popularized, sinking and floating pelleted feed with balanced nutrition have been developed for

different fish species/groups that have increased the production efficiency of resources. More and more feed mills are established day by day to support expanding aquaculture in the country. Studies have revealed that a certain portion of crop loss occurs due to disease in the fish pond which often goes unnoticed unless there is a severe outbreak. But in recent years, disease surveillance has been increased in agriculture including fish farming. Prevention and control methods have been standardized for different diseases. Diagnostics and therapeutics developed by different Institutes against important pathogens and diseases have been helping the farmers for timely control of disease and saving their crops, thereby increasing the return.

2.1.3. Cage and Pen Culture

Research efforts of the ICAR institutes for productive utilization of the huge natural waters such as reservoirs and rivers have contributed towards the development of cage and pen culture. Technologies have been developed for seed rearing in cages and pens in open water system viz., reservoirs and wetlands for the promotion of culture-based fisheries. Research on designing and fabrication has led to the development of low-cost cages with the use of diverse indigenous materials to promote cage farming. Cages are also being used for intensive grow-out production of highly-growing catfishes (pangas) and tilapia in open waters. The last decade has witnessed an increase in cage farming activities in our inland waters with the initiation of different promotional schemes by the States Fisheries Departments with support from the National Fisheries Development Board (NFDB). Ongoing large-scale cage farming in the states of Chhattisgarh, Jharkhand, Assam and Odisha are testimony to this successful technology adoption where large-scale farming of *P. hypophthalmus* is in progress.

2.1.4. Community-based Capture Fishery Development in Open Waters

Developmental activities on community-based fisheries are based upon the principle of common interest groups working together for improving the fisheries resources of the open waters. Over the years, ICAR institutes have intensified their efforts to increase awareness among the local communities about the importance of participatory management of open water resources for improved productivity, maintenance of ecosystem health and better livelihood support. Research Institutes are working to strengthen the knowledge base and capacity building of the local community and line departments to address the challenges in inland waters for sustainable management of the ecosystems. The efforts include habitat fingerprinting, assessment and conservation of fisheries in natural waters such as reservoirs, rivers and estuarine eco-systems including mangroves, benchmarking for the sustenance of the aquatic ecosystem health, pollution abatement, fish disease surveillance, etc. Implementation of the fishing holiday, mesh size regulation, seed ranching, the concept of culture-based capture fisheries and other holistic management of the open waters including reservoirs and floodplain wetlands which have helped in improving their fisheries potentials. The productivity of many of the small and medium reservoirs which have remained as low as 20-25 kg/ha has been improved to 150 kg/ha. Community participation in such fish production activities is helping to improve the livelihood of the local population.

2.2. Technology Development in Brackishwater Aquaculture

2.2.1. Seed production

The utilization of the brackishwater resources in the country started with the popularization of the black tiger shrimp (*Penaeus monodon*) in the 1990s. The tiger shrimp farming was a booming industry during the beginning phase in the 1990s but lost its vigour due to the widespread outbreak of the white spot disease syndrome. With the boom in tiger shrimp farming, a large number of hatcheries were established in the coastal states for seed production. But due to the disease issue, most of the hatcheries remained non-functional. The introduction of the Pacific white shrimp (*Litopenaeus vannamei*) in 2009 has revived the shrimp farming activities in the country and most of tiger shrimp hatcheries have been revived for seed production of *L. vannamei*.

Finfish farming in brackishwater ponds initially was undertaken on the seed collected from natural resources. Such farming of two to three species was going on a limited scale due to inadequate seed availability. Over the years, however, life cycles of several brackishwater species have been closed in captivity. The ICAR-Central Institute of Brackishwater Aquaculture (CIBA) has standardized seed production technologies for several promising finfishes. The list includes sea bass (*Lates calcarifer*), grey mullets (*Mugil cephalus*), milkfish (*Chanos chanos*), pearlspot (*Etroplus suratensis*), etc.

2.2.2. Grow-out culture

The 1990s had witnessed a significant rise in the brackishwater aquaculture which was almost synonymous with the culture of tiger shrimp, apart from the limited scale culture of the Indian white shrimp *Penaeus indicus*. The culture of finfish was almost negligible. Despite the periodic setback due to disease threats, the shrimp farming has thrived with measures like change in cultured species, observation of crop holiday, crop rotation with finfish, reduction of stocking density, etc. The setback in the prawn farming has given impetus to farming finfishes in these ponds. In the meantime, life cycles could be closed in sea bass, grey mullet, milkfish and pearl spot, etc. The culture of these species peaked up until the revival of the shrimp farming activities using the Pacific white shrimp. Commercial farming of *L. vannamei* has also been expanded to the extensive salt-affected areas in landlocked states. Although the culture of this species started with a higher production target of 15-20 t/ha/crop in 4 months of culture duration, the gradual realization of environmental degradation and the threat of disease outbreak has made the farmers to culture this species with utmost caution in recent years. Besides the reduction of the stocking density in monoculture and the adoption of good management practices, there have been some efforts for the culture of shrimps under polyculture with suitable finfish species. The polyculture technology of these fishes has been demonstrated to small-scale farmers, which have triggered the diversification in the brackishwater aquaculture system. The demonstration of the technologies of organic farming of shrimp for higher value realization and biofloc-based shrimp farming for increasing production has also created great interest among the farmers in recent years.

2.3. Technology Development in Mariculture

Mariculture in India has been limited to small-scale farming of seaweeds, edible oysters and mussel on the west coast for a long period. The traditional farming of seaweed *Gracilaria edulis* and *Gelidiella acerosa*, in the coastal waters of Tamil Nadu were catering to the requirement of the food industry, pharmaceutical and marine biomolecule production to a certain extent. Of late the introduction of exotic seaweed species *Kappaphycus alvarezii,* however, has broadened the scope of seaweed farming in the country. The country is now looking for large-scale farming of seaweed and has developed a roadmap to become one of the major seaweed producing countries under the recently launched Prime Minister Matshya Sampada Yojana (PMMSY) of Department of Fisheries, Government of India. The edible oyster *Crassostrea madrasensis* is being farmed along the south Indian coast. Among the marine mussels, green mussel, *Perna viridis* and the brown mussel *P. indicus* are also cultured along the southwest coast. Although the acceptance of mussel and edible oyster was largely confined to the locals of the southern coastal states, the increasing demand in niche market and hotel industry, and further their export potential have now created increasing interest among the entrepreneurs for large-scale farming of these species in the coming years.

The country is a new entrant to the open-sea cage aquaculture. The non-availability of the seed of important cultivable species remained a major issue for the cage culture of finfishes. However, the concerted efforts of ICAR-Central Marine Fisheries Research Institute (CMFRI) in recent years have led to the development of breeding and mass-scale seed production of several commercially-important finfish species, viz., cobia (*Rachycentron canadum*), groupers (*Epinephelus* spp.), pompano (*Trachynotus blochii*), etc. The cage farming technology developed by ICAR-CMFRI has opened up the avenues of fish farming in the open-sea. At present, cage culture is underway in both west and east coasts of the country with the installation of over 3000 cages, which is expected to expand further in the coming days. Efforts are on to utilize the concept of Integrated Multi-Trophic Aquaculture (IMTA) by integrating seaweed farming with cage culture activity, which is not only leading to an increase in the production of fish and seaweed but also helping in water quality amelioration in the cages. Breeding and seed production has been standardized for few other shellfishes such as crab *Portunus pelagicus* and lobster *Thenus unimaculatus*. Production of marine ornamental fish is another area with enormous potential to tap the export market. ICAR-CMFRI has developed seed production technologies for over 20 high-valued ornamental fish species including clown and damsel fishes.

2.4. Technology Development in Coldwater Aquaculture

The coldwater resources of India are spread across the Himalaya including the north eastern states and the Deccan plateau in the form of streams, river, lakes and reservoirs. Nineteen major river systems traverse about 8,310 km in our uplands. Besides, there are about 21,400 ha and 43,770 ha of natural lakes and man-made reservoirs in the Himalayan region while 85 ha and 4400 ha of respective resources present in the peninsular region. Our uplands harbor more

than 258 fish species including commercially important food fishes such as snow trout, garras, minor carps, grass carp, silver carps, tench, etc.; sports fishes such as salmons, trout, mahseers and mirror carps, and a wide variety of ornamental fishes.

While there have been huge demands for fish and the food habit is changing in the upland region, fisheries and aquaculture development have not been promising due to slow fish growth and harsh environment. Schizothoracids and mahseer have been supporting the capture fisheries in the Himalayan system. In aquaculture, carps were cultured mostly in the mid-hill coldwaters and rainbow trout in the higher altitudes. However, ICAR through its research Institute ICAR-Directorate of Coldwater Fisheries Research (DCFR) at Bhimtal has been working hand in hand with people in developing the coldwater aquaculture and fisheries in this region. Besides the assessment of resources and fish faunal diversity, the Institute has developed/standardized technologies for breeding, seed production and grow-out culture of many important coldwater species such as golden and chocolate mahseer, garra, trout, etc. It has facilitated the expansion of the hill aquaculture through increased awareness, capacity building of the local community and fostering linkages. Presently, more than 75,000 tonnes of fish are being produced from the coldwater region and with the recent years' impetus on coldwater aquaculture, the production scenario is changing fast in these regions.

2.5 Technology Development in Harvest and Post-Harvest Management

The open-water fisheries, especially in coastal regions, have been providing needed employment and economic benefits to large sections of society. The livelihood of 4.5 million fishers on both east and west coast has been dependent on marine fisheries and related activities. The significant developments made in the improvement and modernization of boats, fishing gears and other equipment have not only helped the fishers in enhancing the fishing capacity and improving economic condition but also reducing their drudgery and life-threat to a great extent. The important harvest technologies development has been in the areas of boat building, mechanization of propulsion, the introduction of synthetic gear material, acoustic fish detection, satellite-based remote sensing, electronic navigation, on-board fish processing and preservation. With the popularization of mechanized fishing along with the motorization of artisanal crafts, there has been a great shift from the contribution by the artisanal sector to the mechanized sector. The assessment of stocks of different fish species continuously has helped in setting up maximum sustainable yields in both the coasts and also drawing required policy advocacies for different management measures like the closed season, mesh size regulations, etc. Such measures have helped in the effective recruitment of several species and sustaining fisheries of the country over the years thereby helping the coastal fishers to manage and improve their livelihood.

The drying of low-valued fishes has been a common practice in the coastal areas, especially when there is a glut in fish catch. The conventional drying method followed in most parts of the country is exposing fish with or without salting under the sun by spreading over the sand. As such practice often causes risks of heavy contamination, several fishers'-friendly practices

of sun-drying viz., solar tent drying or drying on platforms/rack is advocated to reduce the contamination. ICAR-Central Institute of Fisheries Technology (CIFT) has developed solar fish driers of varied capacity ranging 10-1000 kg with alternate back up systems viz., LPG back-up heating system. Kiln driers, cabinet or tray driers, rotary driers, drum driers and osmotic driers are some other important driers used for fish drying. Considering the increasing demand among the consumers for ready-to-cook, ready-to-eat, fish-based extruded products and also conventional value-added products like pickle and smoked fish, ICAR-CIFT has developed several such technologies which are being disseminated through different programmes including the Agri-Bussiness Incubation (ABI) system operational at the institute and several small-scale enterprises have come up in recent years.

The by-catch of shrimp trawlers contributes a large share of marine fish landings and these low-priced miscellaneous fishes are either discarded in the sea or converted to fishmeal or dried. As in tropics, about 80% of the catch is contributed by small fishes, generally, they do not fetch a good price and are not subjected to pre-process handling techniques like chilling and packaging. Therefore, developing micro-enterprises on the development of various byproducts from these low-valued by-catches or fish processing waste holds great promise in day to come, not only for the effective resource utilization but for elevating economic standards of the fishers in the coastal areas.

3. Lessons Learned and Path Ahead

With regard to agriculture practice, Gandhiji believed in the conservative utilization of natural resources. According to his concept, a farmer should have that much land which he and his family members could manage and cultivate to grow crops and get a complete and reliable means of livelihood, support cattle from its products as well as enough to retain biodiversity and capacity to rejuvenate itself. For effective biodiversity management of rich endemic fish species of the country, ICAR-National Bureau of Fish Genetic Resources has been taking several programmes on aquatic biodiversity assessment in biodiversity hotspots and different natural water bodies and also need-based conservation of threatened endemic fish species. Gandhiji also believed in farmers joining hands together to form cooperatives or communities to cultivate their lands. However, all such efforts should be spontaneous, arising from within the community and completely voluntary and there should be no use of force in these contexts. Most of these principles adopted for the development of fisheries and aquaculture sector are in line with the Gandhian thoughts, which have supported sustainability in fish production in the country while preserving the sanctity of most of these resources. However, future endeavours to increase fish production to cater to the ever-growing demand in the country should give utmost importance to conserve the ecosystem, its floral and faunal diversities and the natural resources. The ICAR can contribute significantly towards this endeavour through enhanced efficiency and effectiveness of its research base with the following strategies.

- Improve the efficiency of aquafarmers/fishermen and their financial resources for the effective utilization of natural resources.
- Facilitate accelerated dissemination of improved technologies, knowledge and information; and enhance the quality of human resources in the aqua-supply chain.
- Commercialization of technologies through organized intellectual property rights and benefit-sharing systems.
- Promote effective, efficient and decentralized governance by introducing best management practices proposed by the research organizations of the Indian Council of Agricultural Research and Agricultural Universities.

4. Conclusion

Gandhian thoughts on agriculture/aquaculture are based on 'Self-reliance' and it also preaches the conservation of the ecosystem for the future generation. Aquaculture in the present day is heading towards intensification partly because of the need of a section of the farmers to sustain in the system against the increasing production cost, and partly because of the greed of the other section of the farmers due to unawareness of the consequence or no thought about the consequence of the ecosystem health. However, unlike the agricultural land resources, a major portion of our natural water resources remain untapped. In such a context, the need to increase in fish production should focus on sustainable development through horizontal expansion of the culture area and judicious utilization of the resource capacity for a vertical increase rather than perturbing the ecosystem balance through intensive farming practices. The country has floated the slogan '*Atma Nirvar Bharat*', thus bringing the ideology of Bapuji to the forefront of our thinking and planning process. Thus, self- reliance in aquaculture/fisheries should encompass the sustainability, social equity, eco-based activities with due consideration for economic viability. ICAR institutes with their state-of-the-art scientific facilities and infrastructure and a pro-farmer policy can fulfil Gandhiji's dream of self-reliance and Gram Swaraj. Both the government and the farmers should work in tandem for the re-introduction of newer techniques aimed at eco-based farming models utilizing natural resources through a sustainable aquaculture approach.

Chapter 6

Agro-biodiversity, Ecology and Agriculture: Gandhian Thoughts

TR Sharma, Kuldeep Singh, Kavita Gupta, N Sivaraj and John K Joseph

"Respect earth and life in all its diversity. Recognize that all beings are interdependent and every form of life has value regardless of its worth to human beings."
MK Gandhi

1. Introduction

Gandhian thoughts and vision of life and diversity on earth and its safety are much older than the systematic scientific studies of biodiversity promulgated since 1980s. Agricultural biodiversity (or agro-biodiversity), as defined by FAO, includes all the animal, plant, and microorganism species that sustain agricultural ecosystems, and the variety between and within them, and is essential to food and nutrition security. The genetic variability for plants, animals, and micro-organisms being explored for food production and agriculture, mainly include crops, livestock, forestry, and fisheries. It also includes the diversity of non-harvested species (soil micro-organisms, predators, pollinators) that support agro-ecosystems including agricultural, pastoral, forest and aquatic life (FAO 2004). Recently, the father of the green revolution in India Dr. MS Swaminathan (2020) stated, *"Agro-biodiversity, thus provides a foundation for food, nutrition, and livelihood security. Diversity, in fact, is the basis for crop security. It is believed that agriculture started over 12 thousand years ago, with women at the forefront of selection and domestication of over 5000 plant species to suit different ecological, climatic, and cultural conditions as well as to meet diverse needs for food, medicines, and indeed incomes*".

With modernization and mechanization in agriculture, monoculture become more extensive resulting in continuously reducing the number of cultivated crop varieties as well as crop species. While in the past several hundred plant species were grown for food, feed, and fiber, in recent years, the focus has narrowed to a few dozen crops only, of which wheat, rice, maize, and potato providing ~50% of the calories. Many traditional crops are out of cultivation, neglected, or have become orphans and at high risk of extinction. One of the goals for all germplasm resource centers is to maintain diversity of species to ensure a larger food basket so that malnutrition can be better dealt with. Gandhian agriculture, in fact, is grounded in the belief in non-violence to nature. Dr. Swaminathan highlighted this in his 1973 Sardar Patel Lectures titled "Our Agricultural Future". Dr. Swaminathan (2017) stated, "*For the purpose of promoting environmentally sustainable technology, I advocated Gandhian agriculture where productivity*

can be enhanced without harm to the environment. Based on the most advanced principles of biological science, we can probably claim to have developed a Gandhian agriculture, because this would be an agriculture where Gandhian concepts become manifested in the form of an advanced rural economy, benefiting all sections of the community. Also, this will be an agriculture which enriches and not harms the environment". In today's scenario, where issues like climate change, environmental pollution, social inequality, and malnutrition became critical, we need to propagate this message. The 150th birth anniversary of Mahatma Gandhi is the most appropriate occasion to initiate and intensify the efforts towards sustainability.

2. Gandhiji's thoughts on Agro-biodiversity, Ecology and Rural Development

As we observe the 150th Birth anniversary of the Father of our Nation, Mahatma Gandhi, our feelings turn to him, who was credibly the greatest 'environmentalist' of all times. Gandhiji knew that unless man and nature live harmoniously and unless man stopped manipulating nature, he would certainly step on the path of devastation. In his own way, Mahatma Gandhi talked about preservation and sustainability. His outlook of non-violence encompassed non-violence to nature as much as to man.

The ecological concern was nominal at the time of Mahatma Gandhi, but his ideas on Village Swaraj, decentralization, Swadeshi, Sarvodya, and many similar ideas, made him a great advocate of environmentalism. The Father of our nation is often considered as a man with an in-depth ecological perspective. Across the globe, the ideas of Gandhiji have been widely followed in diverse streams of environmental philosophy like green and deep ecology, and for various environmental movements. Two of the distinct strands in Indian environmentalism viz. *Crusading Gandhians* and *Appropriate Technologists,* rely heavily on Gandhian philosophy (https://www.mkgandhi.org). India stood to witness several environmental calamities from its colonial time, in the form of de-forestation, high dam controversies, resource exploitation, and many more. Environmental movements in different parts of the country have paved the way for a new model in development, which is known as the sustainable development. Nature has its own self-cleansing mechanism. But it works within limits, beyond which it does not work. The natural systems have been harmfully affected due to anthropogenic activities, which led to the dilapidation of environment through pollution of land, water, and air and abuse of natural resources and, ultimately the biodiversity. About a century ago, the environment was fresh, clean, uncontaminated, and suitable for all. Now it is unclear, impure, contaminated, and unacceptable for living beings. Now, environmental degradation is being felt worldwide. Some of the reasons for which include urban expansion, mechanization, population explosion, use and throw-away concept of human beings, and undue exploitation of our natural resources. Besides this, due to the materialistic nature of man, there is a heavy reduction in of both renewable and non-renewable natural resources which is air, water, minerals, wood, fossil fuels including- petrol, diesel, kerosene, gases, etc. *"The Earth provides enough resources for every man's need but not every man's greed"* with this popular saying Gandhiji had emphasized the

importance of biodiversity and its conservation. He believed that it was the fundamental law of nature, without exception, where nature produces enough to meet all our day-to-day needs only when everybody took enough for oneself and no more. Then there would be no poverty, and no man would die of hunger in this world. This has a direct bearing on the sustainability of the man-environment relationship. He advocated for the generation of energy in village areas, to run rural industries and various other activities. These industries are essential to supplement agricultural growth, act as energy savers, and are less damaging to the environment.

Gandhiji, as a visionary very clearly assessed our Indian villages and made a clear-cut assertion that "*India lives in her seven and half lakhs of villages'*. He further believed that India will have to live in villages, not in towns, in huts, not in palaces. He firmly believed that *"If the village perishes, India will perish too"*. He found that the progress of the country lay in the improvement of the vast majority of its rural villages, development of rural economy, industry, and rural skills. Gandhiji felt that the only way of bringing hope of good living to the rural Indian people was by making the village the center-point for all economic programmes. Rural development, as outlined by Gandhiji, contained self-sufficiency, interdependence for one another's needs, and the development of village industries. He wanted to bring about rural reconstruction with sound scientific, spiritual and cultural values and successfully implemented rural reform activities in 1935 through his 18-point Constructive Programme. Gandhiji identified the *Adivasi's* as the original inhabitants and saviours of biodiversity and he said that the advanced community is duty- bound to contribute towards all-round development of the *Adivasi* communities in India and indirectly save the biodiversity.

Gandhiji had cautioned the world very early about the evils of large-scale industrialization, which we are facing today. He visualized that mechanization would not only lead to massive urbanization, to unemployment but would also lead to the destruction of environment. His seminal work, *Hind Swaraj*, which was written a hundred years ago in 1909, cautioned the world of the dangers it is facing today such as environmental destruction and the threat to the planet. Regarding urbanization, Gandhiji expressed his views as follows: "*It is a process of double drain from the villages"*. He envisioned the formation of small communities that had to integrate with the environment, something that anticipated the philosophy of local food and local communities. Gandhiji's vision was reflected in establishing in *Village Panchayat* through Article 40 of the Indian Constitution. This directly helped farmers in various ways-conservation of local biodiversity and development of community seed banks.

The idea of Sarvodaya is also similar to that of a sustainable development and forms a part of environmental ethics. According to Gandhiji's vision, Sarvodaya implied healthy development and environment that could evolve with man to ensure his harmonious co-existence with nature and other living beings. Gandhiji did not recognise separate rules for separate spheres of human life but saw all spheres in an integrated manner, which exemplifies best the human ecological perspective. What he preached and practiced correspond to what we today call eco-friendly measures and living in harmony with nature (https://www.mkgandhi.org/ebks/gandhiebooks.htm#environment).

3. ICAR's Activities on Agrobiodiversity and Rural Development

Following the Gandhian thought, "*Adopt at all levels sustainable development plans and principles that make environmental conservation and rehabilitation an integral part of all development initiatives*" the Indian Council of Agricultural Research (ICAR) established five National Bureaux for conservation and management of all components of Agro-biodiversity. These are:

ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi

ICAR-National Bureau of Animal Genetic Resources (ICAR-NBAGR), Karnal

ICAR-National Bureau of Agriculturally Important Micro-organisms (ICAR-NBAIM), Mau, UP

ICAR-National Bureau of Fish Genetic Resources (ICAR-NBFGR), Lucknow

ICAR-National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bengaluru

The mandate of each bureau is to acquire, conserve and judiciously use the relevant agrobiodiversity components. Until 1992, globally biological resources were considered as "heritage of mankind", however with the enactment of Convention on Biological Diversity (CBD) in 1992, these are now considered as sovereign rights of nations. Being signatory to CBD, which is a legally binding instrument, the Government of India (GoI) enacted the Biological Diversity Act (BDA) in 2002. All five Bureaux are additionally declared as Designated Repositories, as per provision of section 39 of the Biological Diversity Act 2002. The designated repositories maintain representative voucher specimens of the biological samples accessed along with relevant information. The Bureaux act as a "*Single Window System*" for the exchange of relevant biological material for research purposes and facilitate the export of material to research collaborators in other countries, u/s 5 of the BDA 2002. Hence, the ICAR Bureaux are responsible for the management of genetic resources, which involve a range of activities including exploration & collection, conservation, characterization & evaluation.

4. Status of India's Agro-biodiversity

Agro-biodiversity comprises the diversity of domesticated crops/semi-domesticated species or their wild relatives, land races/cultivars of crops, domesticated stocks/breeds and related wild stocks of animals, strains of fish, and agricultural microbes that are (or could be) exploited and utilized for research and development including food security and health. Among the 12 mega-diversity regions of the world, the gene centre in India is one of the most promising to biodiversity conservation. Thus, agro-biodiversity encompasses the biological diversity of agriculture-related species and their wild relatives as specified in the Section 13(1) of the Biodiversity Act, 2002 of India. It includes plants, animals, fish, microorganisms, and other forms of biological resource(s).

A total of about 1,27,000 species of animals, plants, and microbes are reported to occur in India. India has about 51,000 insect species, which constitute about 6% of the world's insect fauna (Table 1). Of the collection of 160 major and minor crop species, only about 25 crop species were widely domesticated in India. In addition, native tribes have conserved and are cultivating about 1,500 wild edible plant species (NAAS 1998).

All these together form a precious reservoir of genes needed by the plant breeders for development of superior crop varieties (Arora 1994; Tiwari 2006). In addition, explorers and visitors from abroad introduced many new crops and their cultivars. Thus, India has both indigenous plant resources, their wild relatives, as well as species introduced from across the world. Few examples of such introductions includes cereals like wheat, maize, barley, and oats; oilseeds like soybean, groundnut and sunflower; pulses- chickpea, peas, and French bean; fiber crop like cotton; medicinal plants; vegetables like potato, tomato, cauliflower, cabbage, onion and carrot; fruits like grapes, apple, pear, peach, apricot, and cherry.

Table 1. Insect biodiversity in India.

Insect order	Total species
Orthoptera	900
Isoptera	310
Hemiptera	5,216
Thysanoptera	702
Coleoptera	17,289
Diptera	6,093
Lepidoptera	15,200
Hymenoptera	4,264
Neuroptera	315
Mantoidea	162
Odonata	494
Total	50,945
Source: https://www.nbair.res.in/ accessed on 23 September 2020	

Eight agro-climatic regions namely (1) Western Himalayas, (2) Eastern Himalayas, (3) North-Eastern region, (4) Gangetic plains, (5) Indus plains, (6) Western Ghats, (7) Eastern Ghats (the Peninsular regions) and (8) the Islands region, the Lakshadweep and the Andaman & Nicobar group of islands (Chatterjee 1939, Murthy and Pandey 1978) exhibit more uniqueness and richness in crop plant diversity and antiquity of agriculture and ethnic diversity in the Indian sub-continent. They played a major role in the augmentation of crop resources in this region (Arora and Nayar 1984).

Similarly, vast diversity occurs in natural habitats for medicinal and aromatic plant species and for forage grasses. Many of the medicinal plants genetic resources have great industrial

Variability in plant genetic resources at ICAR-NBPGR, New Delhi

applications for instance *Cymbopogon* spp., *Emblica officinalis*, *Nardostachys jatamansi, Ocimum* spp., *Podophyllum hexandrum*, *Rauvolfia serpentina* and *Swertia chirayata*. Different biodiversity hotspots in India collectively have more than 400 species of legume forages (Arora and Chandel 1972). These include *Alysicarpus, Astragalus, Caragana, Cicer, Crotolaria, Desmodium, Indigofera, Lespedeza, Medicago, Melilotus, Pueraria, Rhyncosia, Smithia* and *Trigonella.*, Over 1250 species occur among grasses of which about 600 are considered as promising wild forages.

India is endowed with rich animal genetic resources. The total number of recognized indigenous breeds now in the country is 197, which include 50 for cattle, 44 for sheep, 34 for goat, 17 for buffalo, 7 for horses and ponies, 9 for camel, 10 for pig, 3 for donkey, 1 for yak, 19 for chicken, 2 for duck and 1 for geese (Table 2).

Table 2. Registered breeds of Animal genetic resources in India.

Animal Genetic Resources	Registered Breeds	India's share in world
Cattle	50	7 %
Buffalo	17	14 %
Sheep	44	6 %
Goat	34	7 %
Horse and Ponies	7	NA
Camel	9	11 %
Poultry	19	2 %
Donkey	3	NA
Duck	2	NA
Pig	10	NA

Animal Genetic Resources	Registered Breeds	India's share in world
Geese	1	NA
Yak	1	NA
Total	197	-
Source: http://www.nbagr.res.in/ accessed on 23 September 2020		

Nearly 11 per cent of world's fish genetic resources is reported to occur in India (Table 3).

Table 3. Fish genetic resources of India.

Ecosystem	Species (Nos)
Fresh water	877
Brackish water	113
Marine water	1,573
Total Species	2,563
Source: http://www.nbagr.res.in/ accessed on 23 September 2020	

4.1. Conservation Strategies for Agrobiodiversity: Floral Biodiversity

"Care for the community of life with understanding, compassion and love. Accept that with right to own, manage and use natural resources comes the duty to prevent environmental harm and to protect the right of people." (Mahatma Gandhi, Young India, October, 1921)

The proper conservation and use of agro-biodiversity are fundamental to sustainable development and food security. As plant genetic resources (a major component of agrobiodiversity) providing food, fodder, fuel, fibre are fundamental to the fulfilment of the basic needs of a human beings, their loss will cause serious damage to economic and social development. Hence, genetic resources, including plants, animals, fish, have to be conserved and managed for sustainable use. For the improvement of crops, and animals, germplasm resources are the prerequisite is a fact well recognised worldwide, and continuous efforts are being employed to collect, protect, and manage them. Various approaches being followed for their conservation are described below.

***Ex-situ* conservation:** Ex-situ conservation refers to the conservation of genetic material separate from their natural habitat in facilities under artificial conditions supporting storage and perpetuation. *Ex-situ* conservation virtually safeguards and provides the required supply of germplasm for research and breeding (Singh et al. 2004) and for possible repatriation as and when required. Some of the possible approaches for the *Ex-situ* conservation are grouped as:

Plant conservation: (a) Botanical garden, (b) Herbal garden, (c) Arboreta, (d) Cropping field gene-bank and (e) clonal repositories.

Seed conservation: (a) Low-temperature storage of orthodox seeds (seed genebank), (b) Cryopreservation: storage of orthodox, intermediate and recalcitrant (embryonic axis) seeds

in liquid nitrogen which has temperature -150 to -196 °C. The details of the present status of conservation of plant genetic resources at the National Genebank located in New Delhi is provided in Table 4.

Table 4. Status of Base collections in National Genebank (-18 °C) (As on 31st August 2020).

Crop / Crop Group	No. of accessions conserved*
Cereals	1,66,156
Millets	59,525
Forages	7,270
Pseudo-Cereals	7,820
Legumes 67,101	
Oilseeds	60,496
Fibre	15,912
Vegetables	27,132
Fruits & Nuts	291
Medicinal & Aromatic Plants & Narcotics	8,344
Ornamental	669
Spices & Condiments	3,261
Agroforestry	1,653
Safety backup Samples (Lentil, Pigeonpea) from CGIAR institutes	10,235
Others	10,771
Total	**4,46,636***
*The figure includes 5,034 released varieties and 4,316 genetic stocks No. of Crop Species conserved: 1,762	
Source: www.nbpgr.ernet.in accessed on 21.9.2020	

***In-vitro* conservation:** Conservation of cells, tissues, and organs in glass or plastic containers under aseptic conditions. Such conservation is based on the slowed growth of cultures in highly controlled *in-vitro* conditions. *In-vitro* conservation strategies can be technically divided into two categories (1) *In vitro* active genebank (IVAG) or tissue culture repository and (2) *In vitro* base genebank (IVBG) or cryobank. The former genebank is for short to medium-term storage of germplasm using shoot cultures or plantlets under slow or normal growth procedures, but the cultures are maintained under the growing state. While cryobank is meant for the long-term conservation PGR, usually using embryos (somatic or zygotic), shoot tips and pollen under suspended growth.

Cryopreservation: conservation of cultures (tissues, organs, pollen, cultures, or seed in liquid nitrogen at -150 to -196 °C. The status of germplasm conserved under the *in-vitro* bank and cryo bank at ICAR-NBPGR, New Delhi is provided in Table 5.

Table 5. Crop diversity conserved *in-vitro* in the National Genebank (As on 31st August 2020).

Crop Group	Present Status
***In vitro* bank**	
1. Tropical fruits	443
2. Temperate and minor tropical fruits	360
3. Tuber crops	520
4. Bulbous crops	171
5. Medicinal & aromatic plants	181
6. Spices and industrial crops	227
Total	1, 902
Cryobank	
1. Recalcitrant	0
2. Intermediate	6,948
3. Orthodox	3,911
4. Dormant bud	389
5. Pollen (Mango)	591
TOTAL	11,839
Genomic Resources	
DNA	2,194
Source: http:// www.nbpgr.ernet.in accessed on 21.9.2020	

In-situ conservation refers to the conservation at natural habitats where the genetic resource naturally occurs in its natural ecosystem. It is particularly required for forestry species, species belonging to a complex ecosystems, endangered, and wild relatives of crop plants. There are mainly two approaches for *In-situ* conservation (a) ecosystem approach (biosphere reserves) and (b) habitat approach (national parks, sacred groves, gene sanctuaries). *In situ* conservation is very difficult to monitor and to keep track since it involves continued habitat maintenance.

Although the present article is on agro-biodiversity as a whole, the following examples and case studies are primarily on adopting Gandhian principles for plant genetic resources (PGR) conservation and management which are for illustrative purposes only and by far reflective of all such instances.

4.2. Case Study I: Rural Livelihood Security

ICAR-NBPGR handled a Global Environment Facility (GEF) project entitled "*Harmonizing biodiversity conservation and agricultural intensification through integration of plant, animal and fish genetic resources for livelihood security in fragile ecosystems*" in three distinct agro-climatic zones represented by backward districts namely Chamba (Himachal Pradesh), Udaipur (Rajasthan) and Adilabad (Telangana) based on Gandhian principles and ideology (*Care for the*

community of life with understanding, compassion and love. Accept that with right to own, manage and use natural resources comes the duty to prevent environmental harm and to protect the right of people - Mahatma Gandhi).

The agricultural development in the last several decades have increased yields, but have also significantly reduced the agrobiodiversity due to several forthcoming considerations. For the sustainability of agriculture in India, both components -agricultural reforms and bio-resource conservation should go hand-in-hand. The *on-farm conservation* through use has a exclusive benefit in the whole evolutionary process where the bio-resources are in use, and farmers themselves are the conservators, breeders and users. Therefore, a model on harmonizing agricultural reforms and biodiversity protection was developed through participation of farmers.

The three districts chosen represent distinct agro-ecosystems with specific bioresource components comprising plants, animals, and fish with specific problems owing to their demographic pattern, production systems, fragmented and small land holdings; poor soil fertility, and rainfed farming, which are not remunerative. The socio-economic conditions of farm families are appalling, who have limited access to technological, financial, and proper market support. In order to enhance their livelihood security, it was envisaged to link the conservation and use of traditional crops, livestock breeds, and fishes with their economic development. Agricultural activities were re-oriented towards better use of local resources and evolving farming systems, which provided enough quantity and quality of food and economic security to the rural poor and encouraged them to conserve and enhance diversity in these traditional production systems. An integrated farming system model was developed keeping farmer as a focal point for judicious utilization and conservation of plant, animal, and fish genetic resources with well-designed technological interventions to increase production, "adding value" of the farm produce and their proper marketing for enhancing the livelihood security and empowerment of local people.

4.3. Case Study II: Jeera Phool- Repatriation of Local Biodiversity

Often crop biodiversity is lost partly because there are no growers and no consumers for certain indigenous cultivars. Appreciatively, a substantial number of traditional varieties of rice continue to be grown by small and marginal farmers across India, where they cater largely to the local consumers and, in recent times to quality preferences in certain niche markets. *Jeera Phool* is one such indigenous, superfine, and aromatic rice cultivar which has cumin-like grain that feels very soft in the mouth and remains flaky even after cooling. Like many other rice landraces, *Jeera Phool* also faced the threat of going out of cultivation. In 2005, a group of 20 tribal women farmers from six villages in *Surguja* district of Chhattisgarh, realized the threats to the survival of *Jeera Phool*, and formed a self-help group to promote and protect it. The *Jeera Phool* initiative was adopted for implementation by ICAR-NBPGR under a GEF project, supported by the United Nations Environment Programme (UNEP) in partnership with Bioversity International. Slowly, popularity of *Jeera Phool* grew in local markets, followed by an increase in the number of group members. The group first registered *Jeera*

Phool with Protection of Plant Varieties and Farmers' Rights Authority of India, and obtained the Geographical Indication tag (the *Jeera Phool* variety is primarily grown only in Surguja district) in 2019.

One of the main objectives of the project was to make communities in the seven states (Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Rajasthan, Himachal Pradesh, Uttarakhand, Assam) and the Union Territory of Ladakh more resilient to climate variation as well as make them food secure by getting them to grow a greater variety of crops. The project conducted a thorough baseline survey on the present and past existence of 20 crops and "focal group discussions". It was found that several hundred named landraces and farmers' varieties of the 20 target crops were being maintained by some farmers. To help conserve these varieties, 19 community seed banks were initiated which presently maintain over 2,000 traditional varieties of different crops. This would provide easier access to farmer to a wide variety of seeds. Another unique feature of this project was that *ex situ* collections conserved in India's National Genebank were repatriated to farmers' fields in a way justifying the very existence of Genebanks as a source of germplasm for posterity.

These mainly include cultivars found to have been lost or discontinued. Under the project, over 8,000 farmers took part in 43 capacity-building programs. The project also used sophisticated laboratory analysis for nutrition profiling of 205 landraces of rice, 23 of soybean, and 26 of millets.

Biodiversity-based solutions offer the best means to achieve food accessibility and climate resilience. How we conserve and use our biodiversity will decide the future of humanity.

4.4 Case Study III: Realizing Philosophy of Gram Swaraj through Sustainable Agrobiodiversity Conservation

Sustainability was the key to all actions of Gandhiji. In fact, ICAR-NBPGR also aims at the sustainability of Indian agriculture through PGR conservation for posterity. Over 0.44 million plant germplasm accessions are conserved in its National Genebank. Gandhiji's vision of rural India was self-sustainability in villages where every basic need is met locally and the ecosystem is kept in equilibrium. It is towards this goal that the TSP program of ICAR-NBPGR aims to achieve the nutritional self-sufficiency of vulnerable communities. ICAR-NBPGR has been empowering vulnerable tribal communities through training and inputs in achieving nutritional self-sufficiency. Distribution of seeds of locally adapted landraces of vegetables and fruit trees along with minor agricultural implements and other inputs were taken up by all the ten regional stations and Headquarters. We envisage this Gandhian philosophy in custodian farmer led on-farm conservation programs where species diversity in general and genetic diversity of crops in specific are conserved on the farm. Under the Scheduled Caste Sub-plan (SCSP) program, ICAR-NBPGR has been able to reach many scheduled caste (SC) families across the country with agro-biodiversity conservation interventions. In Kannapuram village of Kannur, Kerala a heritage site has been identified wherein 25 km^2 area, over 200 unique mango trees have been located, out which 68 trees were collected as scions and established in the clonal repository.

This will be rehabilitated in SC homesteads in and around the original collection site.

The Mahatma believed that India's soul lives in its villages. The ICAR-NBPGR envisages a decentralized on-farm conservation approach through SCSP, Tribal Sub-plan (TSP), and GEF programs to make rural livelihoods secure and working out a balance of conservation with sustainable use (Case study II).

He also suggested the necessity to find out simplest and inexpensive foods that would enable villagers to recover their health. In this regard, ICAR-NBPGR has documented over 1000 wild edible species with >30 highly potential species. Some potential species identified are *Allium tuberosum*, *Herpetospermum operculatum*, *Plukenetia corniculata* (as leafy vegetable), *Tupistra clarkei* (inflorescence as vegetable), *Garcinia speciosa* (as fruit), etc. Potential new vegetable crops identified from the wild, like bitterless gourd (*Momordica subangulata subsp. renigera*) has been getting popularised in South India as a high-value vegetable.

Additionally, ICAR-NBPGR has contributed to the identification of useful trees for vulnerable coastal ecosystems by carefully observing the Andaman and Nicobar littoral forests. We could establish a field genebank for over 75 perennial crop wild relatives of horticultural crops and forestry species at Thrissur Station. The Bureau has been freely sharing these resources with line departments and other stakeholders for wider reach. Using this forest tree genetic wealth, the College of Forestry of Kerala Agricultural University has developed an arboretum of Andaman and Nicobar forest trees, which will serve as a seed source as well as an instructional garden for agriculture/ forestry students.

Gandhiji's conservation philosophy was that '*the earth, the air, the land, and water are not an inheritance from our predecessors but a loan from our future generations*'. Realizing this fact, we believe that our native agro-biodiversity is nature's gift nurtured by generations of our countrymen, and it is our prime duty to conserve this precious national heritage. It should provide employment and livelihood to all stakeholders and should be operated with the least disturbance to nature. That is why we believe in the custodian farmer centric participatory conservation program. At the ICAR-NBPGR Regional Station, Thrissur 26 taro landraces retrieved from tissue culture repository were successfully repatriated at two homesteads.

Standing tall: A Mango tree planted by Gandhiji in 1927 at a college near Thrissur, Kerala

Gandhiji believed that exploitation of the natural habitat is *himsa*, a mortal sin. He always advocated the protection of fauna in the wild. We hope that

our recent collection of useful economic plants from Andaman and Nicobar Islands especially dwarf Burmese fishtail palm and three species of seed setting wild banana, can be an answer by way of artificial reseeding of denuded forest habitats with these fodder species.

To the development planners and policymakers, Gandhiji's advice was to think of the poorest of the poor, as to how the intervention will benefit him. ICAR-NBPGR has been successful in conserving a sizable collection of the diversity of nutri-cereals and poor man's food resources like grain legumes, millets, and amaranth.

Once Gandhiji stated '*cleanliness is second only to Godliness*'. His commitment for clean surroundings needs no explanation. It is also well understood that the indiscriminate use of plastics, especially disposable food plates and packaging cause serious damage to our habitat. It is in this context that ICAR-NBPGR has identified Nicobar endemic giant leaf *Macaranga* (*Macaranga nicobarica*) and seed setting wild banana species as renewable and eco-friendly alternatives to plastic food wrapper. Both the species have been successfully conserved in ICAR-NBPGR's field genebank and seed genebank.

5. Lessons Learned and the Path Ahead

The farmer's rights to store, plant and conserve seeds must be protected to maintain the biodiversity. In addition, communities and farmers also need to have property rights to ensure that their seeds and genetic resources are not exploited for commercial purposes without adequate compensation and to ensure that benefits from sales of their crops and seeds are locally protected.

The conservation and use of genetic resources will remain vital for improving productivity in agriculture and sustaining human presence and well-being. Three key functions of genetic resources are identified: sustained production of food, biological support to production, and ecological services. Because of the high level of human interference in the management of genetic resources, conservation in the production system is linked to sustainable use. This makes conservation through protected areas of much less relevance, nonetheless, in an industrial-type agricultural system, much diversity is now held in *ex situ* Genebanks or breeders' materials rather than on-farm. In more traditional systems, farmers actively manage agricultural biodiversity on-farm in order to improve productivity and maintain sustainability; they adapt to the changing needs and circumstances.

Building complementarity among agriculture, biodiversity, and conservation of genetic resources also requires change in agricultural research and development, land use, and breeding approaches. The natural populations of many species of crop wild relatives, wild economic species, wild fauna etc. are increasingly at risk due to habitat loss and by increasing destruction of natural habitat.

6. Conclusion

Effective conservation and use of agro-biodiversity are of immense importance in the present scenario, as was in Gandhian thoughts. There is a need for managing genetic resources for food and agriculture in ways that promote the evolution and conservation of agro-biodiversity to adapt to changing environment by developing new climate resilient varieties/breeds for food and nutritional security, while ensuring their availability to all stakeholders for use. Climate change will also increase the importance of minor or other underutilized crops and plant species. Therefore, all forms of agro-biodiversity needs to be collected through regular explorations, conserved through suitable means, characterized and evaluated using modern technologies to ensure their availability for improvement programmes of food and agriculture today and tomorrow (Mohapatra 2016).

In addition, conservation of agro-biodiversity is vital to increased productivity, food security, robust and stable farming systems, and ecosystems. Traditional communities, particularly women, have played a significant role in the conservation of traditional varieties, especially in fragile agro-ecosystems. The role of women and these communities need to be acknowledged and appreciated through rewards while implementing on-farm conservation strategies. In view of the relevance of agrobiodiversity in the evolving global scenario, there is a need for creating awareness and understanding among the public and Indian masses. The literacy crusade for conservation and sustainable management of agro-biodiversity needs to be undertaken at grassroot level, starting right with school and gram sabha/ panchayat levels. Also, conservation of available breeds/strains of animals, fish and microbes need urgent attention. Most of the developing world looks towards India for suitable models for agrobiodiversity conservation, management, and use. The country is well poised for adopting a lead role within the developed world, being well equipped with institutional support and human resource needed for generating improved technologies. Issues/ problems related to agro-biodiversity, ecology, and rural development could be easily solved by studying, accepting, and following Gandhian philosophy and practices.

Chapter 7

Local Interventions in Natural Resources Management for Global Gains: Gandhian Principles

SK Chaudhari, S Bhaskar and A Islam

"I need no inspiration other than Nature's. She has never failed me as yet. She mystifies me, bewilders me, and sends me to ecstasies."
MK Gandhi

1. Introduction

Soil, water and vegetation are the basic natural resources providing a base for food, nutritional and environmental security. Land, soil and water are the abiotic resources, whereas natural vegetation and wildlife are the biotic resources. India shares 2.4% geographical area and 4% fresh water resources of the world but it supports 16% human population and 18% livestock population. Both biotic and abiotic resources are exhaustible in nature. At present, the country is confronted with widespread land degradation, over-exploitation of groundwater resources, impaired soil health and contamination of soil and water resources, abiotic stresses etc. About 120.7 million ha (Mha) of total geographical area (36.5 % of total geographical area) of the country is affected by various kinds of land degradation comprising of water erosion (82.6 Mha), wind erosion (12.4 Mha), chemical degradation (24.7 Mha) and physical degradation (1.0 Mha) (NAAS 2010). Further, India's per capita water availability has declined from 5177 m^3 in 1951 to 1544 m^3 in 2011, and is projected to reduce further to 1434 m^3 and 1219 m^3 by the year 2025 and 2050, respectively (CWC, 2019). Similarly, low nutrient use efficiencies (30-50% N; 15-20% P; 60-70 % K; 8-10 % S and 1-2% micronutrients) are also a major cause of concern (Chaudhari et al. 2015).

Gandhiji always advocated judicial use of natural resources keeping the future generation in mind. Gandhiji believed that the natural resource like land, water, air and solar radiation are God's gifts, and these should be used sustainably and conserved for future generations to grow crops, support cattle, and retain biodiversity and capacity to rejuvenate itself. He wanted that the farmers should consider the earth as his 'Mother'. His comment "*Man's happiness lies in contentment. He who is discontented, however much he possesses, becomes a slave to his desires*" supports the need for judicious use of natural resources.

Management of natural resources is a complex process as it involves the hydrological cycles, ecological cycles, climate, animals, plants and environment in a socio-political matrix. The

NRM technologies must be location-specific and developed through farmers' participatory mode using local resources and indigenous knowledge so that these are economically viable, socially acceptable and environmentally safe. From Gandhian perspective, the present environmental mess ranging from deforestation, soil and biodiversity loss to pollution and climate change is not a disease but only a symptom (Barua 2015). The disease is the very concept and patterns of growth and development that are being followed everywhere. If the perspective changes, then the disease is diagnosed by a good doctor (Barua 2015).

Keeping in view the above facts, the Natural Resource Management Division of ICAR is engaged in developing location-specific, cost effective, eco-friendly technologies for conservation and management of natural resources to ensure food, nutritional, environmental and livelihood security in the country through 14 research Institutes including 10 All India Coordinated Research Projects, 3 Network Projects and 2 Consortia Research Platforms namely Consortia Research Platform (CRP) on Water and CRP on Conservation Agriculture.

2. Relevance of Gandhian Principles in Conservation of Natural Resources

The most frequently quoted phrase of Gandhiji "*The earth has enough resources for our need but not our greed*" clearly shows the concern of Mahatma for nature and environment, which the mankind embraces today. All the international conferences, summits, etc. convened to give a clarion call to preserve the environment and effects on the basic life on the earth were much later than the concern expressed by Gandhiji. Agriculture is the age old and an essential avocation of the man to cultivate crop plants and domesticate animals which took place thousands of years ago to basically meet the food requirement. As man civilized, his wants were increased so that the natural resources were subjected to exploitation at one or the other point of development. Presently, agriculture not only provides food but also meets the other needs such as fodder, fibre, fruit, flower, etc. In the process of cultivating more and more from the limited natural resources, the farmers have to adopt modern scientific methods of cultivation besides being exposed to the adverse weather and degraded soil conditions (Balamurali 2020).

Gandhiji emphasized the importance of natural resources and its conservation through a saying "*I need no inspiration other than Nature's. She has never failed me as yet. She mystifies me, bewilders me, and sends me to ecstasies*". This expression of Mahatma has direct bearing on the man-and-environment relationship (Tiwari 2019). The dependence on natural resources for production of crops to meet the requirement of population is closely associated with prevalence of a suitable climate, a fertile soil and an abundant water supply around human settlements across the globe. However, the man's greed of producing more has led to depletion of resources besides polluting air, water and soil. On the other hand population explosion, mass poverty, over utilization of renewable resources, over and imbalance use of fertilizers/nutrients, desert formation, deforestation, global warming etc. which are man-made in nature are all causing irreparable damages to our planet earth. Further with rapid changes in environmental

conditions, land use pattern and climate change, the incidence pattern of various vector-borne diseases is also changing globally.

In post-globalization era, agriculture has become global through exchange and free entry of synthetic chemicals for plant protection, genetically modified crops, etc. Farmers have become knowledgeable in acquiring new skills in farming and adopting the same on the parcels of their land. The economic state of today's farmers is much better compared to the earlier generations. The improved economic state of other sectors, buying power, distribution channels and consumerism further increased the demand for agricultural goods mainly food and fodder for cattle. But this has to be got from limited land and water and farmers having small and marginal holdings. It is need of the hour to focus more on increasing livelihood, economic security of more than 85% land holdings which are falling under the category of small and marginal farmers. To address these issues, ICAR has established Indian Institute of Farming Systems Research at Modipuram with a mandate of developing tailor made cropping/ farming systems to secure their food, nutrition and livelihood on a sustainable basis. The farming systems developed on research station and on farmers' fields have resulted in 2.5 to 4.0 times increase in the income of small and marginal farmers.

Thus he insisted on the eternal sacredness of life that included a tree, plant or a cow. The concept of "sarvodaya" is similar to that of a sustainable development and forms a part of environmental ethics. Gandhiji's vision of "sarvodaya" implies a healthy development/ management of natural resources and environment by a man to ensure his harmonious existence with nature and other living beings. Gandhi ji did not recognize separate rules for separate spheres of human life, but saw all spheres in an integrated manner which is being referred today as eco-friendly measures of protecting the nature. Gandhiji stated that "*Forces of nature act in a mysterious manner. We can but solve the mystery by deducing the unknown result from known results of similar events*". Realizing ethos of Mahatma about natural resources in meeting the basic needs, the ICAR created a Natural Resource Management Division.

3. ICAR's Activities in Realizing Gandhian Principles

3.1. Maintaining Soil Health and Productivity

Soil management is extremely important for sustaining healthy life on earth. According to Vedas "*upon this handful of soil our survival depends care for it, and it will care for your food, the fuel that you need, that will shelter you and surround you with beauty. Abuse it and the soil will collapse and die, taking us all with it".* The primary cause of deteriorating human/animal health is actually the poor health of soil. Only a healthy soil can support healthy plant growth to provide nutritious food as quantity and quality of agricultural produce is directly linked to soil quality. Soil test based balanced and integrated nutrient management through conjunctive use of both inorganic and organic sources (manure, biofertilizers, etc.) of plant nutrients are the ideal solution to improve soil health and quality. ICAR-IISS has developed a portable soil test kit/mini lab (Mridaparikshak) to provide soil-testing service at farmers door step. The kit

is capable of measuring all the twelve parameters prescribed under "National Mission on Soil Health Card". The Kit is useful for rapid analysis of soil samples for generating soil health cards along with the fertilizer recommendations, monitoring of soil fertility and preparation of geo-referenced soil fertility maps at block/village level.

3.2. Desilting of Tanks

Droughts and floods are recurring features in rainfed areas affecting agricultural production. By storing excess runoff water during monsoon season, the water harvesting tanks help to mitigate water scarcity problem during non-monsoon period, moderates the flood risks during monsoon season, and improves groundwater recharge (Sikka et al. 2018). Thus, these water harvesting are eco- and farmers-friendly water bodies and multi-functionality of these tanks is well documented (CRIDA 2006; DHAN 2004 and Osman et al. 2001). The strategy of desilting and its recycling will not only rejuvenate tanks with increasing/ regaining the surface water storage but also improve groundwater recharge (Sikka et al. 2018), besides improving the soil properties in a cost-effective manner. Small storages like tanks are much more appropriate and effective for groundwater recharge (McCully 2006) and will also arrest siltation of large reservoirs built at huge cost.. As silt act as an organic amendment, there is also possibility of substituting inorganic fertilizers with silt for improving soil quality, increasing crop productivity, rainwater productivity and economic viability of crop production in rainfed areas. In this context, a study was carried out as a part of Farmers' Participatory Action Research Program (FPARP) of Ministry of Water Resource, Government of India entitled "Tank Silt as an Organic Amendment for Improving Soil and Water Productivity" implemented by CRIDA in four centers namely, Nalgonda (Telangana) Warangal (Telangana), Anantapur (Andhra Pradesh) and Kolar (Karnataka) in collaboration with All India Coordinated Research Project for Dryland Agriculture (AICRPDA) of SAUs and NGOs namely, PEACE (NGO, Nalgonda), MARI (NGO, Warangal), Anantapur (AICRPDA, ORP) and MEOS, NGO) and Kolar (AICRPDA, ORP Bangalore and AME, NGO). The sample farmers (beneficiaries) identified for these centres were 20, 22, 20 and 20, respectively. Castor, cotton, groundnut and mulberry are the dominant crops focused in this study across these four centers as they were the main crops in these centres. "Untreated (without tank silt application) and treated (with tank silt application)" approach was followed for two years for this study. A user-friendly MS-Excel based tank silt applicator was developed and is available on CRIDA website (www.crida.in) for deciding number of tractor trolley loads based on either physical or chemical characteristics of tank silt.

Across the crops and centres, castor in Nalgonda and groundnut in Anantapur were found to be highly significant while cotton in Warangal and mulberry in Kolar were non-significant. Castor and groundnut registered significantly higher yield increase (229% and 153%) in Nalgonda and Anantapur, respectively while lower yield increase registered in case of cotton (19%) in Warangal and as low as four per cent in case of mulberry crop in Kolar. Lower yield increase of mulberry crop is indicative of the fact that silt application had minimal effect on established

perennial plant, however, farmers noticed improvement in quality of mulberry leaves and higher intake by silk worms.

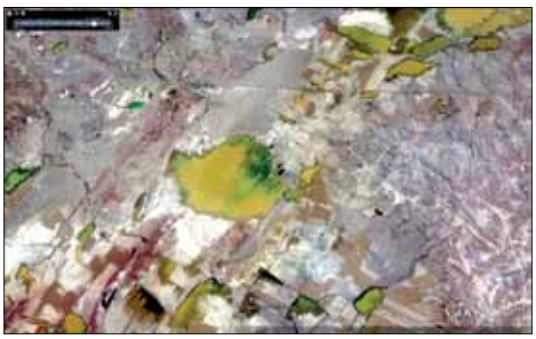
The impact of technology was more pronounced during second year, although it was a mega drought year (2009). As such, cotton in Warangal and Nalgonda and groundnut in Anantapur were found to be highly significant while mulberry in Kolar registered non-significant. Evidently, highly significant yield increase registered 124% in case of cotton, which was replaced on castor in the same plot in the second year in Nalgonda followed by groundnut (about 62%) in Anantapur and cotton (57%) in Warangal. Thus, it is inferred that silt application not only improved yield, but also, motivated farmers to diversify to other crops for realizing higher economic benefits. Silt application technology not only helped the farmers in making their soil rich and get "More Crop and Income Per Drop of Water" but also motivated farmers to diversify to other crops for realizing higher returns. Recycling of silt in rainfed areas not only improves yield and income but also makes use of rainwater efficiently and mitigate dry spells. It is in this backdrop that certain public funded schemes like MGNREGS has included tank desilting as one of the priority works.

3.3. Irrigation Water Management

Sustainable irrigation management requires efficient, precision technologies for irrigation and farming practices that are based on ecosystem approaches to conserve water. As the demand for water from nonfarm sectors increases and availability of water for agriculture sector declines, the conflicts between upstream and downstream users may increase over the time. This may result in possible conversion of existing productive irrigated lands to rainfed lands. Increasing water productivity at farm level is the key management issue. Broadly, the important water management measures for enhancing productivity are (a) proper irrigation scheduling, (b) optimization of rice transplanting date, (c) conjunctive use of rain, canal and groundwater, (d) use of water and energy efficient irrigation methods e.g., sprinkler irrigation, micro-irrigation, (e) multiple use of water, (f) improved agronomic practices, , and (g) acceleration of resource conserving technologies e.g., zero tillage, conservation tillage, raised bed etc. (Chaudhari et al. 2015) . Different forms of multiple use systems, i.e., multiple use of harvested rainwater, canal water after outlet and in the network itself, groundwater where pumped water from tube well used for other productive purposes before it is delivered to field for irrigating field crops etc. have been found to enhance water productivity in different locations (Chaudhari et al. 2015). In the year 1947 at a prayer meeting in Delhi, Gandhi ji emphasized the need for water harvesting for irrigational purposes to avoid famines and food shortages. Check dams confirm to Gandhian concept of creating self-sustaining village to regenerate aquifers and increase fresh water resources for agriculture. Considering the limitations of the traditional concrete check dams, ICAR-Indian Institute of Water Management, Bhubaneswar has developed multipurpose rubber dam for watershed to conserved water by impounding water behind the rubber dam, facilitating enhanced groundwater recharge, and quick and safe disposal of sediments. The multipurpose, inflatable, flexi Rubber Dam can store 20-25% additional water in comparison to traditional check dam.

Khadin system of runoff farming: *Khadin* is a low lying area surrounded by an upland catchment and best considered as a runoff farming system in the arid region receiving <300 mm annual rainfall. This is a locally developed and adopted technology where crops can be grown using the conserved moisture. Rainwater that falls on surrounding rocky /gravelly catchments travels through a natural surface drainage system and accumulates in low-lying areas where a topographical barrier or a constructed bund is encountered. These bunds are called *khadin* bunds, and the transported soils alleviate in the area of water accumulation. With passage of time, the entire alleviated soils form a *khadin*. At the approach of winter season when water recedes, people cultivate *rabi* crops like wheat, mustard and gram on such conserved moisture in the *khadins*. Traditionally, *khadin* system was designed and developed by the Paliwal Brahmins of Jaisalmer (Rajasthan) in 15th century. Central Arid Zone Research Institute (CAZRI), Jodhpur played an important role in an improved version of *khadin* for western region of the Indian *Thar* Desert. More than 500 *khadins* exist in this region.

Rubber dam at Chandeswar-I, Khurda, Odisha



Satellite view of Roopsi and other khadins filled up with rainwater

Field photo of Traditional Roopsi khadin at Jaisalmer)

The *khadin* system is based on the principle of harvesting rainwater on farmland, and use of residual moisture for crops production. The ratio between cultivated and catchment areas varies from 1:15 to 1:56. The water holding capacity and water infiltration, rates are balanced by the shallow depth of soils in the beds. The basement of *khadin* is invariably a hard surface upon which sand-silt-clay tend to accumulate up to few meters depth. This maintains a convenient supply of natural moisture and nutrients within the crop's root zone. Few wells are generally kept on down side of earthen bund; they are recharged from water in *khadin* and the water is used during summer months when *khadin* bed dries. *Khadin* soils are more fertile compared to other desert soils. The organic carbon content in surface and sub-surface soils varies from

0.39 to 0.76% and from 0.12 to 0.40%, respectively. The available P_2O_5 and K in the soil varied from 26-120 and 300-1000 kg ha^{-1}, respectively. The total nitrogen content in different *khadin* ranges between 0.018 to 0.035% and pH of the surface is usually below 8.5. The water holding capacity of *khadin* soils range from 200 to 250 mm per meter depth. ICAR - CAZRI has also contributed for constructing improved *khadin* in different parts of western Rajasthan. One such khadin at Danta in Barmer district has a catchment area of 137 ha with 6.88 ha under submergence. The total water storage capacity of *khadin* is 54.2 x 10^4 m^3 and beneficiaries are four farm families.

3.4. Watershed Management

Gandhiji's sustainable development is based on a holistic paradigm, which lays stress on all round development of individual and society in relation with nature. Participatory watershed management, which conform the Gandhian concept, has emerged as a new paradigm for planning, development and management of land, water and biomass resources with a focus on social and institutional aspects apart from bio-physical aspects following a participatory "bottom-up" approach (Sikka et al. 2018). Watershed management becomes increasingly important as a way to improve livelihood of people while conserving and regenerating their natural resources. Under various Watershed Development Programmes, an area of about 56.96 million ha has been developed since inception up to 2010-11.

Impact, adoption and spread of trench cum bunding: Trench- cum- bunding is an important *in-situ* conservation practice recommended for low rainfall regions with slopes up to 25%. The practice is being demonstrated in 15 districts as a part of the programme in several crops such as groundnut, pigeon pea, finger millet, cotton, maize, mango, etc. Yield improvement to the extent of 56% was recorded due to this practice. The practice also helps in minimizing soil erosion and the excess water was safely drained from the stone outlet particularly in soils with steep slopes. As part of the technology demonstration component of NICRA, so far 24 demonstrations were taken up on trench cum bunding involving 615 farmers in 7 states. There was a demand from the farmers to take up the practice and to facilitate with the department. In some of the NICRA villages, the extent of adoption of the practice was up to 85% of the total rainfed area in the village. The large-scale adoption became possible due to convergence with the developmental programmes.

3.5. Rejuvenation of Traditional Rainwater Harvesting System (Haveli Cultivation)

Haveli system of rainwater harvesting is the age old practice in Bundelkhand region to recharge the weathered zone. ICAR-Central Agroforestry Research Institute (CAFRI), Jhansi in consortia with ICRISAT, Hyderabad selected Parasai-Sindh watershed in Babina block of Jhansi district to manage its natural resources through agroforestry in conjunction with engineering measures. About 100 years back, rainwater harvesting on Haveli principle was done by community near village Parasai. Almost all the wells situated in Parasai village used to get recharged from this haveli. In early eighty's its outlet was clogged through debris and earthen embankment breached out in a length of 20 m. Community made several efforts to make it functional but

did not succeed in absence of technical guidance. In 2012, the community requested ICAR-CAFRI, Jhansi for repair and maintenance of Haveli system. Team of scientist visited the site and suitable cost-effective design of outlet was prepared and it was constructed in December, 2012. Area of submergence and volume were found 8.79 ha and 73000 m^3, respectively. The cost of rainwater harvesting in *haveli* is about Rs. 4.53 m^{-3} of storage. It was filled up by mid-July 2013 and all the wells of village Parasai got fully recharged to support drinking water during summer season. The system is very common in Bundelkhand therefore the experience gained from this will help this region in getting the benefits of rainwater harvesting. Renovated *haveli* with due support from series of checkdams in ephemeral streams resulted in one lakh m^3 surface water storage besides saturation of weathered zone in the watershed. The pre- and post-impact of haveli rejuvenation implementation scenario is given as below.

Particulars	**Before intervention**	**After intervention**
Increase in Groundwater table		
	More than 80% wells were dry during summer season	More than 95% well were wet during summer
Surface water availability for lifting	July – August	Up to 500 distance on both side of water course round the year in case of normal rainfall year
Cropping Pattern – Crops		
Rabi	Wheat, Chickpea, Mustard,	Wheat, Chickpea, Barley, mustard and vegetables
Kharif	Black gram, green gram, sesame, Sorghum.	Ground nut, Chikpea, soyabean, Urd, Moong.
Zaid	Fallow	Vegetables, Forage in fields and Bunds
Changes in vegetation	*Azadirachta indica*, *Butea monosperma*, *Terminalia arjuna, Anogeissus pendula*, *Madhuca longifolia*, *Holoptelia integrifolia* and *Ziziphus*	Tectona grandis, Aegle marmelos, Emblica officinalis, Moringa olerifera, Dalbergia sissoo, Syzizium cumini, Punica granatum, Annona squamosa, Carissa carandas, Eucalyptus tereticornis, Acacia senegal.
Fodder Resources	Berseem	M.P chari, Guinea, Napier hybrid

Haveli rejuvenation in Parasai-Sindh village has led to transformation of the Parasai village of Babina block of Jhansi district into a climate smart village as the farmers are now able to decide the crop/varieties as per their choice as there is no dearth of water even in case of 20-30% deficit in annual rainfall. The farmers have successfully transformed their traditional

Haveli renovation in Parasai-Sindh watershed; Masonry drop spillway (rectangular weir) and embankment along with corewall was constructed in 50 m breached area. Water harvested in Haveli during the monsoon period. Source: ICAR-Central Agroforestry Research Institute, Jhansi

and climate risky agriculture to Climate Smart Agriculture (CSA). Further, the rejuvenation of haveli system has changed thought process of the watershed dwellers about dealing with hazards of climate change.

3.5. Integrated Farming Systems

Gandhian principle advocates for 'natural insurance' by way of farmers choosing their crop without market-based inputs influence. Mixed cropping and farming mechanism encouraged under integrated farming systems provides the natural insurance to the farmers against nature's vagaries. Gandhian economics places importance to means of achieving the aim of development with non-violent, ethical and truthful in all economic spheres, which is also a basic concept of integrated farming systems having maximum complementarity without any competition. Mahatma Gandhiji advocated trusteeship, decentralization of economic activities, labour-intensive technology, and priority to weaker sections. Integrated farming systems developed with judicious mix of two or more enterprises emphasises for achieving household level food, nutrition, round the year income, self-employment, and sustainability especially for marginal and small farmers. The details of the IFS have been discussed elsewhere in this publication.

3.6. Sand-dune Stabilization

The field techniques adopted by ICAR-CAZRI for sand dune stabilization follows systematic processes; (i) fencing of the shifting dune areas for their protection against biotic interferences, (ii) fixing barriers in parallel strips or in checker-board pattern with locally available brushwood or grass materials to act as micro-wind breaks. Geometry of species depend upon whether wind directions, (iii) afforestation by direct sowing of grass seeds and transplanting seeding of indigenous and exotic species, (iv) planting of grass slips or seeds of grasses or leguminous creepers on the leeward side of the micro-wind breaks and (v) continuous and proper management of such dune till the cost of input is recovered in about 10-15 years duration. ICAR-CAZRI identified various plant species in different rainfall zones.

3.7. Shelterbelt Plantation

Shelterbelt plantations are vegetative barriers of tree/shrub/bushes. This technique is suitable for sandy plain areas. Trees were planted according to geometry of sheleter-belts at several sites for nearly 800 km on roadsides, on the state highways, along the railway tracks and also in tube well irrigated area of Lathi in Jaisalmer district and in IGNP area of Mohangarh. Orientation of the shelterbelts should be more or less perpendicular to the prevailing winds. Plantation across the wind of a 13 m wide tree belt, interspersed with 60 m wide grass belt provided the better impact. Eight years old plantation of three different types in Jodhpur condition showed effectiveness to reduce wind velocity and erosion up to 2 to 5 H distance and there was 50% reduction in wind erosion. Maximum benefits were derived from series of shelterbelts planted parallel to each other at distance of 10-15 times the height of the central row of trees. The *Cassia siamea* type shelterbelt (plantation of two outer line of *Cassia siamea* and the central line of *Albizzia lebbeck* was found to be the most effective. Ideal form of shelterbelt should be pyramidal in shape.

Plantations over dunes and shelterbelt plantations along the IGNP canals not only increased the vegetation cover but also stabilized the loose soils. Wind erosion affected area in western

People's participation in the preparation of checkerboard pattern on sand dunes in Bikaner and Churu district

Controlling sand slip over barren dune slopes using shrubs/grasses in horizontal pattern in Barmer-Bikaner districts

Impact of tree plantation: A sand free road side in Jodhpur

Shelterbelts along the IGNP canal

Rajasthan has declined from 76% (during 2000s) to ~73% (2011-13). Between 2003-05 and 2011-13, area under desertification in Rajasthan has decreased by 99092 ha. Wind erosion affected area has reduced by 1.34 lakh ha. Land use wise, wind erosion affected area on rainfed crop-land has reduced by 100667 ha and irrigated croplands by 21390 ha. Similarly, under shelterbelts, average loss in crop productivity was 17% due to cold wave in comparison to 30% on farms without shelterbelts. There was also a reduced 5-14% pan evaporation values on either side of belts.

3.8. Gum Arabic Inducing Technology

In the late 2000, CAZRI has identified a chemical concentration and procedure for the application, which can enhance the gum production without mortality to the trees. The technique developed by the institute has advantage over the traditional method in view that the plant is injured only at one place on tree trunk to inject CAZRI gum inducer and in turn it produces on an average 400-500 g gum Arabic tree^{-1} season^{-1}.The technique has shown an enhanced production (400-500 g gum arabic tree^{-1} season^{-1}) where compared to the traditional method (15-25 g gum arabic tree^{-1} season^{-1}). A 45° slanted hole of 18 mm diameter and about 3 cm deep is made on tree trunk at 1-2 feet above the collar of the tree with the help of hand drill or battery operated drill machine. After that, 4.0 ml of CAZRI gum inducer is injected in the hole with the help of syringe. After injecting the dose of gum inducer, the hole is immediately covered (patched up) by moistened clay. The tree started exuding gum tears after 8-10 days of the treatment.

3.9. Recycling of Weed Biomass through Composting

Mahatma Gandhi was in favour of self-sufficient village economy where the villages will be the independent economic units. Chemical fertilizer and other inputs are becoming too expensive in future, hence there is need to encourage regenerative agriculture. Farmers who generally uproot the weeds from their field and throw the weeds on the bunds or on the road-side without recycling them making compost or vermi-compost. Thus, this huge weed biomass goes waste. The conversions of these weed biomass into compost or vermi-compost helps to rejuvenate the agriculture fields. Many times farmers make complaint that using compost made from weeds increase weed problems in the subsequent crops. This may happen if compost is made from weeds by adopting non-scientific methods. It has been seen that weed seeds are not killed, if compost is made by heap methods and if such compost is used in the field, weed problem is increased. Directorate of Weed Research has evaluated and recommended the pit methods to make compost from the weeds, which has the potential to kill the weed seeds. This method does not require additional inputs and the farmers can easily be empowered about the technical know-how of this technology.

3.10. Climate Resilient Agriculture

In order to address climate variability and climate change due to global warming, ICAR has launched a flagship programme "National Innovation on Climate Resilient Agriculture

Recycling of weed biomass through composting

(NICRA)" in 2011. The vulnerability of Indian agriculture to climate change has been assessed to help the policy makers/planners for prioritization of the risk prone areas and building resilience. The project in the span of 9 years contributed in development of climate resilient varieties that can be cultivated in districts, which are frequently affected by natural calamities such as drought, floods, heat wave, cold wave, etc. Indian agriculture is monsoon dependent in 52% of its net cultivated area. To address delayed-onset of monsoon, mid-season dry spells and early withdrawal of monsoon, district agricultural contingency plans were developed for 650 agriculturally predominant districts. To solve the problems of timely sowing/ field operations in rainfed areas, the custom hiring centre were established in 151 vulnerable clusters under Technology Demonstration Component of NICRA. These custom hiring centres are operationalized through the establishment of Village Climate Risk Management Committees involving farmers themselves fulfilling the dream of Mahatma Gandhi's self-sufficient village economy concept,

4. Conclusion

Mahatma Gandhi envisioned inclusive growth in agriculture sector, leading to self-reliant village economy of India. Gandhiji's dream of establishing an organic link between people and the nature became foundation of sustainable management of natural resources for enhancing food production in India. The Indian Council of Agricultural Research is engaged in realizing Mahatma's dream of inclusive agricultural growth through 14 dedicated research institutes under the umbrella of NRM Division. Through a journey of excellence, ICAR has developed many on-farm technologies of sustainable soil, water, climate, weed and environment management, besides providing multiple livelihood options in the challenging ecosystems, viz. hills, deserts, coastal and rainfed areas. Technologies developed by ICAR institutes became a solid basis of many development programs that led to increased availability of food, fodder and fuel in rural areas. Committed scientific community engaged in natural resource management in the National Agricultural Research and Education System will continue untiring efforts to realize the Gandhian principles through local interventions in agriculture for global gains.

Chapter 8

Organic and Low Input Agriculture: Gandhian Way

AS Panwar, N Ravisankar, SK Sharma and G Suja

"To forget how to dig the earth and tend the soil is to forget ourselves".
MK Gandhi

1. Introduction

"*Gram Swaraj*" vision of Gandhi is based on making a village complete self-reliance in all the basics needed for a healthy life. He built the confidence and strength of organic farming in India (Bhaskar Save, Gandhi of Organic Farming). According to Barua (2015), Gandhiji remains the first and foremost advocate of the sustainable development. Further, environmental principles of Gandhi tailored with inclusive vision for India and the globe that required removing from nature what is needed for human nourishment. Gandhiji foresaw the modern problems back then, so many years ago, and also focused on solution for the same. Local or regional systems for ecological agriculture practiced in India are gathered and collectively called as '*Jaivik Krishi' or 'Jaivik Kheti'*. Emerging from 58,300 ha under certified organic farming in 2003-04, the organic agricultural area grown many folds and by March 2020, India brought 3.67 million ha (Mha) under organic production in which 62.6% area (2.299 Mha) is of cultivated agricultural lands and rest (1.37 Mha, 37.4%) being wild harvest collections. Currently only 1.63% of net cultivable area (140.71 Mha) is under certified organic production systems and Govt. of India has set a target to reach 4% (5.62 Mha) in 2025 considering the growth rate of this sector.

Four core principles of organic farming include health (sustainable enhancement of soil-plant-animal-human-planet health as one and undividable), ecology (living ecological systems and cycles, work, match and help to sustain), fairness (build on interactions which can ensure equality with regard to the collective environment and lifecycle prospects) and care (preventive and accountable manner to guard the wellbeing of present and future generations and the environment). These were taught and practiced by Mahatma Gandhiji in the form of Ahimsa (Non-violent with nature while doing farming), Poshan (nutrition to living systems), Cooperation and Self-reliance (Gram Swaraj).

This Chapter underlines the important concepts of Gandhian principles, which are highly relevant to organic farming and list the technologies generated under ICAR-Indian Institute of Farming Systems Research, Modipuram through All India Network Programme on Organic Farming (AI-NPOF).

2. Relevance and Applications of Gandhiji's Principles in Organic Farming

Complete self-reliance at the village level in all the basics needed for a healthy life was dream of Mahatma under "Gram Swaraj". Some of the important thoughts of Mahatma in the form of famous quotes such as "*Where there is soshan (or oppression), there can be no poshan*" implies and directly relevant to organic farming, low external input based agriculture. Many of these are more relevant in the present context as apart from production, other issues such as sustainability and environment friendly agricultural operations and production systems are being given due emphasis across the globe not only in India.

Gandhiji said, "*To forget how to dig the earth and tend the soil is to forget ourselves*" and it conveys the importance of land preparation and tillage, the basic aspects in any sound organic farming program in tropical tuber crops as the economic produce remains underneath. These crops are designated as "Underground crops with hidden treasures", for higher tuber yield, the soil physical properties need to be improved, which is achieved largely in organic agriculture. Moreover, in organic farming, nourish the soil and not the crops, which is well foreseen in the above quote.

The statement, *"Weeding is as necessary to agriculture as sowing"* indicates Gandhiji's concern for yield loss due to weed competition, irrespective of the farming strategy (conventional or organic). The potential crop yield loss due to weeds is estimated as 34% (Oerke 2006) or even up to 96.5% (Verma et al. 2015). Experimental evidences in tuber crops indicate that weeds result in 45-75% yield loss, besides affecting tuber quality. Weeding in organic agriculture via nonchemical, cultural and biological means, is an inevitable challenge, especially under highly erratic rainfall pattern in the context of climate change.

Gandhiji's view of Gram Swaraj emphasizes *"life of a farmer and a labourer"* is the best and it is based on his social experiments. The farmer, for him, was the central point, and the only sustainable social order was a rural society. In the context of gram swaraj, a farmer's life is necessarily *one of cooperation, not competition*. Exactly, the principle of organic farming systems relies on maintaining diversity of crops having maximum complementarity and without any competition.

In Gandhian way, agrarian economies are classified in to three categories such as Subsistence, commercial and market-oriented (Sudarshan Iyengar 2019). Subsistence farming (farmers grow enough for themselves without a marketable surplus) otherwise known as low external input based farming and commercial farming (farmers produce certain crops for the market, but keep their own food system intact by growing their own inputs) are highly relevant to concepts of organic farming. In the subsistence and commercial model of farming, the payout for purchasing of inputs are either nil or minimal. Integrated Organic Farming Systems (IOFS) promoted under All India Network Programme on Organic farming involving crops for household consumption, cash crops for income and livestock relies mostly on the on-farm

inputs rather than market inputs such as seeds, fertilizers, pesticides, etc. Gandhiji's principles do not support marketized farming (buy every input from the seeds to water, tractor, fertilizers- all of which are cash-based). Organic farming principles and practices also discourages the use of market inputs for several reasons such as cost, quality, timely availability, etc.

Gandhian principle advocates for 'natural insurance' by way of farmers choosing their crop without market-based inputs influence. Mixed cropping mechanism encouraged under organic farming provides the natural insurance to the farmers against nature's vagaries. Non-violent, ethical and truthful in all economic spheres were encouraged by Gandhi for achieving the aim of development. Trusteeship, devolution of economic actions, labour-skill intensive technology and importance to weaker sections were advocated.

Another principle of Gandhian way of farming proposed, agriculture will prosper when farming communities are able to feed themselves and their neighbours and are able to supply decent surplus to urban areas, and villagers don't feel the need to leave villages and go to cities. "*Farming is not man's business, it is his moral duty*" the other quote of Gandhiji implies, it is the honor of each and every person to appreciate and steward Life, whether in spirit or in practice. Gandhiji once said, "*to the hungry, God is bread*". These quotes further support the organic farming and low input based sustainable agriculture in way that even if organic farming results in low yield in the initial years of conversion, other benefits like ecological and social besides health needs to be counted instead of looking in to only the way of production enhancement.

3. Advantages of Organic Farming and Low Input Agriculture

Organic agriculture aims to rural development as it improves the value of all forms of life including rural communities, by satisfying and sustaining their socio-economic and traditional aspirations besides firming their social association, while protecting natural resources. Organic agriculture brings in the aspect of rural development as it combines tradition, innovation and science to help the environment, promote impartial relationships and thereby a superiority of existence for rural people. Holistic approach to organic agriculture adds to rural progress in many ways and most important are:

- **Enhanced governance:** Farmer is kept at the centre of the farming strategy, reinstating a decision- making part to native groups, guarantees their right to manage their individual resources and gives them freedom for engaging themselves and actively participates in value-added sustenance.
- **Vibrant economic space:** Condensed automation and avoiding use of agrochemicals make occupation and increase revenues to labour. Diversified production decreases the effects of crop failures and increases marketing chances. Income and food security is realized through multiplicity of crops and options under organic farming.
- **Healthy environment:** Integrity of the ecosystem and the productivity of natural resources are maintained through ecological approach being adopted under organic agricultural

systems. It conserves natural and wild resources, reinstates life to soils and upholds agro-biodiversity. Organic agriculture provides a healthier working environment to farmers by reducing the use of chemical inputs.

- **Social capital for rural areas:** Being knowledge and skill intensive, rather than capital and resource, it uses traditional information and promotes farmer-to-farmer interchange. Provides tools for review and control that strengthen social organization and authorize rural groups.
- **Sustains traditional food systems:** More and more farmers are dependent on only a few crops which demand considerable investments and create requirement on sometimes inaccessible and unsuccessful agri-inputs. Input costs are high and market prices remain to decrease making farmers and labors to think twice on cultivation. Farmers' knowledge of biological systems, setting and their conventional understanding play more role in making sustainable organic farming.
- **Decreased damage to natural resources:** Using large quantities of chemical fertilizers and pesticides under monocultures provoke degradation of land and water, resulting in the loss of productive lands and ecological biodiversity can be avoided if organic agriculture is adopted by the farmers
- **Reduction in poverty:** Organic farming results in better quality produces and tries to achieve the higher income due to premium product quality as well as eco-friendly production systems.
- **Manages migration:** Migration to cities is increasing mainly on account of search of alternative avenues for employment leading to marginal urban communities there by reducing the ability to purchase quality food. Organic farming with a principle of crop diversity and reduced usage of agro-chemicals ensures the quality products at affordable rates for the rural communities with several options such as value addition, cottage industries etc.

4. Connecting Dots between Gandhian Philosophy and Organic Farming

- *Swadeshi* (Connecting to the local economy), one of the tenets of the organic movement is eating locally and supporting local farmers. Eating organic also means supporting local seeds. In organic agriculture, local varieties with market demand are preferred.
- *Asteya* (Non-stealing), the idea of non-stealing is to pay farmers fairly for their produce, which is possible through the premium price of organic produce. Aswada (Control of the palate), fresh organic produce should be able to taste wonderful and natural without a thousand different ingredients to give it a better taste.
- *Ahimsa* (Non-violence), eating of organic food seems like a truly non-violent way to consume food. Chemicals are not deployed to kill different creatures that live in a farmer's field (with the exception for the main crop). Beneficial insects and microorganisms and useful weeds are preserved for advocating biological methods of control of pests and

pathogens. Organic agriculture actively works to preserve the ecosystem; and also prevents farmers from being overexposed to chemicals that severely affects the health of farmers and their families.

- *Asangraha*, emphasizes that waste is a sin against nature and nature's cycle must be recognized with ecological humility. Describes clearly about enough and satisfaction with the available production, which is being obtained under subsistence or commercial farming as envisaged. Gandhiji stood for integration and cohesion in the form of Yagna meaning replenishment of soil/nature. Principles of organic farming also emphasize health, ecology, fairness and care.

5. ICAR's Activities in Realizing Gandhian Principles

Network Project on Organic Farming (NPOF) was initiated during 2004-05 by Indian Council of Agricultural Research (ICAR), New Delhi with Project Directorate for Farming Systems Research (PDFSR) as nodal institute in order to develop a comprehensive technological package for organic farming in different crops in system mode. Four experiments were planned and conducted at 13 centres to address, all issues such as comparative evaluation of organic, inorganic, and integrated crop management practices, method and source of nutrient application, management of pest, diseases and weeds in various crops/ cropping systems. The mandate of the project was made to infuse scientifically validated organic farming approaches and to develop location/ region specific management protocols for organic farming. During 2014-15, the Directorate was renamed as ICAR-Indian Institute of Farming Systems Research and organic farming programme was further strengthened in 2015-16 by increasing the number of centres under All India Network Programme on Organic Farming from 13 to 20. Several technologies including package of practices for cropping systems, identification of varieties and integrated organic farming systems have been developed under the scheme. Some of the achievements with impact are highlighted below.

6. Technologies Developed for Organic Farming

6.1. Package of Practices (PoPs)

Scientific package of practices for 51 cropping systems suitable for 12 states for organic production of crops in cropping systems perspective have been developed. These packages results in higher productivity in majority of the crops compared to the traditional or indigenous farming practices in niche areas (rainfed, hilly) and crops. For example, the productivity obtained with developed PoPs are 3.9 t ha^{-1} in coarse rice, 3.2 t ha^{-1} in basmati rice, 4.1 t ha^{-1} in wheat and 22.3 t ha^{-1} in potato. Productivity of majority of the crops obtained under scientific organic farming packages is greater than the countrywide average productivity of major crops.

Developed packages have been shared with Department of Agriculture, Cooperation and Farmers Welfare under Ministry of Agriculture and Farmers Welfare for up-scaling through developmental schemes of Government of India such as *Paramparagat Krishi Vikas Yojana*

(PKVY) and Mission Organic Value Chain Development in North Eastern hill region. Around 1 lakh farmers having 70,000 ha area have been federated into 130 FPOs under MOVCD-NER to whom the technological backstopping is being provided through the scheme.

Table 1. Yield ratio of organic and inorganic production systems in multi-location trials.

Crops	Number of observations	Yield ratio	Crops	Number of observations	Yield ratio
Basmati rice	67	1.04	Okra	10	1.18
Rice	52	1.00	Chilli	12	1.09
Maize	37	1.10	Onion	13	1.07
Sorghum	17	1.14	Garlic	9	1.04
Greengram	12	1.07	Cauliflower	12	1.04
Chickpea	24	1.00	Cabbage	5	1.11
Soybean	54	1.04	Tomato	11	1.06
Groundnut	16	1.03	Ginger	12	1.20
Pea	21	1.25	Turmeric	18	1.46

Yield recorded at multiple locations under organic over inorganic management reveals that many crops reacted positively to yield higher or comparable (Ravisankar et al. 2016). Mean yield ratio obtained from multi-location trials of various crop groups indicated that organic-to-inorganic (purely synthetic input based management) was 1.04 indicating clear advantage of organic over inorganic production systems (Table 1).

6.2. Improving the diversity & natural enemies

Key factor in agricultural systems of India during earlier years was diversity in crops providing stability and resilience besides economic security to the farmers. Gandhiji termed it as *natural crop insurance* against weather vagaries. Research experiments proved that reduction in genetic-diversity lead to more susceptibility especially insects. The cumulative improvement in natural enemies due to organic production system in various crops was found to be 175 to 297%.

6.3. Economic viability

Studies conducted under AI-NPOF revealed that across the locations, net return was 17% higher with organic production system compared to inorganic. Cost-benefit analysis of tuber crops indicated that the net profit under organic farming was 20-40% higher over chemical farming (Suja et al. 2016).

6.4. Varietal identification for organic farming

Best performing varieties under organic management have been identified for cereals (coarse rice, basmati rice, durum wheat, maize), pulses (chickpea), oilseeds (groundnut, mustard, soybean), vegetables (tomato, pea, okra, cauliflower, french bean), fibre (cotton) and spices

(turmeric, blackpepper). With scientific packages, many of the traditional varieties and improved varieties of crops are found better for improving the productivity under organic farming systems. Cassava var. Sree Reksha was identified as the most productive under organic, followed by Sree Pavithra.

6.5. Resource conservation under organic farming

Resource conservation practices under organic farming have been standardized for Soybean-Wheat, Groundnut + Cotton (2:1), Greengram-Sorghum and Soybean + Pigeonpea (2:1) with BBF, flat bed with crop residues for Karnataka, Carrot- Okra in raised bed and Rice (Lampnah) -Pea in sunken bed for Meghalaya and direct seeded rice with chickpea on broad bed – greengram for Uttarakhand.

6.6. Integrated organic farming systems (IOFS)

One acre Integrated Organic Farming System (IOFS) models suitable for marginal farmers have been established in seven States namely Gujarat, Kerala, Meghalaya Rajasthan, Sikkim and Tamil Nadu which provides scope to generate more than 80 % of inputs especially nutrients required for organic farming with in the farm, thus significantly reducing the cost of production.

6.7. Geo-tagged characterization of organic farmers

Characterized organic (3,331 farmers) and natural farming (51 farmers under AI-NPOF + 30 farmers under AICRP-IFS) households from 17 States/UTs. These farms are geo-tagged to observe the changes. Yield gap between farmers practice and scientifically developed organic farming packages of 30 major crops analyzed and it ranged from 4% in Garlic to 50% in mustard.

6.8. Documentation, characterization and validation of traditional practices

The traditional practices used by farmers have been documented and some of the practices are also being scientifically validated. Bio-chemical and microbial characterization of indigenous preparations such as *Shasyagavya, Panchagavya, Kunapajala* and natural farming inputs such as *Ghanjeevamrit & Jeevamrit* have been made. Identified the free-living N fixers, phosphorus and potassium solubilizes from these indigenous preparations. Traditional practices have sustained the farmers and farm households with less dependency on market inputs thus reducing the cost of cultivation. These traditional systems or practices were more sustainable though not much productive.

6.9. Impact

Institutional development such as National Programme for Organic production (NPOP) launched during 2001, followed by setting up of National Centre of Organic Farming (NCOF) under Ministry of Agriculture and Farmers Welfare and initiation of research through All India Network Programme on Organic Farming (AI-NPOF) under ICAR-Indian Institute of Farming

Systems Research by ICAR during 2004 laid the foundation for systematic development of technologies for organic farming in the country. Further with the implementation of two flagship programmes namely *Parambharaghat Krishi Vikas Yojana (PKVY)* and Mission Organic Value Chain Development in North Eastern hill region helped to expand the area under organic farming in India. Started with just 58,300 ha during 2003-04 (the year of launch of AI-NPOF by ICAR), the area under organic farming has grown almost 39-fold, reaching to 2.299 million ha by March 2020 (APEDA 2020).

India is now the ninth largest in terms of arable land under organic farming and largest in terms of total number of organic producers in the world. Conducive policy, technological advancements, demonstrations and farmer led innovations have contributed for phenomenal increase in area besides the market. India is producing wide range of crops under organic management with oilseeds, sugar crops, fiber crops, cereals and millets and pulses occupy the large chunk of the basket. India produces around 2.75 Mt (2019-20) of certified organic products export volume and value of 6.389 lakh tonnes, Rs 4,686 crores (689 million US$) respectively. Therefore, launch of All India Network Programme on Organic Farming by ICAR helped significantly for promotion of organic farming practices in India supporting Gandhian principles. Promotion of towards organic (integrated crop management) approach for input-intensive areas (food hubs) and certified organic approach by integrating tradition, innovation and science in the default organic areas (hill and rainfed/dryland regions) will be better option considering national food security, higher household income and climate resilience (Aulakh and Ravisankar 2017) which will further enhance the safe food production and meet the social values of Gandhiji.

7. Low input agriculture

Low input farming encourages farmers to adopt practices that decrease/eliminate the use of synthetic fertilizers while, at the same time, aims to improve the soil carbon content. Reduced tillage, anaerobic composting, using organic fertilizers, mulching, intercropping, multi-cropping, and lot of other techniques specially designed for particular regions, populations and climatic zones are used.

- Establishing fuel, fodder and fruit components and protecting those present already on the farms.
- Planting of multiple crops belonging to different families for supporting biodiversity.

Crop mixes promotes resilience through balancing the ecology thus reduces the risk of crop failures due to pest attack. Multiple cropping further enhances the risk exposure for farmers against unreliable rainfall. In present context, research work done under ICAR-All India Network programme on Organic Farming, Maharana Pratap University of Agriculture and Technology, Udaipur and several other research projects, indicate that organic farming is more economic when local resource based inputs are used in the production packages.

7.1. ICAR Initiatives on Low Input Natural Farming

A multi-location study on "Evaluation and validation of Natural Farming Practices in different Agro-ecologies" has been initiated from *Kharif* 2020 at 20 locations covering 16 States and 8 cropping systems. Components of the study are

- Geo-tagged survey of natural farming farmers field (covers 16 States)
- Characterization of inputs (Jeevamrit, Ghanjivamrit, Beejamrit, Agniastra, Neemastra and Brahmastra) at selected location (Narendrapur, Coimbatore, Udaipur, Ludhiana and Calicut).
- On-station field experiment on "Evaluation of Natural Farming Practices In Different Agro-ecology" at 19 locations in 15 States
- Addition of natural farming input in the existing long-term experiment on comparative evaluation of different production systems (20 locations in 16 States)
- Validation of natural farming practices in farmer's field under SCSP/ STC sub plans (7 locations in 7 States)

8. Success Stories

8.1. Meghalaya (Integrated Organic Farming System cluster)

Mynsain village in Meghalaya was adopted under Scheduled Tribe Component (STC) of All India Network Programme on Organic Farming for demonstration of organic food production through integrated farming systems approach. A total of 120 households having area of about 60 ha were covered to demonstrate and promote organic farming using cluster approach. Scientific interventions such as development of pond, jalkunds, community vermicomposting unit, raised and sunken beds and fruit tree plantations were made to achieve the Gram Swaraj philosophy of Mahatma Gandhiji in Mynsain village of Meghalaya. Organic food production using IOFS approach resulted in saving of costs on account of purchased nutrients, better recycling, safe food and balanced nutrition to the family besides eco-friendly agriculture giving higher returns for the marginal and small farmers in the region. Considering the benefits from the IOFS model with a net return of Rs. 73,005/- per year from 0.43 ha. IOFS gives better family nutrition besides round the year income to the farmers in the region. The organic outlet established in the national highway has linked the farmers to the market.

8.2. Sikkim (First organic State in India)

Agriculture in Sikkim generally was practiced under low input situations (nutrient consumption of <25 kg ha^{-1}). Keeping these in mind, the Government of Sikkim declared in 2003 to transform Sikkim in to totally "Organic State" by 2015. The productivity of all the food grain crops has shown increase after the steps were taken to promote organic farming in the state from 2003 onwards. The productivity of pulses increased from 878 kg ha^{-1} to 954 kg ha^{-1} over time. The productivity of the food grains rose by 19.73% during 1995-96 to 2017-18. Productivity of rice was only 1.43 t ha^{-1} when fertilizer consumption was highest (21.5 kg/ha) during 2002-03

(before Sikkim Organic Mission), but during 2013-14, rice productivity increased to 1.81 t ha^{-1}, and no yield reduction was observed during initial 3 years which are considered as conversion period. Productivity of other crops is also increased to the tune of 11%, 17% and 24% in maize, finger millet and buckwheat, respectively. Study involving sample households in three districts of Sikkim *viz.,* East Sikkim, West Sikkim and South Sikkim indicates farmers uses local cultivars for all the crops except some Cole and other vegetable crops which is one of the *major principles of Gandhiji under Gram Swaraj*. The input used is FYM @ 9.57 t ha^{-1} in case of cereals like maize and @ 15 t ha^{-1} for ginger. Phytoneem (neem extracts) and pheromones traps are used for plant protection.

Improving the productivity of crops in Sikkim through Scientific approach: Scientific packages developed for organic farming in different crops needs to be promoted among the farmers by State agencies as these have potential to improve the productivity and income of the farmers. Rice, maize, soybean, ginger, turmeric and large cardamom yield can be enhanced significantly through adoption of scientific method of organic farming which have been demonstrated in the villages using cluster approach by Regional centre of ICAR-Research Complex for North Eastern Region, Gangtok and also under All India Network Programme on Organic Farming (Table 2).

Table 2. Yield of major crops in Sikkim at on-station, ICAR demonstration plot in comparison with State and National productivity.

Crops	Productivity at research farm (q/ha)	Productivity at ICAR clusters demonstration (q/ha)			State average productivity (q/ha)	National productivity (q/ha)
		Cluster-I	Cluster-II	Mean		
Rice	34.90	32.2	34.9	33.55	18.45	24.40
Maize	32.60	33.0	30.2	31.60	17.53	25.09
Soybean	11.26	28.2	19.0	23.6	8.96	10.09
Mustard/ Toria	8.90	7.9	9.8	8.85	8.85	11.83

9. Lessons Learned and Path Ahead

The Green Revolution ushered in an element of self-reliance at the macro level by bringing in two types of technologies: bio-chemical technology (involving fertilizers and seeds), and agro-mechanical technology (involving mechanization of agriculture). However, considering the sustainable development goals and also providing rural employment, the following pathways need to be promoted for achieving the self-reliant villages in a Gandhian way.

- **Development of resource specific PoPs for *Bharatiya Prakratick Krishi Padhiti* (BPKP):** Current organic farming package of practices developed and are being promoted are based on the nutrient demand of crops to achieve the parallel productivity level among organic

and conventional farming. This was essential to build the confidence of the farmers to choose the alternative production system. However, in order to promote the BPKP, it is essential to develop resource specific (availability of land, labour, capital and ability to generate organic resources within the farm) package of practices for various categories of farmers.

- **Re-designing of existing package for improving the yield of rabi crops:** Due to the weather associated limitations on microbial activity and release of nutrients from soil, productivity level of *rabi* crops are lower under organic production system and BPKPs compared to integrated crop management or conventional systems. Therefore, efforts will be made to re-design the strategies for increasing the nutrient availability from soil for *rabi* crops in both organic and natural farming systems.
- **National Digital Repository on BPKP:** After through study and standardization of various practices, a national digital repository can be created to access the best practices of organic and natural farming.
- **Skill and entrepreneurship development for rural youth and farmers:** Capacity building programmes through the identified institutions shall be carried out for rural youths and farmers with the involvement of SAUs.
- **Scaling up of developed IOFS models with Central and State Agencies:** Linkage with State and Central agencies shall be further strengthened to scale up the developed packages and organic farming system models.

10. Conclusion

Environmentally sustainable technologies such as organic farming systems emphasizes on enhancement of productivity without harm to the environment. This approach of Gandhian agriculture needs to be promoted to achieve the sustainable food and nutrition security. Multi-location research experiments on various crops including tubers shows that organic production system with scientific packages can be promoted as an viable option especially in the low market input consuming areas such as rainfed and hilly areas for sustainable and safe food production. Promotion of "towards organic" (integrated crop management) approach for intensive agricultural areas (food hubs) and "certified organic farming" with mixture of tradition, innovation and science in the default organic areas (hills) and rainfed/ dryland regions will pay towards safe food security and climate resilience, besides augmenting the income of farm households. Generation and addition of crop residues, green manuring, waste recycling, compost fortification, crop rotations involving legumes, establishment of biogas and expansion of agro-forestry are some of the approaches that will help to encourage biological farming and will also contribute to realize Gram Swaraj dream of Mahatma Gandhiji. His vision of subsistence and commercial farming for rural India can be achieved through promotion of organic farming or scientifically designed and integrated packages having *Bharatiya Prakratik Kheti Padhiti* comprising of several methods including natural farming, biodynamic farming and panchagavvya krishi.

Chapter 9

Environment-friendly Agriculture: Gandhian Principles

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"The Earth has enough resources for our need but not for our greed."
MK Gandhi

1. Introduction

The unprecedented growth in consumption and production of food with over-use and mis-use of natural resources has led to environmental stresses globally (climate change, ozone layer depletion, acid rain, acidification of oceans); as well as locally (pollution of air, water and soil and desertification). The United Nations Environment Programme (UNEP) cautions for precarious state of global environment. Questions are being raised whether growth at the cost of environment and its non-renewable resources are sustainable and the advancements in the scientific and technological fields are based on a situation where cooperation of man and machine exists with each other or the machine has overpowered human? The inter-relationship amongst development, environment and poverty, has been identified by the World Commission on Environment and Development, and concluded it as "Poverty is one of the indicators for global environmental problem".

The world and India, in particular is facing the harmful effects of environmental degradation today that Gandhiji envisioned in the early 1900s. The condition of environment at that time was clean and pure. Bapu observed that the world would be hotter as on-coming disaster (Hind Swaraj 1909). He also added that the continuation of trend prevailed during that time can make the world crowded, polluted, ecologically less stable and more vulnerable to disruption leading to serious stresses for both the human and environment. Bapu was also aware about the impact of air pollution. He emphasized that nature has provided fresh air free of cost but the present civilization has priced it. At Ahmedabad meeting on January 1, 1918 he emphasized the need for purity of air, water and food. He said, "*We are generally careless about air, water, food and hygiene*" and opined about River Ganga that "*The washing of the cloth and defecating are recklessness in nature and it leads to pollution of air and water and it will destroy the dharma and disregard duty to society*". In this Chapter we revisited the Mahatma's vision on environment, illustrated the testimonies of Gandhiji's efforts on environment conservation, assessed the contribution of ICAR for promoting environment-friendly agriculture and analyzed Gandhiji's influence on national policies on environment and agriculture.

2. Mahatma's Vision on Environment

In the modern sense, Gandhiji was not an environmentalist and the big environmental issues of the present arose in the post-Gandhi period. Even without losing the quality of life, however his ideals can be implemented to stall further worsening of environmental ill-effects. He was a thinker with a profound ecological sensibility. Bapu gave the world a new vision of harmonising nature with the desires of individuals. Arne Næss, the philosopher from Norway with the idea of "deep ecology", acknowledged his realization of "the essential one ness of all life" from Gandhiji. Bapu believed in four principles viz. Satyagrah (holding onto truth, non-violence, fighting with peace), Sarvodya (universal uplift), Swaraj (self-rule or self-governance) and Swadeshi (self-sufficiency).

His concern about the environment was evident in his speeches, writings and messages. He said, *"The natural resources like earth, land, water and air are not received from our ancestors but it is loan from our children and we have to hand over to them as we received".* He possibly was one of the "world's early environmentalists in vision and practice". Many of the environmental movements in India were inspired by Gandhiji. All the international conferences such as the Stockholm Conference (1972) and the Rio Earth Summit (1992) were convened much later than the concerns raised by Gandhiji about the environment. The international organizations such as United Nations and national organizations of different countries took initiatives such as UN Framework Convention on Climate Change (UNFCCC) and UN Environmental Programme (UNEP) much later. Major movements to protect environment in India such as the Chipko Movement and the Narmada Bachao Andolan derived inspirations from the Mahatma. Gandhiji's seminal work, Hind Swaraj (1909) discussed aptly environmental destruction and the threat to the planet. Today when the world is talking about achieving the Sustainable Development Goals (SDGs), the Gandhian ideas have become increasingly relevant. Gandhiji, through Swaraj or self-rule, showed a realistic sustainable development, which can be accepted without sacrifice the quality of life. He thought that mass production by individual is not better that production by masses, which lead to development of an economical system with less harm to environment and help in achievement of sustainable development.

He taught his followers the problems of ecology, pollution and exhaustion of non-renewable resources. He emphasized that man must recognize the necessity of cooperating with nature and conserve the natural resources of earth for the continuation of human civilization. Animal life and human life are totally interrelated and both need each other for long survival because science and artificial technology are incapable of providing for the continuity of human life by substituting its methods of those of nature. Gandhian holistic ideas included Trusteeship, Swadeshi, Self-sufficiency, Bread Labour, and Village Swaraj (Gandhi 1959). According to Gandhiji, every person on this planet has natural right to get basic necessities of life (Patil 1983). Necessarily, it implied a specific lifestyle of simple living and high thinking. In order to encourage the best possible use of local raw materials, skills and workforce, to encourage occupational equilibrium, ecological balance and cooperative living, he wanted the villages to

be the decentralised economic units. With the aid of local resources, the village will be able to generate whatever is needed and would be intended with whatever has been generated in closer surroundings.

Mahatma was a strong advocate of conservation of natural resources. He emphasized the importance of man-and-environment relationship on natural resources and its conservation. He said "*Nature is the best example for inspiration and I do not need inspiration from other accept nature. She never failed me as yet, she mystifies me, bewilders me, sends me to ecstasies*." The importance of Gandhian philosophy is well-felt in the present period in which the lifestyle of human beings has been developed in a direction of high consumerism and generation of waste. The ideas of Satya (truth) and Ahimsa (non-violence), so profoundly promoted by Gandhiji encompassed all living beings. Once, Edward Thomson, English historian said to Gandhiji that wildlife was rapidly diminishing in India. Gandhiji, in his characteristic sarcastic way replied, "*Wildlife is decreasing in the jungles, but increasing in the towns.*" His concept of Sarvodaya, what we say 'sustainable development' today, implies a healthy development and environment. What he preached and practiced corresponds to what we today call eco-friendly development. 'Simple living' is the well-known Gandhian prescription that helps both to curb human greed and over reaching, and to prevent the visionless manipulation of natural resources.

He was practicing and preaching recycling of waste, decades before the idea caught on in the world. He cherished the principles of non-injury, cared for the environment, practiced vegetarianism, worked energetically to conserve water, air and soil, prevent the destruction of developers, recycled paper, or accorded animals the dignity of humans. He believed that whatever is taken out of nature is to be recycled back through the natural process.

Bapu recommended use of organic manure to retain texture and quality of soil and was apprehensive about use of tractors and chemical fertilizer, which he felt, will spell our ruin (Harijan 1948). He highlighted the potential use of human excreta and urine as valuable manure (Navajivan 1919) and observed that use of animal excreta and backyard kitchen waste carry potential to keep the premises free of disease and to increase fertility of soil with no much labour work (Harijan 1935). Vision of Bapu was full of strategies for environmental safety as evident from the fact that he was very much aware about solar power and he suggested to conserve the energy (letter dated 13-11-1945 to Pt. Jawaharlal Nehru).

Gandhiji could foresee the devastating impacts of deforestation and over-use of renewable resources and chemical fertilizers leading to pollution of soil, water and air; global warming and desertification. His firm belief in nonviolence has unlimited ecological potential. His ideology of nonviolence with vegetarianism as a just one particular consequence of this faith, comprises safety of all living beings that contribute to the diversity of life (biodiversity). Swadeshi is the Gandhian policy that fostered self-reliance through the use of local goods, and showed a way to propel economy and employment in India. While the destruction of India's biodiversity was triggered by rampant industrialization, thoughtfully and systematically applied Swadeshi concept would have gone a long way in promoting environment friendly and sustainable

development models. He was deeply concerned about impact of atmospheric pollution on human health and was worried about the precarious working conditions in manufacturing industries, with employees being forced to inhale contaminated and toxic air.

Gandhiji believed in a life form based on three fundamental principles: Simplicity, Slowness and Smallness. Life of this kind can be based on renewable resources only. The pattern of life predominated by the pastoral and agricultural system is conducive for sustainability of the environment. A society based on renewable resources, such as forestry and agricultural products, is superior to a civilization founded on non-renewable resources i.e., oil, coal, etc. This is because the "*former and not the latter can last; the former co-exit with nature, while the latter rules over it; the former holds the sign of life, while the latter of death*" (Schumacher 1997).

2.1. Testimonies of Gandhiji's Efforts on Environment Conservation

Gandhiji made sincere efforts to practice his ideas of environmental principles in actual life. His Tolstoy and Phoenix Farms in South Africa and the Ashrams he subsequently established in India testify this. Throughout his life he demonstrated the importance and personal practice of health, hygiene and sanitation. Gandhiji was a practitioner and an ardent advocate of vegetarianism. "Nature cure," a traditional Indian method of medicine, was also practiced by him. He was a committed practitioner of recycling and reuse. The ecological dimensions of Gandhiji's thinking can be comprehended in the following examples. He regularly practiced 24 hours of silence, which was an ecological gesture, a mode of energy conservation and a devastating indictment of the current industrial culture of noise and consumption. He was a full-fledged critique of "noise pollution". He did not prevent others from killing snakes but a cobra entering his room was left alone. "*I do not want to live at the cost of the life even of a snake*," he said.

Gandhiji mounted a rigorous critique of the "waste" that is behind modern industrial civilization in more ways than we imagine. His close disciple and associate Kaka Kalelkar, when plucked leaves, Gandhiji advised that we should pluck leaves based on need and before plucking it we should apologise to tree. Gandhiji was a vegetarian but European visitors to his ashram, where only vegetarian meals were prepared, had meat served to them, if they desired. To inflict a new diet upon someone who was habituated to meat at every meal was, in Gandhiji's thinking, a form of violence.

Gandhiji not only believed that "*one must be the change that one wants to see in the world*", he actually practiced it and always preached the same. His life was his message. He used to write brief notes on scrapes of papers and reuse the envelops to send letters by reversing it. He was consciously using only the minimal water required for bathing, even when he used to bathe with free-flowing water from the Sabarmati River. He believed that all living beings had the right to exist equally as human beings and enjoyed a lively bond between humans and the rest of the animate world. He believed that humans should harmonize with its surroundings in all walks of life.

Gandhiji established the Tolstoy Farm, after the name of famous Russian writer Leo Tolstoy of War and Peace fame, in the south-western corner of the Johannesburg, South Africa. Now it has been announced as a heritage site. It had 1000 fruit bearing trees with almonds, apricots, figs, peaches, walnuts and a small plantation of eucalyptus trees. Bapu started satyagraha campaign in South Africa from this farm between 1908 and 1914. Tolstoy Farm was the second of its kind of experiments established by Bapu and first example was the Phoenix farm in Natal in 1904. In the Tolstoy Farm people belonging to different nationality, religion and colour lived together like one family. The people worked hard and shared the fruits of their labour. Bapu spent a good part of his time at Tolstoy Farm in teaching the children and engaged in other constructive activities. Bapu had fight for Black acts and poll-tax from this farm and all people residing in the farm were involved in this movement.

3. Contribution of ICAR for Environment-friendly Agriculture

The Gandhian philosophy, if accepted as the guiding principles for development planning, can provide a practicable conceptual basis for building sustainable development. In tune with the principle of Gandhiji for practicing environment-friendly agriculture, Indian Council of Agriculture Research (ICAR) is working on the concept of applied, basic and strategic researches to develop sustainable technologies for management, conservation and optimum utilization of the natural resources ensuring food, nutritional and environmental security in the country. ICAR remains committed to generate cost-effective and environment-friendly technologies by harnessing the developments in science for the cause of sustainable agriculture and self-reliant farmers. For location-specific soil and water conservation measures, ICAR has established 75 model watersheds. Resource conservation technologies (crop management, laser levelling, zero tillage, bed planting and site-specific) are also developed and popularized to save water, nutrient, labour and energy. ICAR has initiated Pt. Deendayal Upadhyay Unnat Krishi Shiksha Yojana under which 130 capacity building programmes on organic/natural farming and cow-based economy have been introduced in 32 State Agricultural Universities (Anonymous 2018). It is further working on various aspects of conservation agriculture, residue and waste management, mitigation of climate change, soil health improvement and many other areas to find the solution for climate change, low factor productivity and degrading natural resource base in environment-friendly manner. Some of the prominent examples in this aspect are presented below.

3.1. Integrated Farming System

Several Institutes of ICAR have successfully implemented and promoted Integrated Farming System (IFS) models in various agro-ecologies (Singh et al. 2016). The IFS is a multi-disciplinary holistic approach for cultivation of different crops and growing of animals including livestock, poultry and other enterprises on the same land to ensure sustainable use of farm resources. It is diversified farming based on spatial, temporal and ecological factors for maintaining and regeneration of the biotic interaction for development of suitable ecosystem services. The

IFS involves best utilization of the growing space; ensures nutritional and economic security by growing different cereals, vegetables, fruits, other cash crops and livestock products from same piece of land; improves food security through local production and consumption; control migration; enriches soil nutrient status and biological components while improving soil physical and chemical properties and provides a strong base for best agricultural practices to increase productivity. Bapu's thought on the sustainable development thorough IFS approach has been implemented by ICAR-Mahatma Gandhi Integrated Farming Research Institute, East Champaran, Bihar and ICAR-Indian Institute of Farming Systems Research, Modipuram, Utter Pradesh. The institutes selected crop components such as a cereals, pulses, oilseed, vegetables, sugarcane and green fodder, which were grown in various cropping sequences and enhanced the productivity. The dairy components selected are Murrah buffaloes and Gir cow along with their calves. The horticulture component included mango, guava, peach, pear and karonda plants as boundary plantation across the garden boundaries. With respect to fishery components, composite carp culture (Rohu, Catla, Common Carp, Mrigal, Silver Carp and Grass Carp) has been adopted (ICAR-IIFRS, Annual report, 2018-19). Sixty integrated farming system models suitable to 26 States and Union Territories have been developed to enhance productivity, profitability and livelihood for sustainable agriculture. These models are being promoted across the country in order to reach the farmers through different ICAR institutes, Agricultural Universities and KVKs. All these models have different agricultural components ranging from crop to livestock, which use every opportunity to recycle the byproducts for higher productivity with no cost to environment.

3.2. Organic Farming

Organic farming aims for higher productivity and income without damaging the environment and relies on the principles of ecology and sustainability. ICAR has improved the practices with the modern concept of innovation and science to mitigate the degradation of critical resources (water, soil and bio-diversity) and minimize the consequences of climate change. During the tenth Five-Year Plan, it was established as a 'Network Project on Organic Farming (NPOF)' at 13 centres. Subsequently, in the 12th plan, seven new centres were included for organic farming in some of additional crops such as seed spices and tuber crops and hilly and rain fed regions. Scientifically generated data revealed yield advantage (after 8th cycle across the locations) of all crops including basmati rice, soybean, garlic, groundnut, cauliflower, tomato. In addition, improvement of soil organic carbon; increase in soil microbes (fungi, bacteria, actinomycetes) and nutritional quality improvement in ginger, turmeric and soybean under organic production were observed (IIFSR 2019). Organic farming has become a major movement in the country and several states such as Sikkim and other states in North-East Hill region, Uttarakhand, Himachal Pradesh, Andhra Pradesh, Madhya Pradesh are adopting this practice in a big way. Several Institutes in ICAR such as ICAR-National Organic Farming Research Institute (NOFRI), Sikkim are working on organic farming, the practice firmly adopted and promoted by Bapu. Package of practices for organic farming for 51 crops/cropping systems have been developed by ICAR to keep environment safe. These practices return at least as much as being

taken from the soil in tune with Bapu's thoughts. These practices are being promoted in 20 states including north-eastern states through various programmes. Recently, recycling the crop residues has gained momentum to prevent environmental pollution and institute like ICAR-IARI have successfully demonstrated use of microbial products to degrade paddy straw that can rapidly become component of soil. This can prevent the air pollution due to straw burning and can safe-guard health of human as well as soil.

3.3. Waste Recycling

Bapu had a vision for recycling of every waste. Institutes like ICAR-Indian Institute of Water Management, Bhubaneswar and ICAR-National Institute of Abiotic Stress Management are working to fulfill the dream of Bapu. The use of organic manure in the form of vermin-compost as a fertilizer has been successfully demonstrated in the farmers' fields by ICAR institutes.

3.4. Climate Change: Adaptation and Mitigation

Climate change is causing significant shifts in weather patterns throughout the world. It has emerged as the biggest challenge of the present era to the sustainable development. As per the Intergovernmental Panel on Climate Change (IPCC 2018), greenhouse gas accumulation due to increased anthropogenic emissions has caused 1.0 °C rise in global temperature above the pre-industrial levels, which may further increase to reach 1.5 °C between 2030 and 2050, causing greater frequency of extreme weather events and obstruction to the normal functioning of ecosystems. India is considered to be one of the most vulnerable regions to witness such changes at a large scale, and is likely to have significant impacts on agriculture production and farm livelihoods. Due to increased temperatures, altered rainfall patterns and more frequent and severe floods and droughts, food production would be affected. ICAR institutes are working for reducing the impacts of climate change on agriculture and started a mega-project as National Innovations on Climate Resilient Agriculture (NICRA). It is also working for mitigating greenhouse gas emission. Many options have been developed to minimize the harmful impacts of climate change and reduce risks to agricultural systems (Pathak et al. 2014, 2019). Options range from change in crop management to modification in cropping systems and land use to adapt to new climate. Options for mitigating methane, a greenhouse gas emission include water and nutrient management in crops and efficient fodder management for livestock. For reducing emission of nitrous oxide, options include soil-test and leaf-colour chart-based application of N, use of slow-release fertilizers and nitrification inhibitors such as neem-coated urea. In addition to reducing emissions, these options also have co-benefits, such as cost savings, increased productivity, improved soil quality and reduced pollution. ICAR has come out with the estimation of C sequestration capacity in the country's agricultural soils. It has developed and validated contingent crop plans for 623 districts, which includes technological solutions to overcome weather disasters in crop, horticulture, animal husbandry, poultry farming, fisheries and other fields. These contingency plans provide information on the selection of alternative crop varieties/crops and agronomic steps to be taken in cases of extreme weather events.

3.5. Renewable Sources of Energy in Agriculture

One of the key requirements for sustainable development in agriculture is the efficient use of energy. Rapidly depleting fossil fuels and their detrimental effects on the environment have now placed greater focus on use of renewable energy. ICAR has developed agri-voltaic solar farming system for raising income from agriculture and generation of electricity. The model enables growing crops under the solar panels. Other solar devices like solar photovoltaic (PV) pump, PV mobile unit, PV winnower cum dryer, PV duster, dryer, cooker, are also developed for domestic and small agricultural applications. These devices enable farmers to grow more and generate income because they have low operating costs and have an environmentally sustainable and uninterrupted power supply.

4. Gandhiji's Influence on National Policies on Environment and Agriculture

Since Independence the country has focused on food security in short and long terms along with sustainable development of agriculture and environment. Major initiatives of Govt. of India for developing environment-friendly and climate-resilient agriculture have the underlying principles of Gandhiji. Most of the environmental movements in India took inspiration from his ideals and strategies. Forest Satyagraha, which was used against deforestation in Chipko Movement is a good example. To save nature, Padayatras and Anashans were conducted. Environmental activists including Baba Amte, Chandi Prasad Bhatt, Sunderlal Bahuguna, Medha Patker and others have been using dispute resolution strategies based on non-violence and self-sacrifice. Some of the major initiatives of Govt. of India are presented below.

4.1. National Mission on Sustainable Agriculture (NMSA)

This mission seeks to resolve sustainable agriculture concerns and strive to establish suitable adaptation strategies to ensure better livelihood opportunities, food security and economic stability. The NMSA has identified 10 main areas including improved farm practices, nutrient management, water use efficiency, integrated pest management; improved crop seeds, livestock and fish culture; credit support; markets; agricultural insurance; access to information and livelihood diversification.

4.2. Rainfed Area Development (RAD) Programme

The RAD programme is launched to ensure agricultural growth in the rainfed areas, and focused on Integrated Farming System (IFS), which is useful for enhancing productivity and minimizing risks of climatic variability. It can be integrated with the crops/cropping system such as agro-forestry, fishery, livestock, horticulture and apiculture to improve livelihood of the farmer and also solution for the negative impact of extraneous climate viz. flood and drought.

4.3. National Agroforestry Policy (NAP)

The NAP aims to provide a platform for stimulating agroforestry development in India and

consider, it as integral component of farming system. It helps to fulfil the demand of fodder, fuel timber, food, fibre, organic manure and also conserves the natural resources and forest, protect environment and enhanced the forest area. Agroforestry is the most important farming system, which maintain and mitigate the negative effects of climate change. It also maintains the natural resources through sequestration of carbon in short and long terms.

4.4. Pradhan Mantri Krishi Sinchai Yojana (PMKSY)

The PMKSY not only meant for establishing assured irrigation sources, but also aims to create protective irrigation by rain water harvesting at micro level through its components 'Jal Sanchay' and 'Jal Sinchan'. Under the scheme 'Per drop-More crop' is ensured through popularisation of micro-irrigation. The PMKSY enables States to formulate their own framework for the development of irrigation based on District and State Irrigation Plans.

4.5. Govt. of India's other initiatives

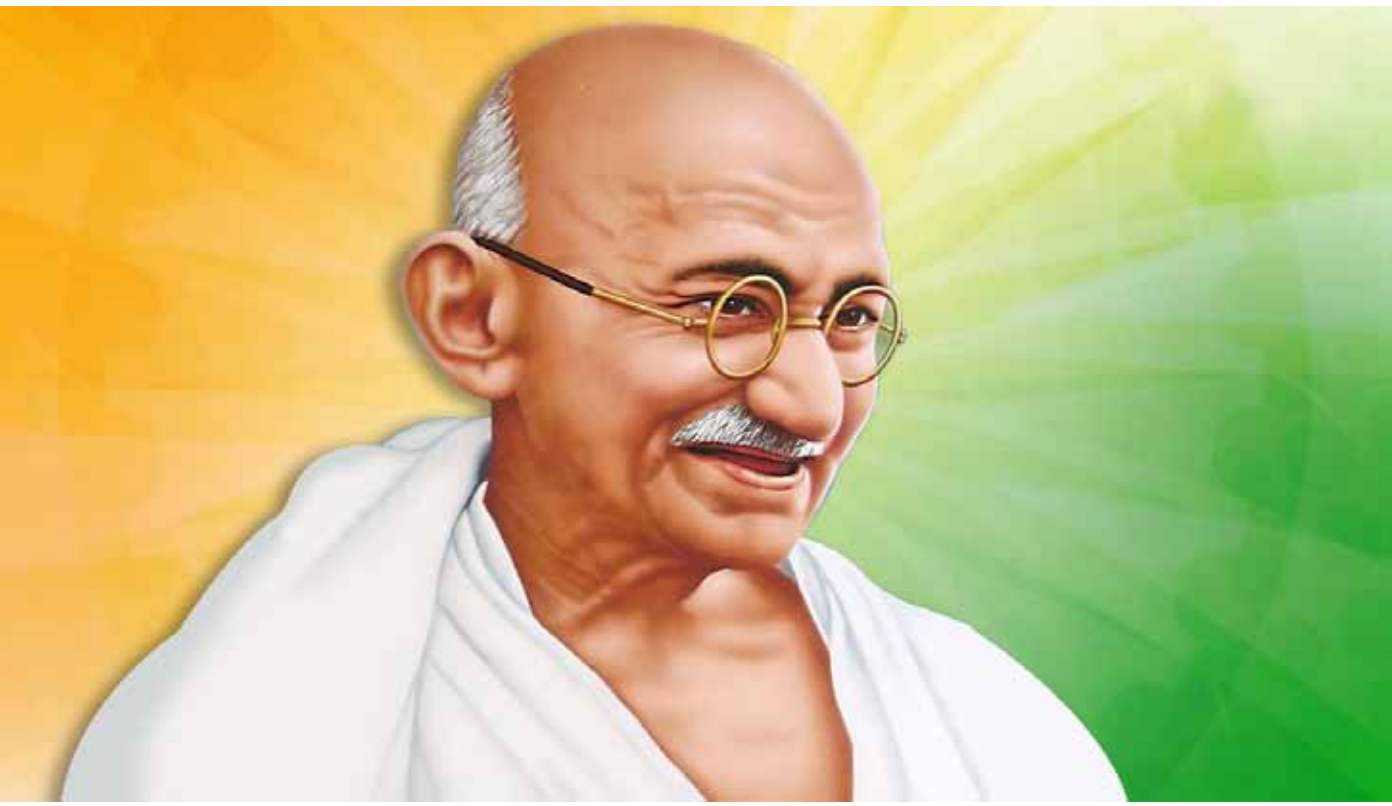
Other major programmes of Govt. of India such as Mission for Integrated Development of Horticulture (MIDH), Pradhan Mantri Fasal Bima Yojana (PMFBY), National Food Security Mission (NFSM), National Mission on Oilseed and Oil Palm (NMOOP), Paramparagat Krishi Vikas Yojana (PKVY) and Rashtriya Krishi Vikas Yojana (RKVY) put emphasis to implement climate-resilient technologies in farmers' fields. Indian government also started scheme for solarisation of farm irrigation at national scale with, *Kisan Urja Suraksha Evam Utthaan Mahaabhiyan* (KUSUM) for solar farming.

The water conservation technology *in-situ* and *ex-situ* in rainfed agriculture are being upscaled through Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). The scheme is for promotion of water management in farmer field through On-Farm Water Management (OFWM) to improve on-farm water use efficiency. The National Livestock Mission (NLM) has been initiated for improving livestock productivity besides protection of environment, preservation of animal bio-diversity and safeguarding bio-security and farmers' livelihood. For the sustainable development of fisheries the organisation has been setup as National Fisheries Development Board (NFDB) to achieve the goal. Mission Antyodaya for poverty reduction aims to primarily realize the long-standing dream of Bapu with respect to poverty-free India and also at sustainable developmental goals, which depends on elimination of poverty and hunger across the world. Panchayat Raj implemented at the smallest administrative block of the country derives its principle from Swaraj and Gram Raj. This gives sufficient decision-making power at village level and to protect their environment.

Bapu observed that most of our villages and cities are ground of dirt and diseases due to lack of proper sanitation facilities. Bapu's dream of making our villages free of dirt, diseases and pollution is now being realized by Swachha Bharat Mission of the Government. The mission implements the suggestion for cleanliness emphasized by Bapu in day-to-day life. This scheme has made many of our villages defecation-free, which was strongly advocated by Bapu.

5. Conclusion

The essence of the Gandhian approach was treating Nature as a friend and benefactor of humanity. Gandhiji a century ago had a vision of sustainability and environmental concerns. Even today unequal distribution of income, unemployment, poverty and inequality exist as they were when Gandhiji used to advocate sustainable development. There is no doubt that we need to safeguard our planet from pollution and adverse effects of climate change through adoption of sustainable approaches. We need to follow principles of Bapu as Satyagrah, Sarvodya, Swaraj and Swadeshi. The ICAR, along with its Institutes and universities is engaged in research and development of natural resource conservation and environmental protection since its inception with substantial positive impacts on rural livelihood and environment.



Chapter 10

Small Agri-Enterprises and Waste Management: Gandhian Thoughts

CR Mehta, S Gangil, R Naik and SK Giri

"It is quite strong to say I don't believe in machinery. This spinning wheel is a beautiful piece of machinery. How can I be against machinery? This body itself is the most delicate machinery".
MK Gandhi

1. Introduction

Increase in agricultural production has simultaneously resulted in the generation of large quantities of agricultural crop residues, livestock waste and other agro-industrial by-products. A significant increase in global agricultural wastes production is expected if the developing countries continue intensification of farming systems. This has opened up ample scope for the establishment of rural entrepreneurship based on utilization of various agro-wastes viz. residues from the growing and processing of raw agricultural products such as crops, fruits, vegetables, meat, poultry, and dairy products. It is estimated that about 350 million tonnes (Mt) of agro-based organic waste is produced in India every year (Harshwardhan and Upadhyay 2017). Converting some of the waste materials into valuable products or energy could be an efficient way of waste management. People in rural India have limited access to energy. The rural energy situation at present is also characterized by a low quality of fuel, low energy use efficiency and low reliability of supply leading to lower productivity of land, water and labour, ultimately leading to poor quality of life and environmental degradation. Thus access to quality, reliable and affordable energy is very much essential for promoting economic and social development in rural areas. Gandhiji wanted to use the resources of a village in that village itself. The energy should be generated using the energy resources available at the village and the generated energy should be used by the residents of that village.

Gandhiji had firm belief in self-sufficiency and self-reliance of rural India. His dream was to see each and every farmer and villager working for all round development of village and nation. All rural people should get the proper work and substantial money for their livelihood. The essential facility should reach to the villagers and if possible, to be managed by villagers. The dependency of rural area to the urban area and industries should be as low as possible. The resources available in the villages should be adequately managed, engaged and channelized to give employment to rural mass specially covering the rural youth and women.

Agro-based industries can prosper in rural India where manpower is abundant and labour cost is also low. Developing agri-enterprises can immensely benefit the rural economy by generating employment opportunities, reducing the burden on agriculture, reducing the need for migration from rural to urban areas, and increasing the individual and national income in rural areas. The objective of this chapter is to highlight some of the agricultural waste based technologies developed by ICAR-CIAE for rural entrepreneurship development.

2. Gandhian basics of rural development and its link with small enterprises and waste management

Mahatma Gandhi had a very clear perception on villages and made an assertive statement that "*India lives in her seven and half lakhs of villages*'. He believed that the progress of the country lies in the development of the majority of its rural sector through development of skills of rural people and rural industrialization. Gandhiji found the only way of improving the livelihood of the rural people is by making villages as the central place in the economic programmes. Rural development as outlined by Gandhiji contained self-sufficiency, inter-dependence for other wants and development of rural industries. The Gandhian strategy of rural reconstruction was based on village Swaraj and Swadeshi movement.

Agriculture was given prime importance in Gandhiji's conception of Swaraj. He desired that policies would help strengthen agriculture and establish cottage industries for production of goods essential for the people. According to Gandhiji, the village economy cannot be completed without essential village industries such as hand-grinding, oil-pressing and other agro-based industries. The village industries would generate employment to millions of people, and provide an outlet for the creative skill and resourcefulness of the people. Under Village Industries Scheme, individuals need to engage themselves in home industries in their homes and cottages. Mahatma Gandhi emphasized on production by the masses and not on centralized mass production. While production is to be carried out individually in a large number of places on a small scale, the sharing of raw materials and marketing of finished goods are to be carried out collectively on a corporate basis. He wanted to carry production units to the homes of the masses, particularly in villages. As Gandhiji was for the development of the cottage and rural industries, he also suggested delocalization of industries as he believed that decentralization is essential for the survival of democracy and for the establishment of a non-violent state.

In rural areas, people generally depend on the locally available resources to generate their wealth and for their livelihood support. The enhancement in the income of rural folk and sanitation were the basics of Gandhian thought of rural self-reliance. This can be achieved only by optimizing the use of human and other resources available in the villages. Rural development is closely linked with the biomass resources that any village may have. The rural area produces ample wastes which can be efficiently used to provide energy security, enhance income and employment to rural livelihood. The waste management plants to be introduced for such types of resources in the rural area may be small or cottage level industries. Examples

of such industries may be briquetting plants, bio-gas plants, biomass based power plants, bio-fertilizer plants, bio-char plants, etc.

Integration of cottage industries with agriculture will provide work to the farmers in their extra time and thus will harness all the energy that at present is being wasted. In fact, these industries are best suited to the cadence of rural life. These industries can increase the income of the villagers and help in satisfying their basic requirements. They not only remove poverty and unemployment from the villages but also make them self-sufficient in economic units.

3. ICAR's Technologies for Agro-waste Management and Rural Entrepreneurship Development

3.1. Use of biomass/crop residues for rural livelihood

Biomass contributes a major share (1/3rd) of primary energy in India. Biomass fuels are largely used for cooking and water heating in rural households and by traditional and artisan industries. Different researchers have given different estimates of biomass availability in rural India. Pathak et al. (2004) assessed the quantity of recoverable biomass from cropland, grassland, forest, roadsides, and agro-forestry. The amounts of crop and agro-processing residues produced and the surplus available for the energy generation in 2008-09 were estimated at 699 Mt and 233 Mt, respectively (NAAS 2010). This quantity of biomass is sufficient for sustaining 15,000 to 16,000 MW power potential. Under the Gandhian philosophy, such vast energy resources should be used for development of the nation, especially for development of rural India. The agricultural waste, especially crop residues can be diverted for making briquettes, carbonaceous material, composts etc.

3.1.1. Improved cook stoves for clean rural kitchen

Gandhiji stated that the cooking in rural India should be clean enough so that women health is not compromised. The cook stoves or *chulhas* play a major role while using solid fuels like crop residue based briquettes, fuel wood or cow dung cakes. In rural India, 50 millions of households still use solid fuels and kerosene based stoves for cooking due to economical and temperamental issues. Inefficient stoves pollute the kitchen and home environment that adversely affects health of women, old people and children who spent more time at home. To reduce the emission while cooking, several improved cook stoves have been designed by different organizations. Family size-batch type and community size-continuous type cook stoves are also promising. These stoves have precise fuel and air supply control. Improved cook stoves with higher thermal efficiency, higher heat transfer, lower emissions, low particulate matter and safety features can successfully reduce emission by 90% and can save 40-50% of fuel. The Ministry of New and Renewable Energy, Government of India has also taken steps for promotion of biomass-based improved cook stoves through standardization of designs, quality assurance and quality control of the stoves which is showing success in recent years. Cost of the family size stoves ranges from Rs. 1,000 to 3,000 and of community size stoves from Rs. 15,000 to 40,000 depending on

size. The community size cook stoves can be used in various small scale industries and reduce cost of production of their produce, as 54% of small scale industries are installed in rural area.

The rural kitchens need to be targeted first. This is because rural women are facing an acute pollution problem in household kitchens. Further, the uses of firewood also need to be reduced drastically to save our forest and green cover. By serving rural women, we will serve 50% of the rural population and the foundation of future generation. Gandhiji also propagated that woman equality is needed for a balanced society. The first thing than can be done is to introduce the smokeless improved cook stoves all over India. This will save about Rs. 10,000-12,000 lakh at the national level being spent by rural people for firewood due to enhancement in the efficiency of cook stoves.

3.1.2. Briquetting of biomass

Briquetting is the process of densification of the loose biomass to high density. The briquettes can be produced using either binderless technique where no external binders are added or with binder where molasses, clay, soil, sodium bentonite tar or any other materials are added. The density, transportation, storability, and usability of loose biomass are enhanced due to such briquetting process.

CIAE Improved cook stove

In binderless technique, the biomass is subjected to high pressure (5 to 60 MPa), which affects the lignin to fluidize resulting the binding of cellulosic particles. Binderless briquetting machines are piston press type, screw press type and roller-die type. Due to high pressure and heat, powder form of crop residue is converted into solid cylindrical briquettes. Crop residue briquettes have density from 650 to 1200 kg m^{-3} and calorific value from 3900 to 4200 kCal kg^{-1}.

Such binderless briquettes are in high demand from many industries for thermal applications and power plants. Gandhiji thought that small units of agri-waste based industries may be installed well within the villages. The rural panchayats can establish such plants and nearby cottage industries can be served with solid bio-fuel obtained from crop residues which is a by-product of village itself. The average cost of production of such briquettes is about Rs. 3 kg^{-1} of briquettes which can be sold at the average price of Rs. 5.0 kg^{-1}. Such briquetting plants have payback period of six months.


Binderless briquetting of crop residues

Briquetting with binder is low pressure technology where some binder binds the base material. A small plunger type or screw type manually operated machine can be used to produce briquettes from biomass char. The char produced is normally mixed with cattle dung or soil in the ratio of 10:1 by weight. An adequate amount of water is added to the mixture to obtain the moisture content in the range of 30-35%. ICAR-CIAE Bhopal has developed an extruder type power operated charcoal briquetting machine with a rated capacity of 80 kg hr^{-1}. In this technology, cow dung is used as a binder with grinded crop residue at 30:70 proportions and kept for overnight. This machine consists of a screw press which compresses the feed mixture and produce briquettes through the multiple dies of 25 to 30 mm size. These briquettes are sun-dried and have calorific value of 3700-3800 kCal kg^{-1}. Different types of machines for briquetting of biomass with different binders have been developed and are commercially available. These briquetting machines can be used on custom hiring basis and produced briquettes can be sold for the household purpose in *chullahas*, brick kiln, small scale food industries and *anganwadis*.

Power operated charcoal briquetting machine

3.1.3. Biomass based decentralized power generation system

The grid electricity supply in rural areas is characterized by unreliable supply, fluctuating voltage, and shortage of power in most parts of India. Coal-based power plants (accounting for 70% of electric power generation) are leading to environmental degradation and global warming. Hence, there is need for decentralized and renewable energy-based options to meet the rural energy needs in a sustainable way. Among all the available renewable energy sources, biomass is considered as the largest, most diverse and readily exploitable resource. In India, the biomass gasifier is an option among different bio-energy technologies for meeting the rural domestic electricity needs as well as for agricultural and rural industrial activities.

Biomass gasification involves partial combustion of biomass under controlled air supply, leading to generation of producer gas. It constitutes the combustible gases like hydrogen (20%), carbon monoxide (20%) and methane (1-2%). The energy value of producer gas is about 5.0 MJ m^{-3}. The producer gas can be used as a fuel for internal combustion engines for mechanical and electrical applications. Biomass gasifier systems based on woody biomass, raised on wastelands have the largest potential to meet rural electricity needs in most parts of

A crop residue based electricity generation plant

India. The small size of gasifiers can be installed at community scale or at road side *dhabas* saving about 20-30% of fire wood per installation.

The decentralized biomass gasifier-based power generation system can provide electricity for lighting, drinking water, irrigation water and flour-milling services in rural areas. A 20 kW gasifier engine generator based system can meet all the electricity needs of a village of about 200 people.

3.1.4. Bio-char production

Bio-char is a carbonaceous material produced by pyrolysis of biomass. It is increasingly recognized for its potential role in fuel, carbon sequestration, soil amendments and reducing greenhouse gas emissions. It is a stable carbon rich solid that can be used to lock carbon in the soil. Bio-char is of increasing interest because of concerns about climate change caused by emissions of carbon dioxide (CO_2) and other greenhouse gases (GHG). Biomass feedstock and the processing conditions are the main factors determining quality of charred material. The major constituents of the charred material are organic matter, volatile matter, mineral matter (ash), and moisture. The use of bio-char as soil amendment is proposed as an approach to mitigate man-induced climate change along with improving soil productivity. In order to sequester carbon, a material must have long residence time and should be resistant to chemical processes such as oxidation to CO_2 or reduction to methane. It has been suggested by many researchers that the use of bio-char as soil amendment meets the above requirements, since the biomass is protected from further oxidation from the material that would otherwise have degraded to release CO_2 into the atmosphere.

3.2. Bio-gas technology

For management of animal excreta in rural sector, a systematic approach is still lacking to make them self-reliant and provide a sustainable source of income generation. Besides many other resources, bio-gas technology could be one of the important aspects to support the livelihood of the people in rural areas. The method to generate bio-gas includes anaerobic digestion of organic wastes as feedstock in a digester. This technology is well proven and has the ability to fulfill cooking, electricity and thermal needs. This clean and green technology will also help in satisfying Gandhiji's Swachh Bharat concept and livelihood support using Swadesi technology. The bio-gas technology has already played vital role in managing the animal excreta in rural India. The animal excreta can be digested anaerobically to produce bio-gas using different types of biogas plants. At present KVIC and Janata type plants are two most popular and basic designs. Both are good designs and have been installed in lakhs in rural India. The bio-gas or *gobar* gas generated is a good fuel gas which can be used for rural kitchen as clean fuel for cooking. The digested slurry coming out of the plant is a good organic fertilizer and be directly applied into the agricultural fields. The digested slurry can be dried and the dried portion becomes good and valuable garden fertilizer whereas the liquid fraction is recycled in bio-gas plants. The bio-gas can also be used for illumination using mental-burner and electricity generation using alternator. The requirement of bio-gas for powering a 60 W bulb is 0.13 m^3 hr^{-1}. For electricity generation, bio-gas can operate a dual fuel engine to replace up to 80% of diesel-oil in diesel genset.

Pile foundation based structurally modified floating drum type bio-gas plant for vertisols.

3.3. Generation of wealth from crop waste (banana pseudo stem)

By virtue of its gigantic growth, banana plant produces a large amount of biomass. More than two-third of total biomass produced during banana cultivation consists of the pseudo stem, leaves, mid rib, peduncle and corm. As banana is cultivated throughout the year, it can supply raw materials round the year for production of a wide array of products. Banana pseudo stem, which goes as waste or cut and recycled into the field can be utilized for making many kinds of value added products and handicrafts from different parts of the stem (Naik et al. 2015). This will help in generating an additional income to farmers and rural entrepreneurs.

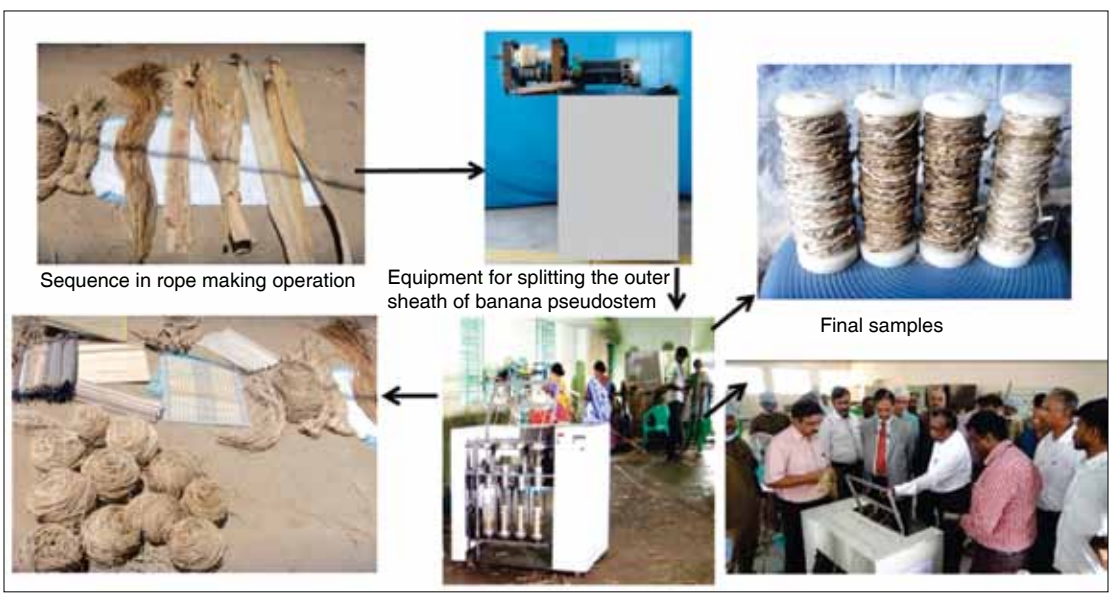
3.3.1. Rope making from banana pseudo stem fibre

In the pseudo stem, out of 14-18 layers, only 9-10 layers of inner sheath of the plant yield fibre. The fresh banana pseudo stem yields about 1.5 - 2.0% of fibre. It is estimated that annually 30 million tonne of biomass is produced through banana cultivation, from which there is scope to produce 1.5 million tonne of banana fibre across the country as by-product. The importance and use of banana fibre has been under exploited due to the lack of awareness and lack of systematic research on structural and physical properties of the fibre. From outer sheath, coarse

fibre is extracted while fine fibre is extracted from the inner sheath. Both the fibres can be utilized for making many kinds of handicrafts and household products like hand bags, purses, table mats, mobile cover, CD pouches, net bags, ornamental covers, door mats, curtains, file covers etc. There is a good scope for setting up of banana fibre based industry in India. It has been reported that about 300 kg of banana fibre which can fetch a value of about Rs. 1.2 lakhs can be extracted from *nendran* variety of banana plants from one hectare. It can provide employment generation to rural sector, particularly women.

ICAR-CIAE has developed a package of equipment to mechanize the rope making process in collaboration with ICAR-NRC Banana, Trichy. The package of equipment consists of equipment for splitting the outer sheath of banana pseudo stem and twisting and winding of splitted strands (Naik et al. 2016). It has got advantages over manual method of twisting and winding in terms of more uniform twist, lower space requirement by 70-80%, less dependency on skilled labour by 65-70%, cheaper than manual labour and higher output. The capacity of the equipment is 10,000 to 15,000 metre strands/day. The twisted rope is used for production of various eco-friendly handicraft materials like bags, window curtains, table mat etc which has huge demand both in local and international markets.

There is a huge production of banana in the country and banana pseudo stem is mostly a waste product. Farmers have to make investment to clear the field for the next crop. The outer sheath of banana pseudo stem when processed for rope making would fetch about 2.4 lakh metre of banana sheath rope valued at Rs. 1.0 lakh ha^{-1}. It is a win-win situation for all the persons in the supply chain.



Flow chart of mechanization package for rope making from outer sheath of banana pseudo stem

3.3.2. Value added products from banana central core

About 12,000 to 15,000 kg of edible central cores can be extracted from one hectare of banana crop. It is rich in digestible fibres, iron, vitamins B3 and B5. It can also be blended with any other fruit pulp. Banana central core is cut into small pieces and served in cooked form is traditional culinary dishes in south Indian homes. The brief details of products made out of central core of banana stem are given below.

Pickle: The product is prepared by making slices of the central core of banana stem and by adding spices and preservatives to it. The product can be stored up to a period of six months and is rich in fibre.

Juice: Juice is extracted from the central core of banana stem, which is having property of dissolving kidney stone. It can be stored safely up to six months.

Powder and core soup: It is one of commercial products made out of central core of banana stem. The central core powder is used as a source of carbohydrate and fibre. Soup is used as an appetizer and taken before any meal to aid in digestion.

Candy: The core part of banana stem is used for preparing candy, which is sweet in taste and rich is fibre. It can be stored safely for three months.

The mechanization package for minimal processing of banana central core has been developed by ICAR-CIAE Bhopal in collaboration with lCAR-NRC for Banana, Trichy. It consists of slicer, dicer, fibre remover, surface water remover, juicer/grinder and juice squeezer. By using this package of equipment, one can save time and cost up to 65% and labour by 70% for minimal processing of banana central core. The banana central core which is wasted mostly can be converted into value added products for human consumption, thus helping in generating additional revenue to banana farmers/entrepreneurs/ processors.

Mechanization package for minimal processing and juice extraction from banana central core.

3.4. Technologies for waste management from soybean processing industries

Soybean is an environment friendly grain legume and a major source of protein, oil and health promoting phytochemicals for human nutrition and livestock feed around the globe. Soymilk, a water extract of soybean, is gaining popularity in recent years and is one of the fastest growing market segments. Special features of soymilk are low cost, good nutrition and suitability for lactose intolerant people. Properly processed soymilk and its derivatives offer many nutraceuticals and health benefits and are widely used in India and across the globe.

3.4.1. Soy based food products using okara

Soy okara

Okara is a by-product from soymilk production industries. It consists of 3.5-4.0% protein, 76-80% moisture and 20-24% solids. On a moisture free basis, okara contains 12 to 14.5% crude fibre and 24% protein. Okara has a limited shelf-life and is highly prone to putrefaction due to its high moisture and nutrient content. It has thus a limited commercial use at present. ICAR-CIAE has developed technology for preparation of protein rich bakery products and other fermented products using okara. The use of okara in preparation of food products will help in eco-friendly disposal of soy processing unit waste by making soy based food products like biscuits, cakes, muffins, *Gulabjamun,* idli, dosa, etc., which are rich in high quality protein. Okara can also be used as animal feed, especially for farms in vicinity of soy milk or tofu production plants. It can be added to compost to add organic nutrients and nitrogen. Use of okara can provide regular income to rural entrepreneurs associated in soy milk and tofu production thus improving their economic status.

3.4.2. Tofu whey for starter culture production

Tofu whey based culture media

In the process of tofu preparation, soymilk is coagulated by heating in combination with salts, acid or enzymes. This generates a liquid by-product called tofu whey, which is highly perishable and is discarded by most of soybean processing industries. There is a need for effective utilization of this waste product as it is a good source of carbohydrates, some free amino acids, isoflavones and protein. Tofu whey contains valuable compounds like non-digestible oligosaccharides and is recognized as pre-biotics.

Technology has been developed for converting tofu whey into culture media for micro-organisms. An easy and low-cost production procedure has been developed to facilitate preparation of lactic starters for food fermentation. Several combinations of sugars, salts, yeast extract and tryptone are added as supplements in tofu whey.

3.5. Solar energy based gadgets for rural upliftment


Solar pumping system

Economic development of India depends on self-sufficiency in the village economy through upliftment of rural individuals and community. Availability and utilization pattern of energy at village level play an important role in deciding self-sufficiency with regard to their food, clothing and shelter. Besides above basic needs, people should have good options to avail different energy resources for cooking, drying food products, post-harvest operations, value addition and safe storage of crop produce. To fulfil the rural energy demand, solar energy can be a good option. But, harvesting of this energy needs different devices such as solar photovoltaic cell, heat collectors, concentrators, dryers, cookers, etc. Solar energy can be utilized through solar thermal route and solar electric (photovoltaic) route. Solar thermal route uses the sun's heat to produce hot water or air, cook food, dry materials, etc. Solar photovoltaic uses sun's heat to produce electricity for lighting homes and buildings, running motors, pumps, electric appliances, etc.

To strengthen the activities, the Government of India is promoting and distributing/installing solar street light system (SLS), home lighting system (HLS) and solar lanterns (SL) in different states for upliftment of rural individuals. The number of SLS, HLS and SL distributed/installed were 7.53, 17.21 and 75.86 lakh, respectively. Total cumulative solar pumps of different capacity installed in different states of India are 2.57 lakh on 31.08.20. The technologies like solar cookers, sprayers and dryers along with solar powered refrigeration system may also play an important role in supporting the rural livelihood. These technologies will help in all-round development of rural people by utilizing local available solar energy to conduct different on-farm and off-farm activities. The Ministry of New and Renewable Energy (MNRE) of GOI has launched a scheme on "Scale Up of Access to Clean Energy for Rural Productive Uses" with an aim to enhance the use of reliable and affordable renewable energy for rural productive uses/livelihoods in un-served and under-served areas in three states (Assam, Madhya Pradesh and Odisha) for strengthening rural livelihoods, improving income generation and reducing use of fossil fuels. Thrust will also be given on solar dryers, solar cold storage, solar aerators, etc. The use of solar energy for livelihood support of rural people not only reduces the air and water pollution but also a sustainable source of energy generation with less maintenance. The developed technologies on solar energy have multi-dimensional aspect for enhancing energy

sufficiency in the rural India and could be a constant source of income generation. As the energy is being extracted from solar, the need of using the firewood energy and other fossil fuel based energy reduces which create clean and green environment.

4. Dissemination of Waste Management Technologies

Teaching and preaching through practical demonstration are the most effective Gandhian ways to disseminate ideas to the public. For any technology and concept for rural development, the practical example should be shown first to people and then approach of "learning by doing" is to be followed. Gandhiji was of the opinion that the rural mass should be educated about the new technologies and they may be motivated to use these technologies/methods or ways of living. Further, Gandhiji considered that school education was the foundation of rural development. We should educate the rural youth, student and children first about the new and future technologies which can save our environment and nation future. The information given to rural youth, student and children remains longer in the society and has long term positive and tested impact. It is because the children grow and judge the knowledge given to them on many forums for long time and then the real implementation of technology/knowledge occurs. Gandhiji used to say that children learn much faster than others. Also, children are our future and thus the best level of education should be given to them.

5. Conclusion

The Gandhian philosophy of overall development of rural sector is based on the use of local resources for self-reliance. The use of waste for rural benefits further adds into this philosophy. The waste to wealth was also one of the main ideas of Gandhiji. The rural sector produces mainly two types of wastes viz. agricultural wastes and animal excreta/waste. All these can be channelized to generate the energy and to provide rural livelihood security in Indian context. The agricultural waste can be dealt using different technologies like briquetting, charring, composting, bio-methanation, gasification and electricity generation, and converting those into food, feed or industrial material. Animal waste mainly excreta can be converted into wealth using bio-gas generation, composting, pelleting, electricity generation and bio-CNG for automobiles. The excreta produced in the villages can also be routed to bio-methenation system to generate the fuel gas which can produce either electricity or illuminate by burning in mantels. The integration of all these technologies can also solve the problem of rural India. The final target is the use of these resources for income and employment generation in rural areas for their sustainable livelihood security.

Chapter 11

Nutri-cereals for Food and Nutritional Security: Gandhian Principles

Vilas A Tonapi, Nepolean Thirunavukkarasu, Lakshmi Kant and K Haiprasanna

> *"I submit that scientists have not yet explored the hidden possibilities of the innumerable seeds, leaves and fruits for giving the fullest possible nutrition to mankind. It almost seems to me that it is reserved for lay enthusiasts to cut their way through a mountain of difficulties even at the risk of their lives to find the truth. I should be satisfied if scientists would lend their assistance to such humble seekers."*
>
> MK Gandhi

1. Introduction

We take Mahatma's above statement as a founding principle of our science. We consider seed is the life and has immense possibilities to contribute the nation's food and health security. We took his message forward and contributed to the nation's food security thus we become a food surplus country. Though our plates are full, the nutrient content of the food is challenging in terms of balance of essential nutrients. Inadequate nutrients in foods leads to health problems resulting in drastic reduction in individual's performance. Hence the logical conclusion of the food security is the "nutritional security" and the "Nutri-Revolution" is an order of the day. This, in fact is envisaged by the *Father of Our Nation,* 100 years ago.

Millets, as it is called commonly, comprise of an array of small but strong grain species such as sorghum, pearl millet, finger millet, foxtail millet, kodo millet, little millet proso millet and barnyard millet. Millets are part of the Indian civilization and rural wisdom. Since time immemorial, cultivation of millets is the integral part of the Indian farming. India is considered as either primary or secondary centre of origin for most of the millets and our ancestors were domesticated the millets.

"The result of reading all this literature was that dietetic experiments came to take an important place in my life. Health was the principal consideration of these experiments to begin with. 999 cases out of a thousand can be brought round by means of a well-regulated diet, water and earth treatment and similar household remedies" (MK Gandhi, The Story of My Experiment with Truth).

Consuming all-cereal-based foods in the last 50 years and less diversification in the food plate causing health risk to the population. The current food habits ultimately lead to development

of life style disorders such as diabetics, obesity, less immunity and other diseases like cancer. Diversification of food plate is a necessity and food must be diluted with millets since millets by nature bestowed with pack of nutrients which are gluten free and alkaline forming in the gut. The antioxidant components of the millets are very important for the human health since they have anti-cancerous properties, boost immune systems and delay the ageing. These nutrients are important for school-going children, pregnant women and also the other social groups of all ages. Selling antioxidant-enriched millets would economically viable for the start-ups as well as the existing commercial companies through niche-markets.

The routine consumption of nutritionally-enriched millets will improve the overall health of the population. Expenditure towards health will be minimised which in turn reduce the burden on public health system. Physically and mentally sound population will significantly contribute to a better society as a whole. Additionally, development of niche market for the antioxidant-enriched millets will fetch more income to the farmers and seed companies. Selling antioxidant-enriched millets would economically viable for the start-ups even at village-level through niche-markets. All these factors directly and indirectly contribute to the village economy and improve the livelihood of rural families as envisaged by Gandhiji.

2. Mahatma's vision

"What Mahatma Gandhi said of the role of food in a human being's life in a 1946 speech at Noakhali, now in Bangladesh, remains the most powerful expression of the importance of making access to food a basic human right. Gandhiji also wanted that the pathway to ending hunger should involve opportunities for everyone to earn their daily bread, since the process of ending hunger should not lead to the erosion of human dignity" (MS Swaminathan, The Hindu, 2011).

Our institutes are engaged in achieving *Gandhian goals* through innovative-led research in millets. We take *Mahatma's* message and thoughts as our preamble to address the food and nutritional challenges of our great nation. Through his vision, we conceived research strategies to develop superior varietal technologies that bring prosperity to the farmers and general public. Our focus has always been on developing nutri-cereal technologies to transform rural economy into a sustainable system. We believe that food and nutritional security will be achieved by developing rural-centric agriculture technologies and markets which can generate sustainable income to the small and marginal farmers of the dry land ecologies. Our technologies will directly and indirectly produce employment by means of cultivation of superior varieties, and production and marketing of value-added products. Our value-added technologies created new opportunities in national and international markets.

2.1. Why millets are importance to achieve nutritional security in India?

Gandhiji is perhaps the first *Diet Guru* as he experimented on different diet regimes by using his body and soul as experimental materials. His diets were economically viable, giving less or no drudgery to the women, provide vitality to the body, locally grown, unfired food and rural income and sustainability.

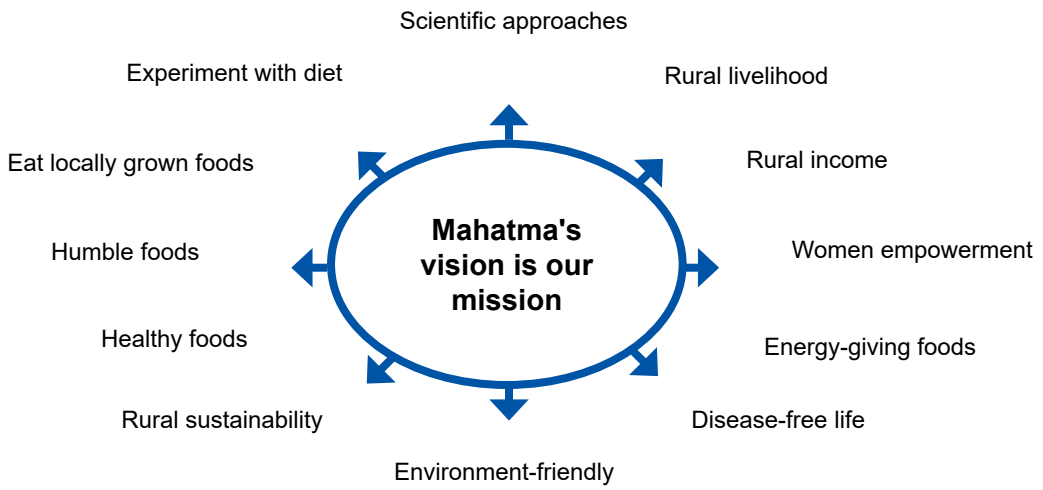
Mahatma's experiment on diet

"As I searched myself deeper, the necessity for changes both internal and external began to grow on me. As soon as, or even before, I made alterations in my expenses and my way of living, I began to make changes in my diet" (MK Gandhi, The Story of My Experiment with Truth).

"Absence or insufficiency of minute traces of certain substances other than protein, carbohydrate, fat and mineral salts present in natural foodstuff causes certain well- defined symptoms of diseases and ultimately produces death. These substances were called vitamins" (Harijan 30-11-1935).

It is worth to mention that we have been doing research on crops, which are directly connected to human health and welfare. Our mandated millet crops are bestowed with pack of nutrients, which are aptly meant for balanced and healthy diet regimes as desired by Gandhiji.

2.2. Nutritional and health benefits of millets



Gandhiji's thoughts on diet, nutrition and health.

Millets contain excellent nutritional profiles for leading a healthy life as envisaged by *Mahatma*. Millets have ample quantity of anti-oxidants in the form of flavonoids and carotenoids. The dietary fibres available in the millets are insoluble in nature. Copper, calcium and iron are some of the important minerals available in high quantity in different millets.

Sorghum grain is rich in minerals and array of vitamins, which can be traced in the aleurone and germ portion of the seed. Among several vitamins available, vitamin B complex is the major one and consuming sorghum regularly will reduce B complex-based disorders. Additionally, the soaking of the grains can induce the synthesis of vitamin C. The color of the grain is directly associated with the quantity of the mineral content such as the yellow grain has good quantity

of carotenoids (beta-carotene, leutin and zeaxanthin). Among minerals, potassium, magnesium and copper are rich in the sorghum grain.

Pearl millet is known for high quality nutritional profile. The high level of starch and glucose (Jambunathan and Subramanian 1988) in the pearl millet grain making it as an energy-giving food. It contains significant amount of essential amino acids such as threonine, cysteine, lysine, methionine, and tryptophan. Among fatty acids, oleic linoleic, and palmitic acids are the saturated and unsaturated acids available in the grain. The dietary fibre content (20.4%) of the pearl millet is about 150% and 20% more than rice and wheat, respectively. Pearl millet is a rich source of iron and zinc over any other millet crops and cereals (McDonough et al. 2000). The consumption of the pearl millet balances the acidity in the gut by forming alkalinity, a unique feature, to prevent stomach ulcers and related problems. Grain also contains strong anti-oxidants that can fight against the free-radicals and prevent several diseases including heart-related. The high level of magnesium in the pearl millet is known for controlling blood pressure, heart diseases and improving respiratory-related problems.

Finger millet is a king of calcium source and the regular consumption of finger millet will enrich the calcium content in the body and helps for bone quality. Like pearl millet, finger millet also contains lysine, methionine and tryptophan in substantial quantity (Chandrasekara and Shahidi 2011; Devi et al. 2014). Of the 12% total dietary fibre in the grain, the insoluble dietary fibre content is 12% and soluble is 2% (Ramulu and Rao 1997). The high quality fibre food is very good for increasing the rate of nutrient absorption in the stomach, helps in reducing the blood lipids, prevents the colon cancer and improves the digestion (Tharanathan and Mahadevamma 2003). It is also noticed that germinated grain increases the haemoglobin content. The anti-oxidant rich grain extracts help in scavenging the free-radicals and have antimicrobial properties.

Foxtail millet contains 11% and 4% of protein and fat, respectively. A range of anti-oxidants including carotenoids, phenols, and phenolic acids found in significant level in the grains (Saleh et al. 2013; Zhang and Liu 2015). The yellow grains are used for medicinal purposes such as to control bleeding and skin softening. Most of the digestive issues including, poor digestion and food movement in the stomach are improved by the regular consumption of the foxtail millet. The white grain is used for treating cholera and green seeds are used for kidney-related issues and improving virility. The good amount of protein (12.3%) and minerals (3.3%) in the grain are considered as a good source of food for over-all healthiness (Vithal and Machewad 2006).

Like other millets, kodo millet is meant for its own nutritional superiority. The fibre content is 14.3% followed by protein (11.0%) and fat (4.2%). The high fibre content of the grain is good for better gut heath. Moreover, it is gluten-free hence an alternative source of food for the gluten sensitive people. The lecithin present in the grain is very important for the nervous system. Kodo millet contains most of the B-complex vitamins, including B_3, B_6 and folic acid. As for the mineral profile is concerned, the grain is a good source of calcium, potassium, zinc

and magnesium. It is said that the positive role of kodo millet in curing some health issues faced by the post-menopausal women.

Barnyard millet, a millet of Indian origin has an excellent source for quality carbohydrate and fibre. It helps in preventing diabetics (Ugare et al. 2011) and other gut-related health issues. The retrogradation nature of amylose presence in the grain is another reason for balancing the blood glucose level and helps in managing diabetics. Barnyard millet has both unsaturated fatty acids (linoleic and oleic acids) and saturated fatty acid (palmitic acid). The grain contains several anti-oxidants that help in fighting several diseases (Kofuji et al. 2012; Sharma et al. 2016).

Proso millet has 11.6% protein content of the total dry matter, which is on par with wheat protein except that it has no gluten. It has a good distribution of carbohydrate, fatty acid profiles, minerals and vitamins. The important minerals are copper and magnesium and essential amino acids are methionine, leucine and isoleucine (Kalinova and Moudry 2006). B_6 and folic acids are present in significant level in the grain. Similar to other millets, regular eating of proso millet showed better glycemic responses and good for diabetics (Park et al. 2008).

Overall, millets are the wholesome food in terms of good carbohydrates, proteins, fats, minerals and vitamins. Millets also have a substantial amount of several forms of anti-oxidants to prevent and protect the body from variety of diseases. The anti-oxidants are much needed for the current stress-related lifestyle. Regular consumption of millet helps in either managing or preventing a range of diseases and disorders in heart, kidney, respiratory, skin, stomach, nervous system, immunity system and so on (Saleh et al. 2013; Chandrasekara and Shahidi 2012). Considering the high nutritional value of the millets, all-cereal-based diet can be replaced for better food diversity and nutritional security.

3. Nutri-cereal technologies

3.1. Sorghum technologies

"As a result of the painstaking researches of scientists the importance of vitamins in our diet has been brought to light and some of these substances, which were at one time considered to be mysteries, have also been prepared in a pure state. But as night follows day some evil also followed this very laudable work of the scientists. There came a large number of artificial preparations in the market, which brought fortunes to some at the cost of many poor men. These artificial preparations should by all means be avoided. Nature has provided ample amount for us - even for the poorest amongst us" (MK Gandhi, Harijan 15-2-1936).

Three-grain sorghum hybrids [(CSH 37, CSH 38, Jaicar Gold (CSH 41)], and two varieties [Jaicar Heera (CSV 36) and Jaicar Sona (CSV 39)] were released for increasing the productivity in rainfed cultivation and one grain sorghum hybrid (CSH 39R) has been released for *Rabi* season.

Our sorghum cultivars produced 69% more grain and 36% more stover yield as documented from the Frontline demonstrations (FLD). Our technologies generated a net return of

Rs. 43,266 ha^{-1}, almost double, compared to the local checks (Rs. 21,481 ha^{-1}), which would help in attracting the sorghum farmers.

Tribal sorghum farmers were benefitted with 60% higher grain and 43% higher fodder yield by cultivating high-yielding cultivars compared to their traditional sorghum cultivars.

Impact of the demonstrated production technologies under *Rabi* sorghum indicated that grain yield was significantly higher (91%) than the pre-demonstration period, followed by grain quality (49%) and fodder yield (15%), which has resulted the increase in net returns by 47%. About 28% area under *Rabi* sorghum of the adopted FLD farmers has increased in Maharashtra, Karnataka and Telangana due to enhanced adoption (45%) of the demonstrated technologies.

3.2. Gandhiji's thoughts on milk

"Milk may undoubtedly be increased if the purse allows it" (Young India, 18-7-1929).

"Milk is an essential article of diet" (Harijan 2-11-1935).

"To begin with, one meal may be raw vegetables and chapatis or bread, and the other cooked vegetables with milk or curds" (Harijan 25-1-1942).

Milk production can only be achieved by developing superior fodder and forage crops along with superior animal breeds. Fodder and forage are the integral part of the rural farming to rear milch animal such as cow, buffalo and goats, and to increase the milk productivity. ICAR-IIMR, plays an important role on developing forage varieties in millets to sustain the income and health of the people.

For fodder security of the country, one forage sorghum hybrid [CSH 40F] and three forage sorghum varieties [CSV 33MF, Jaicar Hariyali (CSV 38 F), CSV 40 F)] were released for cultivation.

First ever-brown midrib sorghum variety, CSV 43 BMR (*Jaicar Nutrigraze*), with low lignin content was released in India during 2019 with 64% total dry matter and 6% more organic matter digestibility. The improvement in the quality of the hybrid is expected to increase the milk yield by 20 to 30%.

More than 100,000 acres of forage sorghum hybrid CSH 24MF is planted every year (a multi-cut forage hybrid developed under the AICRP on sorghum), which has helped in area expansion under forage sorghum. The demand for the seed is increasing rapidly year after year because of increased rate of adoption by the farmers.

3.3. Pearl millet technologies

Since pearl millet is rich in iron and zinc and to exploit the mineral content for the benefit of the public, an important policy decision was taken in 2017, in consultation with the stakeholders, to keep iron and zinc level with a minimum 42 ppm and 32 ppm, respectively in the varietal promotion criteria. Hence, cultivation and consumption of iron and zinc-rich varieties will help in preventing the micronutrient mal-nutrition.

"The next important thing is that Millet, which forms the main food in the evening contains 7.4% oil, and Kodari, which is the noon day meal, contains 5.9% oil. In spite of the farmer's inability to provide for necessary portion of free fat in his daily diet, he is still getting it unawares by taking Kodari and Millet" (Harijan 12-12-1936).

New high-yielding varieties for various arid and favourable ecologies were developed. Simultaneously, we ensured the availability of the quality seed of those cultivars to the farmers. In the last five years period, 159 hybrids and 61 varieties were identified and released for cultivation suitable for different agro-ecological zones of the country. The combination of technologies increased the productivity from 688 to 1243 kg ha^{-1} in the last decade. The total production of pearl millet has increased more than double to 8.83 million tonnes. Because of the improved technologies, the area under high-yielding varieties is increased to 50% so as the sustainability.

Greater breeding efforts and use of novel technologies such as identification of better heterotic hybrid combinations produced 113 hybrids for various niche ecologies in the last 20 years. The continuous and concerted efforts have increased the yearly productivity to 27 kg ha^{-1}.

Bountiful harvest brings happiness to the small millet growing farmers.

Pearl millet is the first crop where the latest breeding science such as marker-aided selection was applied to develop a hybrid "Improved HHB 67" to overcome the deadly downy mildew disease and productivity to ensure the better harvest.

3.4. Small millets technologies

A total of 39 varieties of small millets (Finger millet-17, Foxtail millet-4, Kodomillet-2, Barnyard millet-4, Little millet-8 and Proso millet-4) are released for cultivation.

Gandhiji's opinion on Kodari (Foxtail millet)

"The farmer's daily food in Gujarat is Kodari, Millet, Dal of Tuver or Math the last two being replaced sometimes by Mag, Val or Dal of Udad" (Harijan 12-12-1936).

His statement on importance of calcium and Ragi:

"Rice being very deficient in calcium, its insufficiency is one of the most important defects of the rice-eater's diet. The milled rice-eater, therefore, needs more "protective" foods - milk, green vegetables, fruits etc., than the consumer of whole wheat or ragi" (Harijan 12-4-1942).

Agronomic practices were developed for SRgI (System of Ragi Intensification) of transplanted finger millet under irrigated conditions for better yield. More than 900 FLDs demonstrating new technologies were developed showcasing the newly developed varieties of different millets. About 50% to 125% increase in yield over farmers' practices were demonstrated. Organic input-based technologies for crop protection (neem and other biopesticides) and biofertilizers were standardized to support organic millets production. Popularisation of small millets was achieved in tribal areas of various states under Tribal Sub Plan (TSP) and in North Eastern Hilly states under NEH programme. Post-harvest processing of small millets made accessible to farmers through establishment of requisite machinery at centres located in higher tribal community concentration. Capacity building of farmers, tribals, self-help groups and entrepreneurs for value-addition of small millets was achieved through establishment of self-sustaining food products manufacturing facilities.

Sensitized state and central governments to support the promotion of small millets as nutri-cereals and climate resilient crops that resulted in re-classifying millets as nutri-cereals, and initiation of NFSM sub-mission on nutri-cereals, with the components of enhanced breeders seed production and millet seed hubs entrusted with our AICRP centres, among others. Production of quality seeds to take up mini-kit programmes is being facilitated through these seed hub centres.

Improved high yielding disease resistant varieties (VL *Mandua* 352 and VL *Mandua* 324) were demonstrated by ICAR-VPKAS in 10 finger millet growing clusters. It is an early maturing variety (<100 days) with an average yield potential of 25 to 30 q ha^{-1}. VL *Mandua* 324 is suitable for both organic as well as inorganic cultivation.

3.5. Technologies that reducing women drudgery in hills

The threshing, pearling and de-husking of millets is traditionally done manually, which consume a lot of time, labour, cost and drudgery. To solve this problem, the ICAR-VPKAS, Almora developed a machine called "*Vivek* Millet Thresher-cum-Pearler". It increases the working efficiency thereby saving time and energy and reduces drudgery. A total of 765 units of this machine was purchased and being used by *Krishi Vigyan Kendras*, Agriculture Universities, ICAR Institutes, Borlaug Institute of South Asia, farmers, NGOs and other stakeholders throughout the India covering thousands of farmers. This machine was developed for simultaneous threshing and pearling of finger millet as well as threshing, de-husking and polishing of barnyard millet. There was a lack of interest among the farmers to cultivate the small millet due to cumbersome threshing and low yield of the farmers' varieties. This technology led to the renewal of interest in farmers in cultivation of millets in large areas.

Table 1: Popular value-added products developed from nutri-cereals by ICAR-IIMR to increase the rural income and nutritional security.

Product category	Product name
1. Millets instant mixes	Sorghum instant kichidi mix
	Millet instant idli mix
	Ragi instant vegetable soup mix
	Little millet instant idli mix
	Little millet instant dosa Mix
	Little millet instant kichidi mix
	Little millet instant bisi bele bath mix
2. Ready to cook millet-based products	Finger millet vermicelli
	Foxtail millet vermicelli
	Foxtail millet pasta
	Zinc-rich jowar pasta
	Zinc-rich jowar vermicelli
	Iron-rich jowar pasta
	Iron-rich jowar vermicelli
	Ragi pizza base

Product category	Product name
3. Ready to eat bakery snacks	Finger millet cookies
	Jowar jeera cookies
	Jowar choco chip cookies
	Multi millet cookies
	Zinc-rich jowar cookies
	Jowar almond cookies
	Ragi chocolate cake
	Ragi bread
	Jowar bread
	Multi millet bread
	Ragi muffins
	Sorghum muffins
4. Ready to eat flakes	Jowar thinner flakes
	Finger millet roller flakes
	Pearl millet roller flakes
5. Ready to eat puffed snacks	Jowar puffs
	Pearl millet puffs
	Barnyard millet puffs
6. Ready to serve products	Sorghum muesli
	Sorghum khakhra
	Millet nutri bar
7. Milled products	Multi millet rawa
	Proso millet rice
	Little millet rice
	Kodo millet rice
	Barnyard millet rice
	Foxtail millet rice

4. Gandhiji's vision on importance of healthy diet

"*It is not only the poor, whose choice is extremely limited, who are ignorant and prejudiced, but also those who can afford an excellent diet who do not feed properly, with the result that their children suffer from malnutrition and food-deficiency diseases*" (Harijan, 12-4-1942).

4.1. ICAR-IIMR innovative value-chain model of nutri-cereals

We developed valued added technologies (Table 1) in the form of millet-based ready-to-cook, ready-to-eat products and delicious recipes. These technologies attract the consumers towards

consumption of millet products and encourage the farmers to cultivate the millet varieties.

Capacity building and training along with NIMSME, MANAGE, NIRDPR to various stakeholders such as state governments and independent FPO's, NGO's and entrepreneurs, farmers, students on value-addition components were achieved. Cooking with millets and ignition programs on business opportunities in millets are conducted once in a month. A two months capacity building is conducted on agri-entrepreneurship for pre-incubation funding up to 5 lakhs and seed support funding up to 25 lakhs per start-up under RKVY=RAFTAAR.

Currently, 400 start-ups established in five states during past four years are technologically backed-up either directly (incubation) or indirectly nurtured by ICAR-IIMR. Some of these start-ups have registered GEM so as to connect with pan India millet market's share. More than 300 start-ups are operational in promoting millet foods and millets processing.

Delicious and popular recipes from millets created revived interest in cultivation and consumption.

5. Conclusion

Our aim is to continuously develop nutritionally superior millet varieties with higher yield in the rainfed and drought-prone ecologies. We have a strong quality seed production program to ensure the availability of superior and quality seed to the farmers and source seed to the companies. We have been creating interests in cultivation and consumption of millets. An overall impact has been visible in the consumption of millets in urban and rural consumer markets due to our constant popularization of millet products. Since there has been renewed interest of farmers and general public on nutri-cereals, the dissemination of nutri-varieties will create an impact on the rural livelihood and the economy. The regular consumption of nutri-cereals and value-added products will realize the *Mahatma*'s dreams of alleviating poverty and improving health of people.

Chapter 12

Science-led Agricultural Development: Gandhian Thoughts

Ch Srinivasa Rao, P Krishnan and V Ragupathy

"My life consists of nothing but experiments".
MK Gandhi

1. Introduction

In India, agriculture is a major livelihood for more than half of the population, accounting for 15% of gross domestic product, featuring as a backbone of Indian economy. Traditionally the manual labour, supplemented by assistance from domestic animals like horses and bulls along with certain tools like axes, crowbars, and ploughs, constitute the agricultural infrastructure. The machinery was gradually introduced in farming. Tractors and other machines helped farmers in ploughing the soil and harvesting the crops. This mechanization reduced time and effort put on farming as a whole. Natural climatic conditions are the main concern of the farmers. Sowing and harvesting largely depend upon the start and the end of the seasonal rains. India's thousands of villages relied upon such normal state of agriculture. The traditional methods of cultivation yield a minimum, just satisfying the minimum needs of the farmers.

In 1943, the world's first recorded food disaster "Bengal Famine" occurred in British India in which 4 million people died of hunger. Poor rainfall and conditions aroused due to India's freedom struggle were the two prominent factors that drove the farmers in Bengal out of their profession. After independence in 1947, the "Green revolution" was ushered in to achieve a significant increase in crop production using chemical fertilizers, pesticides, and high-yielding crop varieties. It aimed at the supply of enough food for the growing population. Farmers were periodically exposed to advanced agronomic measures and tackling of problematic areas in cultivation. Semi-intensive scientific approach and introduction of machinery added more vigour to the farming sector. Production increased to achieve self-sufficiency to a greater extent. In this transitional stage, farming witnessed two important transformation: 1) the adoption and adaptation of the modern methods of cultivation and 2) coping with the challenges from environmental damages and economic instabilities.

In the present scenario, agriculture has become substantially global. The science we experience today in everyday life is techno-science (Ihde 2009). There is a change in the idea that science is an abstract knowledge as techno-science, which brings significant changes in natural resources (Lenk 2007). Power is a significant dimension of techno-science. Techno-scientific activities are energy-hungry and encompass economic, scientific, and social development models practically

separating human communities from nature. The introduction of processed quality seeds, some genetically modified traits of crops, organic farming and other newer methods of plantation, etc., have provided many farmers higher income and better living conditions than before. The economic state of today's farmers has grown much better than their ancestors owing to an overall improved state of economy in many sectors. Buying power, distribution channels and consumerism have made the agro-markets more profitable.

Gandhiji considered agriculture as the main stay for the upliftment of the entire nation. He also had the firm belief that "the future of India lies in its villages". To Gandhiji, the practice of agriculture signified a promise of limitless reach. Gandhiji said, "*to forget how to dig the earth and tend the soil is to forget ourselves"*. Gandhiji desired that the workers in village should feel confident of the science inherent to their work, and that the modern scientists should sensitize the villagers about the scientific developments, relevant to them. This has been internalized in the ICAR's technology demonstrations and implementation with rural institutes like commodity groups and common interest groups in agriculture. This chapter captures the views of Gandhiji on science and technology with special reference to those relevant to agriculture and analyses them in the contemporary context of development. The initiatives of the Indian Council of Agricultural Research (ICAR) towards institutionalizing the Gandhian thoughts and principles in developing Indian agriculture are also highlighted.

2. Gandhiji's Perspectives on Science and Technology

Science and technology have played a significant role in the development of our society. Gandhiji campaigned during his lifetime for an economic development through the promotion of cottage and village industries. But he was not favourably inclined to the setting-up of heavy industries, especially in villages and rural areas. The stalwarts like P.C. Ray reiterated the possibility of general progress through basic education and promotion of traditional industries. Though Gandhiji was not against science and technology *per se* as being perceived, he had detested their misuse- e.g., destructive weapons, vivisection or machines.

He had pointed out that "Modern civilization, far from having done the greatest good to humanity, has forgotten that its greatest achievements are weapons of mass destruction, the awful growth of anarchism, the frightful disputes between capital and labour and the wanton and diabolical cruelty inflicted on innocent, dumb, living animals in the name of science, falsely so-called. The boast about the wonderful discoveries and the marvelous inventions of science, good as they undoubtedly are in themselves, is, after all, an empty boast" (Gandhi 1902).

2.1. Gandhiji on Science and Knowledge

Gandhiji's critique of Western society against the propagation of modern science and technology since early nineteenth century is found in *Hind Swaraj* (Gandhi 1909). Numerous arguments proposed by Gandhiji and his followers such as J.C. Kumarappa, which highlighted the strong inter-relationship among science, technology, education, and socioeconomics in the progressive technological society, were recognized very late (Ninan 2009).

Gandhiji is widely portrayed as a spiritual leader or political leader, which he had himself contested. He is a pragmatic theologian, down-to-earth lawyer, development planner and a researcher (Brown 1972). A popular narrative on Gandhiji as against Science and Technology has been woven by some intellectuals, influenced by the western idea of science. Gandhiji was a man of experiments. The projection of Gandhiji as a saint or politician, in a wider world-view was only to mask his image as a scientist, which he was actually. Gandhiji had been an arduous student of the art of experimentation which is evident from the title he had chosen for his autobiography: 'The Story of My Experiments with Truth'.

He was an ardent inventor and an assiduous innovator. He was fabricating, and refining snake-catching tools, made footwear from used tyres, and innovated more efficient methods for rural sanitation. His trademark is the small cotton-spinning wheels used by him. All through his life he was engaged with experiments in different spheres of life. He did extensive research on diet and its impact on body and mind. His experiments in health were recorded in his book 'Key to health". He did lengthy experiments in the processing and production of clothing. He inspired the world-renowned architect Laurie Baker to undertake the construction of low-cost houses for the poor with the locally available materials.

The Gandhian scheme for science intends to find alternative for much criticized 'western' or 'modern' science by redefining the objectives and the premises (Ninan 2009). The non-western, traditional systems of knowledge (e.g. *Ayurveda* and *Unani* systems of medicine) and specific skills such as village crafts and handloom spinning were integrated into the realm of science and the practitioners of the above were to be recognized as 'scientists'. For Gandhiji, the purpose of science must be welfare of the humanity. He considered "*science without humanity*" as one of the seven great sins.

2.2. Gandhiji on Scientists

Gandhiji saw himself as a scientist experimenting all through his life, focusing more on the practical science. According to him, the scientist has to be conscious and self-reflecting. The scientist should not be working for exploiting market nor with the stifling state, but work for the people. He called upon the scientists to introspect and relate how their efforts would benefit the poorest and weakest man ever encountered by them (Gandhi 1945).

He believed that scientists are not only those working in laboratories, but also the community workers who do research in their own pursuit. He desired that the community workers should not only learn necessary skills, but also conduct experiments and make discoveries for development in a rural background. Gandhiji proclaimed that scientific pursuit required an attitude for research, beyond academic qualifications. He laid more emphasis on the scientists' sacrifice and dedication first. He advised the new generation scientists to pursue original researches avoiding duplication.

Gandhiji believed that there should be large number of scientists and engineers in the villages. Just an increase in the number of university degrees would not be sufficient but the scientific

manpower should substantially increase. He wished that students should be exposed extensively to the dynamic view of scientific knowledge and should not be just engrossed to the structured, disciplinary-bounded truths about the world.

2.3. Gandhiji on Technology

Gandhiji is recognized as an early adopter of developing and improving technologies using crowdsourcing. A competition was organized by him in 1929, with a cash prize, for designing a lightweight spinning wheel for producing thread using raw cotton. Gandhiji opined that the negative impacts of technologies are often faced disproportionately by the poor rural populations.

Gandhian politics intended to redefine science and technology encompassing modern ideas. The criticisms of terms such as 'modern' 'machinery' etc., which were to an extent alien to the 'Indian civilization', were also given due concern while integrating them into ideas of democracy and equality, (Habib 1995).

2.4. Gandhiji on Machines and Mechanization

Gandhiji was not against machine *per se* and insisted that it should meet two aims, namely self-sufficiency and full employment. According to Gandhiji, villagers would have no objection to use modern machines and tools if they could make and comfortably use. Gandhiji's concept of development emphasized the uplift of the common man. He preferred village habitats to be protected by promoting Swadeshi craft instead of depending on imported technology for economic well-being. He supported adopting cottage industries instead of setting-up heavy industries in rural areas. He emphasized that education, health, and vocation should be properly integrated for effective and sustainable rural development.

Gandhiji, through his writings, provided his ideas and holistic meaning of thoughts on specific issues and did not strive to particularly influence the academic audience. Bakker (1990) attributes this to Gandhiji, not being quoted much in the social science literature on social change. Gandhiji said, *"It is quite strong to say I don't believe in machinery. This spinning wheel is a beautiful piece of machinery". "How can I be against machinery? This body itself is the most delicate machinery".* He called upon the scientists to invent new machines and equipment to serve humanity and not for maximizing profit. Science and technology must focus on serving the poor and not making fortunes for the rich. Gandhiji had a fascination for the sewing machine. He noted it as a product of the love of its inventor to his wife. Mahatma Gandhi, who eschewed many other machines, made an exception for Singer sewing machine, which eased the life of many women in the world. His subjects of experiments were not on the machines but the very machination or verities of life, which most of his contemporaries influenced by western definitions of scientists, consciously missed to note.

Gandhiji's view on mechanization in agriculture is quite explicit as published in Harijan (Gandhi 1934). He opined that mechanization is ideal only when the number of people available to do the work are too few for the work and it should not be used indiscriminately with the motive of

profit maximization, in situations where there are adequate number of people, as is the case in India (Jayalani 2018). He wished that machinery should not become their master but be only subservient to ensure wellbeing of the people. Gandhiji was reluctant to accept any machinery, which would enable only to enrich a few, depriving many poor of their livelihood as labour. His had believed that a machinery which improves the efficiency of masses without depriving their labour opportunities is good for the society (Gandhi 1935).

Gandhiji founded the All India Village Industries Association (AIVA) in 1934 to develop rural technologies suitable for the artisans of villages and use of Science and Technology for the upliftment of the villages of India, in which great scientists and industrialists of India *viz.,* Dr. CV Raman, Dr. JC Bose and Dr. SC Gupta served as advisers and Board Members. AIVA is testimony to his concept and understanding of the scope of industrialization within the Indian ethos and not influenced by the western idea of industrialization. Gandhiji encouraged *'working with the hands',* which served both fulfilling human needs and the acquisition of knowledge at the same time. Manual and practical work was central to the educational program as outlined by Gandhiji.

3. ICAR's Initiatives for Realizing Gandhian Principles

Gandhiji considered the village as a basic unit of ideal social order. He believed that India would perish if the villages perish. He spelt out the fundamental concept of Sarvodaya in Hind Swaraj (1942), which was to ensure socio-economic benefits to all in every Indian village, achievable through the autonomy in self-development. The Gandhian concept of "Gram Swaraj" envisioned self-sufficient village republics. He considered the villages to stay independent of their neighbours for all their vital wants like food, clothing, sanitation, education etc., including other essential amenities required by a community, but yet stay interdependent for other needs, in which the village cannot attain self-sufficiency (Kumar 2002; Colucci-Gray and Camino 2016). In such cases, he added that, the village should produce more of what they can, so as to obtain in exchange, such items which cannot be produced locally (Gandhi 1959).

Gandhiji visualized that the houses in villages must be built with locally available material, with adequate ventilation and a courtyard where vegetables could be grown for domestic consumption and maintain cattle. He emphasized on eco-friendly approach to conserve the natural resources. He visualized integration of production systems such as the agriculture surplus being used for the development of animal husbandry.

The Farmers FIRST program of ICAR is a platform for science and technology-based agriculture-led village development. ICAR has implemented nation-wide programs through its network of KVKs and research institutes to promote homestead farming and integrated farming system (IFS) where in cropping is integrated with various animal components. Location-specific package of practices have been developed and are extensively disseminated to all the stakeholders through its extension functionaries.

3.1. Farmer-centric Participatory Approach in Research

Gandhiji's early criticisms on science and technology stemmed from his core concern that the direction of research of the scientists was not people-centric, or more specifically that the villagers get neglected in the scheme of scientific experiments. The poor are greatly affected by fast changing environmental, social, and technological processes. The agricultural research centres need transformation as 'learning centres' with constant exposure to field realities and addressing the issues based on feedback knowledge. They should adhere to client-responsive scientific research handling multi-disciplinary problems and availing multiple sources of innovations (Prasad 2005).

ICAR has extensively contributed to establishing greater connect with the villagers while planning and implementing its scientific research. It has a structural mechanism for research problem identification based on participatory rural appraisal techniques (PRA) where the villagers contribute to assessing the problems and prioritizing the solutions. In order to emphasize the village-centric interventions, the agricultural researchers during their Foundation Course, before starting their professional career, spend one month in different villages across the country and learn the basic tenets of village dynamics and bottom-up approach for research. The contemporary interdisciplinary research in agriculture sector revolves around the Gandhian philosophy of participatory and inclusive agriculture research.

3.2. Revival of Textile Industry

Indian textile story is a successful case of reaching the global markets by artisanal industries, which were so widely dispersed and deeply rooted in Indian cultural ethos and traditional or ancestral skills. Gandhiji emphasized that *"the village should produce food-crops and cotton in order to meet its requirements"*. His push to spinning has to be seen in this historic context. India's share of the world economy was 23% at the beginning of the eighteenth century, which shrank to about 3% by the time the British rulers departed from India. The industrial revolution of Britain had been mainly founded by destroying many of India's manufacturing industries, which were flourishing then. Textile was a classic case of structural destruction by the British, which represents the first great de-industrialization of the modern world. India had about 25% share of the global textiles trade during early eighteenth century. The industry was systematically damaged by cutting off export markets, the introduction of modern techniques, and many ruthless measures, which led Lord William Bentinck to remark – "*the bones of the cotton weavers were bleaching the plains of India*" (Tharoor 2016).

Gandhiji believed that re-introduction of spinning in the homes of villages would help save millions from starvation (Gandhi 1920). Spinning wheel, the foremost artefacts of Gandhian propaganda represented different values like economic self-sufficiency, mastery over machinery and harmony between the rich and the poor (Parel 1969).

Reviving the weaving and spinning skills is fundamental to develop a village-centric economy. ICAR has two research institutions on cotton, one with the focus to develop farm technologies

to enhance cotton production (ICAR-Central Institute of Cotton Research) and another with focus on cotton technology (ICAR-Central Institute for Research on Cotton Technology).

Till the time India got independence in 1947, diploid Asiatic cottons (*Gossypium arboreum*, *G. herbaceum),* which were suitable for marginal and rainfed area owing to their tolerance to drought, pests and diseases, *were under cultivation in over 97% of the cotton grown areas*. However, the traditional Asiatic cotton cultivars were considered as low yielders and of poor fibre quality. Development of the high yielding upland cotton varieties (*G. hirsutum*) and the hybrids especially Bt transgenic cotton hybrids, led to the replacement of traditional Asiatic cotton cultivars and which now occupy nearly 97% of the cotton acreage. Efforts made by cotton breeders of NARES resulted in long-linted *G. arboreum* cotton varieties like PA 812 that are having higher productivity and better fibre quality with inherent tolerance to drought, diseases and pests and are better suited to the climatic conditions of our country. This kind of climate-smart native cotton varieties offer the marginal and rainfed cotton growers a choice to produce quality cotton of more than 30 mm staple length with minimum inputs. ICAR-CICR demonstrated that seed priming treatments using KH2P04 and *Trichoderma viride* give superior performance over control concerning percentage germination, speed of germination, highest index, etc. Also showed that the Foliar spray of micronutrient mixture followed by neem kernel extract were highly promising in obtaining higher quantity of de-linted seed yield (ICAR-CICR- Annual Report: 2018-19).

ICAR-CIRCOT has developed a miniature ginning machine, which can process the seed cotton at farm level for obtaining the cotton fibre (Lint) and seeds. The village-level carding machine (CIRCOT Mini Card) can be used to make cotton sliver at the farm level. The cotton slivers thus prepared can be further used to make fabric in the cottage industry. ICAR provides regular training to farmers on post-harvest processing of cotton and value addition to biomass and clean cotton-picking programs are organized to create awareness about the package of practices to harvest clean cotton to fetch a better price.

The national productivity of jute crop has been doubled and jute crop has been integrated into the multiple cropping sequence (Vision 2025, CRIJAF). Raw jute, which is widely used as a raw material in textile and paper industries, building and automotive industries, and various other uses, is an important driver of national economy (https://farmer.gov.in/cropstaticsjute.aspx). ICAR made significant contributions in the development of high yielding varieties and improved production technologies of cotton and jute crop.

3.3. Towards Localized Food Security

Gandhiji always emphasized to “eat local” which in turn would reduce carbon footprint by limiting transportation, directly support farmer’s livelihood, and increase the local economy. It would facilitate the restoration of soil and ecology. He desired that the food production at the village level should be adequate to provide access to quality food for the villagers, and should reduce the reliance on imports from outside. He preferred millet consumption and had

conducted a lot of experiments on this crop and its grains. He regarded it one of the medicinal grains which contain a myriad of beneficial nutrients (Yadav 2012).

Green Revolution in India, which led to increase in food production, alleviating hunger and poverty was driven by the introduction of high-yielding varieties of rice and wheat. While the wheat and rice production doubled, the production of indigenous rice varieties and other food crops like millets declined (Nelson et al. 2019). ICAR has pioneered focused research programs on other grains like sorghum, finger, and pearl millet, which would greatly reduce the energy use by up to 12% for cereal production nationally. The water-use can be further reduced by almost 25%, and greenhouse gas emissions would be reduced by up to 13%. The protein availability can be boosted by up to 5% in people's diets, and iron by up to 49%, by the use of varieties of grains. Further, the switching over to rotation of crops would significantly increase drought tolerance and overall climate resilience of cereals by 13%. Thereby, the losses would be substantially reduced in comparison to the water-dependent rice crops (Bryce 2019).

Millets are now called as nutri-cereals. Enhancing millets' production and consumption in India depends on the consumers. The realization of the fact that Millets offer a solution to lifestyle disorders would encourage more consumption. Further, if producers realize that millets require less inputs and is an economically viable option, they will go for preferential cultivation. The Centre and many States have decided to promote millets in a major policy shift.

In India, the coarse cereals, such as millets and sorghum, can ensure better nutritional security, and reduce resource demand. The greenhouse gas emissions can be controlled, and climate resilience can be enhanced without reducing calorie production or requiring more land. ICAR has taken significant strides in this direction.

3.4. Introduction of Appropriate Technology

Gandhiji always emphasized using appropriate technologies in meeting basic needs and achieving equity. The phased manner development activities should be taken up so that the beneficial aspects reach the society sustainably, promoting positive development at the same time. His concepts of *Swadeshi* and *Swaraj* implied the use of appropriate technology and development approach to meet basic needs, respectively (Bakker 1990). He advocated the self-help approach (*Swadeshi*) as a strategy for rural development.

ICAR has developed many innovative, cost-effective, and eco-friendly farm technologies and implements (e.g., coconut de-husker, power tiller, etc.), which has reduced the drudgery of the farmers, reduced the gender divide, and has contributed to enhancing farm productivity. Various machines and suitable methodologies were developed by ICAR to mechanize different labour-intensive farm operations in plains and hilly regions. A self-propelled site-specific fertilizer applicator was developed for top dressing in wide spaced field crops. The Government of India has provided support for research and human resources development in support of agricultural mechanization. The agricultural engineering programs conducted in many state agricultural universities have facilitated agricultural mechanization in India.

Bakker (1990) provides a comprehensive contemporary account on the Gandhian "basic needs" approach in developing particularly "appropriate technologies" for food production systems. He concluded that new technologies are developed and more often used regardless of their appropriateness to the context and which he attributed partly to the disciplinary specialization which blurs the complexity of food systems. Gandhiji had a conviction that research should be sensitive to the local needs and should not lead to introduction of technological innovations forcefully on such systems which are not adequately prepared for willingly adopt them (Bakker 1990).

ICAR has internalized this principle and has structural mechanism to sensitize the community regarding new innovations and also to evaluate them in the farmers' fields to build their confidence. It has implemented a novel initiative called *Mera Gaon Mera Gaurav*, where in all the ICAR institutions and its network of KVKs have adopted a village and nurtured them to adopt contemporary technologies and varieties developed by various ICAR institutions so as to evolve as self-sufficient models.

3.5. Natural Resource Conservation and Environmental Sustainability

Gandhiji believed that the earth is not merely there to be mined, logged and hollowed out and we have to first preserve the ecological equanimity of the body. He was a staunch critic of the "waste" generated from modern industrial practices and its long-term consequences on humanity. The idea of modern agriculture systems promoted by ICAR which factors "wealth from waste" stems from this Gandhian philosophy. Gandhiji considered even plucking leaves was violence and remarked, "we should pluck the required number of leaves after offering an apology to the tree for doing so". Today's Green India Initiative has typical reflection of Gandhiji's sentiments towards this.

Gandhiji believed the consumption of meat adds pressure of the meat industry on natural resources like soil and water. The modern science on water and soil conservation is deeply associated with his philosophy of nurturing natural resources. The extent of energy or greenhouse gas (GHG) emissions from meat production compared to local traditional foods is well-documented. He advocated the production of paper using recycled material to save wood. South Asian countries are most vulnerable to climate change and the Gandhian philosophy has particular relevance for climate change adaptation and co-benefits of mitigation.

3.6. Organic Manures, Sanitation and Hygiene vis-à-vis Framing

Gandhiji's ideal village focused on public hygiene and sanitation. He gave great importance to sanitation and personal hygiene. He was deeply involved in the science of sanitation. He experimented with different types of toilet constructions and made attempts to convert human excreta into manure. In his Ashram, an army of workers was engaged in the conversion of human excreta into rich organic manure. Our Hon'ble Prime Minister Shri. Narendra Modi took up this important mission of Gandhiji under the "*Swachh Bharat Abhiyan*". He said that sanitation is more important than political independence. ICAR has institutionalized the

Swachh Bharath Abhiyan in all its institutions and also through its network of institutions and centres to many villages.

Gandhiji's vision for clean India has its root in agriculture. He considered that organic manure would only enrich soil and never would impoverish the soil. He opined that use of manure prepared by composting daily wastes would significantly reduce cost and enhance crop yield, while also contributing to keep the surroundings clean and people healthy (Gandhi 1947). Gandhiji's vision now has manifested as centres and *Gobar Dhan* schemes in Rural India (Jayalani 2018). In Harijan, Gandhiji described how to make compost manure with local labour and least capital. The practice of using cow urine in various biodynamic formulations, has great resonance with Gandhian thoughts on farming with natural inputs.

The organic farming mainly enriches the soil nutrients. A Network Project on Organic Farming (NPOF) was initiated during 2004-05 by ICAR with Project Directorate for Farming Systems Research (PDFSR) as nodal institute to develop and promote a comprehensive technological package of organic farming for different crops in system mode, in different agriculture zones of the country. The current technological practices of soil health management with improving soil organic carbon (SOC) stem from the Gandhian thinking of using organic manures for enhancing soil fertility.

3.7. Cooperative Farming

Gandhiji recommended co-operative farming for sharing labour, capital, and tools and equitable wage earning to all adults in the villages. He was concerned with fragmentation of land and called upon people to resort to co-operative farming, for promoting rural development. India now has the pride of having the world's largest network of cooperatives. The cooperatives play a vital role in India's rural economy.

ICAR has played a pivotal role in institutionalizing cooperatives and also in establishing farmer producer organizations (FPOs) towards bringing farmers together. Agriculture land is fragmented, and majority of the farmers currently has marginal and small farm holdings, the Ministry of Agriculture and Farmers Welfare policies promote cooperative farming or collective farming. ICAR has a significant role in extending this Gandhian philosophy across the country, which contributes to wide-spread adoption of the practices.

3.8. Sustainable Development Goals

Gandhiji has been a strong advocate of strengthening rural India and agriculture-led development, which form the bedrock of sustainable development goals (SDGs), particularly those about achieving zero hunger, ending poverty, securing education, health, employment, gender equity, climate change adaptation and mitigation. His environment-friendly lifestyle, simple, traditional systems of life amply provide the recipes for achieving the SDGs. Gandhiji's teachings reflect to a large extent the importance of sustainability in all development fields propounded by SDGs with a focus on rural background. He mentioned that, "*We should not*

look upon the natural resources – water, air, land – as inheritance from our forefathers; rather consider them as loan given by our next generation".

Nutrition security is one of the important SDG targets to be achieved by 2030. The current push to promote *"eat local"*, would lead to having more fresh, high quality food and to leave a low carbon footprint by reducing transportation of food, thus, benefitting the local farmers, rural economy, soil health and ecology. This is an important strategy for climate action, one of the important SDGs.

4. Lessons Learnt and Way Forward

India ranks second in the world agricultural production and is the leading producer of food grains, horticultural crops, cotton, dairy and poultry, aquaculture, and spices. India's agricultural GDP rose from $25 billion (1970s) to $401 billion (2017), registering a stupendous growth of $376 billion out of which $300 billion increase was recorded during the period from 2001-2017 (NAAS Presidential Address, 2019). The net area under cultivation increased from 118.75 Mha (1950-51) 140.86 Mha in 1970-71 and has largely remained constant since then. (Directorate of Economics and Statistics, GOI). Foodgrain production increased from 50.82 million tonnes (1950-51) to 284.95 million tonnes (2018-19). Similarly, horticulture produce of 313.85 million tonnes in 2018-19 showed significant gain as compared to 166.94 million tonnes in 2004-05. The total livestock population increased from 292.80 (1951) to 535.82 (2019) millions. The total fish production increased from 1.536 million tonnes (1990-91) to 13.422 million tonnes (2018-19) (Pocket Book of Agricultural Statistics 2019, GOI).

Gandhiji always wanted India to be self-sufficient.

"My idea of self-sufficiency is that villages must be self-sufficient in regard to food, cloth and other basic necessities. But even this can be overdone. Therefore, you must grasp my idea properly..." (Gandhi 1959).

The Green Revolution in India which had begun in the mid-1960s had been instrumental in transforming from the traditional agriculture to intensive farming. Introduction of high-yielding varieties replaced the traditional rice varieties consumed before the Green Revolution and the availability of local rice varieties has decreased. Many high-yielding varieties (HYVs) of wheat, rice, barley, sorghum, oilseeds, legumes, etc., were developed by ICAR and introduced as part of the Green Revolution to increase agricultural productivity. Farmers could increase their knowledge on improved agronomic measures due to extension services from NARES. This period also coincided with the extensive use of chemical fertilisers and pesticides which have significantly impacted the natural resources like soil and water. The overuse of chemical fertilizers, pesticides, and mismanagement of soil and water resources degraded the land and groundwater became scarce in agricultural areas. The agriculture sector is undergoing tremendous stress due to various factors both natural vagaries and human mismanagement resulting in farmers' suicides, malnutrition, economic and livelihood stress, etc., in spite of

governments' efforts to enhance the capacity of farmers through education, skill development and transfer of improved technologies.

Gandhiji said, "*to forget how to dig the earth and tend the soil is to forget ourselves*", which described the basic philosophy of farming and the toiling necessity of the farmer (Balaji, https://www.mkgandhi.org). However, with the introduction of machinery like tractor, electric water pumps and other machines the effort and involving time in farming activities have been reducing.

In recent times, climate change has become a big challenge to manage. Changes in temperatures, rain fall, water levels, evaporation, and groundwater recharge, and issues like floods and droughts, etc., are greatly affecting water resources and the dependent economies like that of agriculture (Prasad 2001). The climate change impacts on natural resources would greatly affect food security as the production from terrestrial and aquatic systems would be hit.

An ecological crisis is not a technological problem. It is basically a social and human problem. Unprecedented exploitation of nature by industrial society is a threat to the survival of future generations. Resources are depleted so fast that nature is not able to replenish the resources. Over-consumption and wasteful consumption are the two major reasons for the decline of natural resources. Consumption of resources only for the basic and essential needs of the human society is the best alternative for the crisis. As Gandhiji said, *"Earth provides enough to satisfy every man's needs, but not every man's greed"*. He pioneered the three sustainability principles '*Reduce, Reuse and Recycle',* in India. All his life he did experiments, created awareness and published articles on these principles. The prospect of increasingly technology-led development is likely to bring in more social inequalities and environmental instabilities and expose the limits of the biosphere, in supporting the humanity's dependence on the natural systems. The decline of valuable natural resources like forests, top-soils, water bodies and oceans will bring hardships to the people. It will deprive the livelihood opportunities of the poor permanently. The decline of resources like ground water will bring down the standard of living of a vast section of the society. It will result in the decline of the world economy in long run.

The current concerns in India on sustainability, biodiversity conservation and environmental protection could have been much less, had we resisted the western model and embraced the Gandhian model of industrial development, rooted to the ethos of Indian civilization. The major focus of ICAR in the coming years shall be to mainstream Gandhian thoughts in all its research and development endeavours and to uphold agricultural sustainability, conservation of agro-biodiversity and natural resource management, as a prime focus for all newer farm technologies.

5. Conclusion

The structure of ICAR, with various subject matter divisions, comprising an array of commodity or domain specific research institutions, and a nation-wide network of Krishi Vigyan Kendras (KVKs) is a reflection of Gandhian idea on self-reliance and creating local

institutions. Gandhiji's economic principles are relevant in the context of Gandhiji's view of gram swaraj (village self-rule). He thought that the lives of farmers and labourers are the best. The farmer, for him, was the central point, and the only sustainable social order was a rural society. Any system, be it agriculture or non-agriculture as we have today characterized by urbanization and centralized production, requires huge and intensive resources but they are concentrated only in fewer hands. A rural society with more equitably distributed income and resources, as visualized by Gandhiji, would greatly reduce farm distress.

The Green Revolution ushered in an element of self-reliance at the macro-level by bringing in two types of technologies: bio-chemical technology (involving fertilizers and seeds), and agro-mechanical technology (involving mechanization of agriculture). These technologies work for water-rich areas, but half of the districts in India are rain-fed.

There are three types of agrarian economies: 1. Subsistence agriculture economy where farmers grow enough for themselves without a marketable surplus. 2. Commercial agriculture, where farmers produce certain crops for the market but keep their own food system intact by growing their inputs. 3. Marketized agriculture – which is cash-based to buy every input from the seeds to water, tractor, fertilizers, etc., and it is most risky and distressing. A farmer borrows cash, spends to buy inputs, and faces the risk of crop loss due to rain-fed farming. In such a scenario, if a crop fails, he gets stuck in debt. Gandhiji saw the subsistence and commercial agriculture models as viable in broad sense since the cash pay-out and the risks are minimal. Indian agriculture can prosper much more sustainably when agriculture, agro-industry and non-farm cottage industry are developed holistically in rural areas.

> *"Based on the most advanced principles of biological science, we can probably claim to have developed a Gandhian Agriculture, because this would be an agriculture, where Gandhian concepts become manifested in the form of an advanced rural economy, benefiting all sections of the community. Also, this will be an agriculture, which enriches and not harms the environment."*
>
> - MS Swaminathan (1991)

The new eco-technologies have become important in the context of achieving the sustainable development goals (SDG) through integration of economic viability with social and environmental sustainability. Gandhian philosophy on agriculture, wherein productivity can be enhanced without harming the environment, is ideal for promoting environmentally sustainable technology.

Chapter 13

Gandhian Philosophy of Agricultural Education

RC Agrawal, G Venkateshwarlu and PS Pandey

"Literacy in itself is no education. Literacy is not the end of education or even the beginning. By education I mean an all-round drawing out of the best in the child and man-body, mind and spirit."
MK Gandhi

1. Introduction

Gandhiji was a great educationist and he believed that the social, moral and economic progress of a nation ultimately depends on Education. In his opinion, the highest aim of education is the Self-Realization. His philosophy of education is a harmonious blending of Idealism, Naturalism and Pragmatism. Most of Gandhiji's important writings on education have been compiled and edited by Bharatan Kumarappa in two books, Basic Education (1951) and Towards New Education (1953). Though these writings are mostly consisting of letters, speeches and extracts from books, together they constitute a Gandhian philosophy of education.

About the Agricultural Education, Gandhiji has written *"Commerce will have its college. There remains arts, medicine and agriculture. Several private arts colleges are today self-supporting. The State would, therefore, cease to run its own. Medical colleges would be attached to certified hospitals. As they are popular among moneyed men they may be expected by voluntary contributions to support medical colleges. And agricultural colleges to be worthy of the name must be self-supporting. I have a painful experience of some agricultural graduates. Their knowledge is superficial. They lack practical experience. But if they had their apprenticeship on farms which are self-sustained and answer the requirements of the country, they would not have to gain experience after getting their degrees and at the expense of their employers"* (Harijan, 31-7-1937).

In Gandhian philosophy, education is more comprehensive than that of the literal meaning. He says, "*By education I mean an all-round drawing out of the best in child and man–body mind and spirit. Literacy is not the end of education not even the beginning. It is one of the means whereby man and women can be educated. Literacy in itself is no education*." He strongly believed that education is closely associated with the socio-economic development of the society. He took up scheme for basic education in which vocational training or work experience played an important role. It is based on the fact that it stimulates the human mind for creative thinking or dignity of manual labour. He also proposed that such creative thinking should be taken up from primary to higher-level education.

2. Gandhian Principles of Education

Gandhiji always maintained that education is essential for the attainment of the goal of peace. It can be attained only through morality and ethics. As we all know, the 'ethics' and 'morality' are integral components to Gandhiji's life. That's why, all his principles and actions are based on these two concepts. From the ethical point of view, he advocates that the education may be considered as a means of attainment of salvation. As a daily practitioner of non-violence, Gandhiji right from his earlier stage considered that non-violence is an indivisible, important and essential part of education. For this purpose, Gandhiji has given some rules for all students so as to ensure that morality and righteousness always be considered as an essential part of their education. He strongly believed that such rules can make the students to imbibe right thinking, self-control, service to the society, respect to others and constant awareness for their duties and responsibilities.

Gandhiji's concept of education is quite significant and highly relevant in the current situation. His philosophical concept of education is entirely based on the development of human personality, to maintain the discipline, to create the manual work with learning and to develop the culture of the peace. He was a great educationist and an individualist par excellence. He realized that education is the most important instrument in the society, which translates into socio-economic progress, material advancement, political evolution and moral development of an individual. It was interpreted that his concept of education is full of religious ideas. However, his idea of religion is quite different from commonly believed concept. His concept of religion is known as 'service of humanity'. For the spirit of religions, he propounded 'Nai Talim' or 'basic education'. His philosophical thought on education is so unique that becomes the basis for the socio-economic development of the society.

He says, "*If one takes care of the means, the end will take care of itself.*" End and means are the two most important concepts in Gandhian philosophy, which are foundations of his doctrine of truth and non-violence. His principle of *aparigraha* is one of the most important to bring simple and peaceful living, co-operation with one another. However, in our present society we are facing so many challenges. One of them is the disconnect between knowledge and work-ethics. Knowledge is separated in thought, in life as well as in market values. In this background, the education plays an important role to equip individuals with the skills and attitudes that are necessary in order to adapt in changing situations and to add the creative spirit in the task of social change. '*Work and knowledge should go together*' is the Gandhian principle of education. The educational systems try to develop the individual soul and mind, courage and self-reliance, cultivate the highest intellectual, scientific, moral and ethical accomplishments.

His principle of '*learning by doing*' tries to stimulate the individual's mind to think creatively, independently and critically. He laid emphasis on work-culture to the learners from the primary stage to higher stage in order to start producing from the time one starts training. So, his philosophy of basic education is Head, Heart and Hand rather than Reading, Writing and Arithmetic.

3. Gandhian Principles and ICAR Activities

3.1. Education to satisfy the needs of villages

Gandhiji observed, "*If we want to impart education best suited to the needs of the villagers, we should take the vidyapith to the villages."* ICAR through its Agricultural Education Division, is involved in strengthening and streamlining of higher agricultural education system to enhance the quality of human resources. The division strives for maintaining and upgrading quality and relevance of higher agricultural education through partnership and efforts of the ICAR-Agricultural Universities (AUs) system comprising of State Agricultural Universities (63), Deemed to be universities (4), Central Agricultural Universities (3) and Central Universities (4) with Agriculture Faculty. As foremost step for quality improvement of education, the ICAR has periodically been appointing Deans Committees for revision of course curricula of under-graduate programmes of agricultural education. In this series, the Fifth Deans' Committee has developed the report by undertaking comprehensive consultations and a bottom up approach for curriculum development. Inputs from different stakeholders of agricultural education were obtained at different levels. In the report, the course curricula have been restructured and reoriented to develop much needed skills and entrepreneurial mind-set among the graduates to take up self-employment, to sustainably enhance rural livelihood security, and to propel agricultural transformation through science informed policy options and actions. The Rural Awareness Work Experience (RAWE) imparts diagnostic and remedial knowledge to students relevant to rural field situations through practical training. The communication skills of students are strengthened by the use of extension teaching methods for the transfer of technology. Students are encouraged to develop their confidence and competence to solve agricultural problems. RAWE also acquaints students with on-going extension and rural development programs. The RAWE primarily helps the students to understand the rural situations, status of agricultural technologies adopted by the farmers to prioritize the farmers' problems and to develop skills & attitude of working with farm families for overall development in rural area. The timings for RAWE are made flexible for specific regions to coincide with the main cropping season.

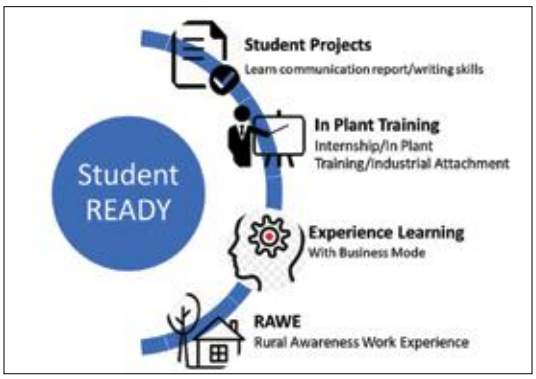
3.2. Education for self-reliance

Gandhiji advocated, *"Education should be made self-supporting through some productive work. Education should lead to economic independence and self-reliance for livelihood."* The academic programmes in agriculture and allied sciences in ICAR have been designed to create human resources who would become "Job Providers rather than Job Seekers". Further,

these programmes have been declared as Professional Courses. The word 'experiential' essentially means that learning and development are achieved through personally determined experience and involvement, rather than on received teaching or training, typically in group, by observation, study of theory or hypothesis, and bring in innovation or some other transfer of skills or knowledge. Experiential Learning (EL) is a business curriculum-related endeavor, which is interactive. ICAR has established about 480 EL facilities in Agricultural Universities. The EL is for building (or reinforcing) skills in project development and execution, decision making, individual and team coordination, approach to problem solving, accounting, marketing and resolving conflicts, etc. The programme has end-to-end approach. Carefully calibrated activities move participants to explore and discover their own potential. Both activities and facilitation play a critical role in enhancing team performance. The EL provides the students an excellent opportunity to develop analytical and entrepreneurial skills, and knowledge through meaningful hands on experience, confidence in their ability to design and execute project work. The experiential learning programme is being offered for 180 days (one semester) period in the final year. As the programme is enterprise oriented, students and faculty are expected to attend the activities of the enterprise even on institutional holidays with total commitment, and without any time limit or restriction of working hours for ELP. The Experiential Learning Programme runs for full year by making two groups and rotating activities of the final year in two groups.

3.3. Education for Industry

"All education should be imparted through some productive craft or industry and a useful correlation should be established with that industry. The industry should be such that the child is able to achieve gainful work experience through practical work." argued Gandhiji. The course curricula in ICAR have been restructured and reoriented to develop much needed skills and entrepreneurial mind-set among the graduates to take up self-employment, to sustainably enhance rural livelihood security, and to propel agricultural transformation through science informed policy options and actions. To reorient graduates of Agriculture and allied subjects for higher employability and greater entrepreneurship, the Student READY (Rural Entrepreneurship Awareness Development Yojana) programme has been introduced in all the Agricultural Universities as an essential prerequisite for the award of degree to ensure hands-on experience and practical training. To enrich the practical knowledge of the students, In-plant Training has been made mandatory in the last semester for a period of up to 10 weeks. In this training, students will have to study a problem in industrial perspective and submit the reports to the university. Such In-plant Trainings will provide an industrial exposure to the students as well as to develop their career in



the high-tech industrial requirements. In-plant Training is meant to correlate theory and actual practices in the industries. It is expected that sense of running an industry may be articulated in right way through this type of industrial attachment mode.

Student Ready Programmes of Agricultural Universities

The objectives of In-plant Training are to expose the students to industrial environment, especially to familiarize the students with various processes, products and their applications along with relevant aspects of management. It also helps the students to understand the scope, functions and job responsibilities in various departments of an organization and exposure to various aspects of entrepreneurship during the training period.

3.4. Education for Environment

Gandhiji's popular quote *"The earth has enough resources for our need, but not for our greed."* expresses his views on environment. ICAR's National Agricultural Higher Education Project (NAHEP) is being implemented by ICAR since 2017-18 to enhance the quality and relevance of agricultural higher education in the country. Based on the environment assessment under the NAHEP, an Environment Management Framework (EMF) is prepared for each partner university to 'ensure the environmental sustainability of the project interventions and to integrate the key environmental concerns in agriculture into education and research'. The EMF presents the 'legal and regulatory framework'- a compilation of applicable acts, rules and regulations of GoI and identifies potential environmental risks and presents the mitigation measures

In this background, every individual has a responsibility in protecting the environment. In order to create awareness among all the graduates of agricultural sciences, a common course on "Environmental Studies and Disaster Management" has been introduced through Fifth Deans' Committee. It is being implemented in all the agricultural universities. The course was intended to make the students to realize the importance of Natural Resources encompassing both renewable and non-renewable resources.

Mahatma Gandhi said *"Sanitation is more important than independence". He made cleanliness and sanitation an integral part of the Gandhian way of living. His dream was total sanitation for all. Cleanliness is most important for physical well-being and a healthy environment. It has bearing on public and personal hygiene. It is essential for everyone to learn about cleanliness, hygiene, sanitation and the various diseases that are caused due to poor hygienic conditions."* A few of the major activities under the NAHEP envisage faculty and student skill

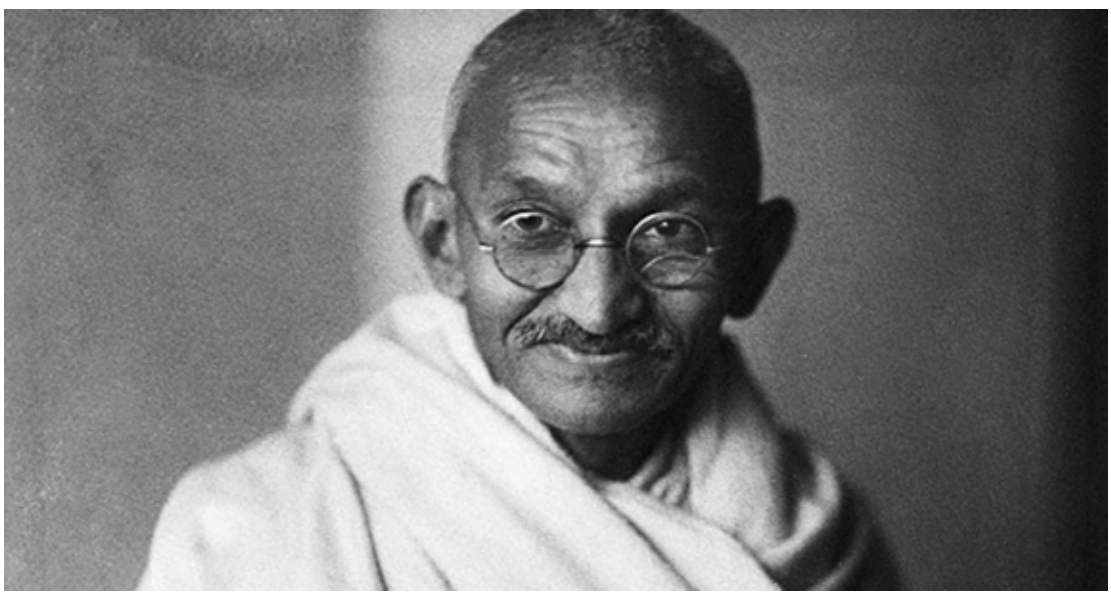
and entrepreneurship development, imparting international outlook, leveraging infrastructure, HRD, networking and technology to enhance learning outcome, activating alumni network, involving industry in curriculum design, course evaluation and pedagogy option on pilot basis, novel revenue models, provide support for better and effective governance of agricultural universities through state of art of academic, examination and innovation management. As part of the funding by the Multi-lateral financing agencies like the WB, it is mandatory to ensure following reforms and best practices pertaining to finance, procurement, safeguards, etc. The Project Implementation Unit as part of its efforts in ensuring compliance and promoting adoption and implementation of best practices related to environment safeguards came with the idea of this clean and green campus award. A Green Campus is a place where environmentally friendly practices and education combine to promote sustainable and eco-friendly practices in the campus. The green campus concept offers an institution an opportunity to take a lead in redefining its environmental culture and developing new paradigms by creating sustainable solutions to environmental, social and economic needs of the inhabitants. For ideal educational institutional buildings, it's imperative to put in place sustainable environmental management in terms of green cover, solid, liquid and e-waste management, rain and roof water harvesting, water and energy conservation, waste reuse and recycling, to cite a few. Greening the campus is all about turning around wasteful inefficiencies and using conventional sources of energies for its daily power needs, correct disposal handling, purchase of environment friendly supplies and effective recycling program.

3.5. Education for Personality Development

Gandhi's concept of education is of quite significance in the contemporary situation. His philosophical concept of education is entirely based on the development of human personality, to maintain the discipline, to create the manual work with learning and to develop the culture of the peace. The Indian Council of Agricultural Research has been striving to aid, impart and coordinate agricultural education to develop quality human resource in the country. In order to address the concerns of quality higher agricultural education, the National Agricultural Education Accreditation Board (NAEAB) was established to advise the Council in evolving norms and standards for accreditation of institutions and programmes of agricultural education. The Board started accreditation of Agricultural Universities in the year 2001. Recently, it has reorganized with more objective assessment. Thus, the new guidelines for accreditation follow three tier accreditation system i.e. Programme, College and University. Scorecard based evaluation, awarding grades, provision for grievance redressal and preliminary examination of Self Study Reports by Regional Centres are some of the new features in the revised guidelines. Introduction of Scorecard based on the criteria, key aspects and its pre-determined weightage; together with grading of agricultural universities are expected to inculcate transparency and competitiveness in the accreditation process.

4. Conclusion

Though the current situation is completely different from the time of Mahatma, his educational thoughts are quite relevant for the overall development of human resources in agriculture and allied sciences. An attempt has been made in this chapter to discuss how the curricula of agricultural universities are developed based on the Gandhi's educational thoughts. His philosophy of education is not only the eradication of illiteracy but learning by doing. This concept has been fully integrated in the agricultural education in the country. In both undergraduate and post-graduate programmes, the practical component is being given higher weightage with an idea that the students would be learning while doing. Especially, the Student READY, which is a mandatory component of all the under graduate programmes in agriculture and allied sciences encompassed RAWE and Experiential Learning based on this concept. He preaches the doctrine of simple living and high thinking. His education systems greatly emphasize the culture of peace, sincere work, dedication to the nation, right feelings, economic advancement, physical improvement and socio-cultural progress. While framing the syllabus, the due importance is being given for the development of national human resources capital in the field of agriculture and making our graduates professionally competent, socially sensitive and ethically strong. On the path of Gandhian philosophy, the highest priority has been given to agricultural education for the alleviation of hunger, undernutrition, poverty and inequity. Accordingly, the framework of agricultural education has been designed to ensure excellence, relevance, and creation of skilled and entrepreneurial human resources to achieve high quality of products, farmers profitability, high input and natural resources use efficiency and inclusiveness.



Chapter 14

Gender Empowerment through Village Institutions and Education

SK Srivastava and G Maharana

"Woman is the companion of man, gifted with equal mental capacity. If by strength is meant moral power, then woman is immeasurably man's superior."
MK Gandhi

1. Introduction

The role and position of women in India has been witnessed in different eras and in different classes, religion, and ethnic group. Exploitation of women in and outside their home was prevailing in the society. There were many philosophers, social reformers and thinkers like Raja Ram Mohan Roy, Swami Dayanand Saraswati, who strived endlessly to bring the change in the condition of Indian women during the period which may empower them to become *"better wives"* and *"better mothers*. He believed that man and women are as equals and complementing each other. Women were considered as *'self-conscious objects'* according to Gandhiji and he integrated them in the *'masses'* in a most natural way. He recognized that due to the conservativeness attitude of the men, different traditional customs and law, women have been concealed under different circumstances. There had been many examples where women have been taught to consider themselves as slaves of men. But now the time has come to realize the status of women in society and give them equal right as equals of men. Mahatma Gandhi characterized women as of *'ahimsa*', which represents love and infinite capacity for suffering.

2. Gandhiji's view on Gender Equality

Mahatma Gandhi, the father of the nation was a great human being in the form of a leader, philosopher, and an educational pioneer of great repute. He tried to establish a free and casteless society without any exploitation and racial discrimination. Gandhiji strongly emphasized that there should be no inequality in the wages paid to men and women. He could understand that the success of the Swadeshi movement was possible as women spun yarn and weave cloth in large numbers. He felt that women should not feel any legal disability, which is not suffered by men. Women should learn the rights as well as duties. She thereby has the right to participate in every activities of man and has an equal right to freedom and liberty with him. Therefore both boys, as well as girls, should be educated but it is only the primary education for the two sexes that have much in common. According him there must be certain provision for separate

arrangements for the education of girls after their attaining a particular age. Domestic tasks should be taught to them for practical application in daily life.

Gandhiji was seriously worried about those widespread social issues during the period. He was against of the child marriage, *purdah* system, dowry system etc., which crippled women's movement in the society and restricted their advancement and capacity for doing work useful towards the society. He was against of the celebration or feasting on different occasions like marriage, birth anniversaries etc. He took steps towards to remove all social and religious barriers to start widow remarriage. He realized that social institution and education play an important role in empowering women and bringing gender equality and equity in the society. Mahatma Gandhi is encouraged women's active participation in the freedom struggle, which gave him identity of a great promoter of women's liberation. Women's participation in national politics through non-violent methods brought unbelievable changes in the past. They crossed the boundaries of their protected homes and joined in non-violence movement without any hesitation. These moments witnessed to observe the women empowerment, which started from home to country level.

3. Concept of Gender Empowerment

The term empowerment has a meaning to enable gender especially women to obtain and acquire power and resources to participate in decision making to achieve their family goals. This can be achieved by giving equal rights and ownerships in assets and also giving equal opportunities for accessing the resources. Women's participation in decision-making process and access to and control over resources are considered as the significant indicators in the development of gender empowerment. Women especially from rural background possess have lack of knowledge about their rights on the proportions of material resources and which show them as powerless and dependent on the powerful. Empowerment of women can be achieved by education and participation in different level of social institution play an important role. This should be accepted starting from the family members to the policy makers.

4. Role of Village Institutions in Gender Empowerment

Role of social, political, religious and educational Institutions is very much important in gender empowerment. There were many social taboos, conservative mindsets and gender stereotypes role prevailing throughout the country. There are many social and economic institution supports for economic empowerment of women in particular exists at village level. According to Gandhiji, an ideal Indian village can be constructed with cottages having sufficient light, ventilation and sanitation facilities within reach of the people. There should be enough space for rearing domestic animals. There should be common meeting place, common grazing place for cattle, a co-operative dairy, primary and secondary schools in which people can access to basic facilities and have a village Panchayat for resolving their personal and social disputes. Villagers may able to produce their own food grains, vegetables and fruits and weave *khadi*

to fulfill amenities. This was the idea of a model village proposed by Gandhiji. Home is the primary social institution gives many lessons and moral values to prosper in the society. Gradually this can be extended from home to village level for overall empowerment of village women in several areas.

4.1. Role of Self-Help Groups

Women led Self Help Groups (SHGs) at village is a micro level institution plays significant role in income generation by women to reduce poverty. The women in rural areas go together with 10-20 members and form different SHGs in a village, which helped them to bring a change in the mindset of the people who are very conservative and illiterate. The women mostly generate fund by contributing their own and do some income generating activities at village level. These income-generating activities include post harvest and value addition of agro produces, beekeeping, mushroom cultivation and making handicrafts. These have increased the awareness of SHGs members and defend themselves from the exploitation by middlemen. It gives a feeling of solidarity.

4.2. Entrepreneurship Development among village women

Entrepreneurship is an emerging concept, perceives as challenging by women and requires competence to take appropriated decisions and responsibilities. Stepping into entrepreneurship development is dynamic could bring the preferred change in attitude of rural women through income generation, socio personal development and support for others employment. Women can initiate and channelize production possibilities with the help of other group members at their locale. They are more capable to overcome the negative impact of social pressure and gender biasness prevailing against them by creating their group identity and dynamic activities. Women in a group feel more confident in approaching bank or any Government departments for assistance under different schemes.

5. Gender Empowerment through Village Institutions: Role of ICAR

Under the umbrella of Indian Council of Agricultural Research (ICAR) there are many Institutes, SAUs and KVKs playing major role in empowerment of both the genders in agriculture and allied sectors. Research, extension and education are the three basic services provided by ICAR in which girl students and farm-women are also the major stakeholders. Programmes and projects are being undertaken for income enhancement, livelihood security and food and nutritional security of farm families with specific emphasis to farm-women. Women are considered as the backbone of Indian agriculture but much of their work goes unrecognized. They have remained as “invisible workers” contributing in the development of agriculture.

Realizing the enormous needs to address the problems and gender issues in agriculture, India is pioneer in institutionalizing research on women in agriculture by establishing National Research Centre for Women in Agriculture (NRCWA) at Bhubaneswar, Odisha in 1996 upon recommendation of the Working Group on Agricultural Research and Education constituted

by the Planning Commission. This was subsequently promoted from NRCWA to Directorate and now as ICAR-Central Institute for Women in Agriculture (ICAR-CIWA) in the year 2014 with a vision to emerge as a principal centre for conducting gender research and women empowerment in agriculture to increase productivity and sustainability of agriculture. ICAR-CIWA is implementing various research projects with mandates to carry out Gender equitable agricultural policies/ programmes and gender-sensitive agricultural-sector responses.

Since its inception, the Institute has been undertaken various research on several gender issues in agriculture and gender mainstreaming by increasing opportunities of women in agriculture. The Institute is globally one of its kinds and has demonstrated its leadership in the emerging area of research on women in agriculture. It is co-ordinate the AICRP on Home Science for gender mainstreaming and empowering women in agriculture at 13 centres in 12 states in the country. The researches have been carried out in five components such as Food & Nutrition, Family Resource Management, Human Development and Family Studies, Clothing and Textile, Home Science Extension Education. The main thrust of the project is to empower women in agriculture for their improved nutrition, livelihood security and drudgery reduction, occupational health hazards and capacity building of agrarian families. To take up the ergonomic issues and safety of women farmers in rural area, ICAR-CIWA is working as one of the centre of All India Coordinated Research Project on Ergonomics and Safety in Agriculture (AICRP on ESA) during the year 2017.

The Institute has been consistently working as a Single Window System on Women in Agriculture to understand the needs and issues of women in agriculture and it has been regularly giving inputs to researchers and policy makers for gender responsive policies on the basis of research results. Apart from research on gender issues and assessment of technologies with gender perspective, research on methodologies and gender-disaggregated data were initiated. Its activities expanded to different parts of India through networking and collaboration with more than 40 Centres in National Agricultural Research and Education System. Gender sensitization of R&D stakeholders was given more emphasis. ICAR-CIWA attracted the attention of government departments and participated in policy level discussions on gender organized by Govt. agencies.

During past two decades of its existence, the institute has implemented research projects in a number of areas such as Integrated Farming System, IPM technologies, horticultural models for income generation, empowerment of women in fishery, processing and value addition, gender sensitive extension, technology assessment and refinement with women's perspective, mitigating occupational health hazards and drudgery, gender information system, gender sensitization, gender based methodologies and approaches, etc. For enhancing income of Farm Households, certain technologies and methodologies/ models developed/ tested/refined such as Resource Efficient Horticulture Model for improved nutrition and income of Smallholders, Low Cost Backyard Poultry Farming, Low cost poultry feed utilizing acid treated and fermented fish silage, Integrated Pest Management Model, Low cost weaning mix using rice flakes, wheat,

green gram, bengal gram, sesame seeds and sweet potato powder and azolla based low cost poultry feed. These were adopted at famers field for increasing their income and fulfilling family nutrition. ICAR-CIWA also has been developed and commercialized 'DRWA Hand Operated Maize Dehusker-sheller. These above technologies and methodologies/models can directly help both the gender and especially for increasing their work efficiency, reducing drudgery, saving energy, time and cost and ultimately achieving the livelihood security by adopting those at field level. Programmes are being carried out for wide dissemination and demonstration of technologies at village level and in particular to Women SHGs for entrepreneurial development. Different national flagship programmes *viz;* Mera Gaon Mera Gaurav, Tribal Sub Plan programme, Aspirational Districts, Swachch Bharat Abhiyan and SPSC programme are also being carried out by ICAR-CIWA for overall development of agrarian families especially farm women at village level.

ICAR-CIWA the only institute working on women in agriculture at global level. The scientists are striving hard and giving their best output to empower women farmers by address the issues such as food & nutritional security, livelihood improvement and technological empowerment. These can be only achieved when the women farmers get proper recognition, access to get resources, linkages with line departs, access to credit and marketing facilities and availing various Govt. welfare schemes for their socioeconomic upliftment. Ultimately this will also able to create women agri-preneurs and leaders who may contribute the growth and development of women in agriculture. There are also many scopes for ICAR-CIWA to work with other Govt. and private agencies across the country for development of women farmers. Finally it will help in reducing gender gas and bringing gender empowerment at village level among the grass root stakeholders.

6. Gandhiji's Philosophy on Women's Education

Gandhiji was the first Indian educationist who advocated a scheme of education, which should be based upon the important values of Indian culture and civilization. The methods and techniques proposed by him were unique. His philosophy of education is based on the harmonious blending of idealism, naturalism, and pragmatism. Idealism is the foundation of Gandhiji's philosophy, where as naturalism and pragmatism help to translate philosophy into practice among all. He believed on the ideal truth, non-violence and moral values to achieve the ultimate truth of self realization. He is a follower of naturalism when he revealed that during the life span development, a child can learn by doing experiences in nature. These will help in integration of effective education and personality development of gender in general and women in particular. This philosophy of Gandhiji play major role in educating both the gender and encourage them to hone skills in different crafts for self-sufficient.

According to Gandhiji education is meant out of the best in human- body (hand), mind (head) and spirit (heart). It is only one of the systems where both the gender can be educated. Gandhiji philosophy of education aimed for providing better opportunities for the all round welfare of

the moral, spiritual and physical attributes of human being as general and women in particular. Gandhiji's educational philosophy is based dynamic and realistic. His vision on education was based for the betterment of society as well as whole country. His emphasis on body, heart, mind and spirit in the educational process is most significant in today's era. The most essential characteristic of Gandhiji's philosophy of education is not emphasizing the curriculum but focused for the handicrafts. The sustaining aspect of the craft can be chosen as a means of education. All education should to be based on trust and self-supporting. He also emphasized for the character development of individuals. The above principles of education are applicable for both the gender during their early childhood period. It enhances their physical, motor skill, cognitive, moral, social and personality development of the children irrespective of their gender. This enable their all round development. Care should be taken about the gender stereotypes and breaking the traditional gender roles for gender empowerment during the formation stage of children. It will automatically help in reduce the gender gaps.

6.1. Need of education for Gender Empowerment

The problem of girls' education is very much prevalent and it needs to be identified through out the country. There is a wide gap in the status which reflects the differences access to education. The girls belong to higher classes in the society receive better achievement as compared to the boys belong to poorer communities. The women who come from landless households, belong to social and economically backward communities living in the most interiors of the country have been totally neglected by educational and developmental programmes. Schooling is the most important part of social norm to educate both the gender. This is very much important is to maintain the quality parameters of education to make certain that children in school actually get education and girl children should get equal benefits for getting education. For Govt. has undertaken various schemes and programmes such as *Beti Bachao, Beti Padhao*, Mid-day Meal, ICDS schemes, etc. for ensuring increase in enrolment of girl students in schools and colleges

6.2. Role of Education in Gender Empowerment

Education as an important mechanism among women and which brings the desirable changes in shaping the future of women and give equal opportunities to attain education and equal status in our society. Gandhiji's philosophy of education was come out from his long experiences of political, social, and economic experience in life. According to him, there is a need to promote the physical, mental, and spiritual development of an individual among both the gender and women in particular. Reading and writing are the ways of education but not for overall development. His basic education was based on the practical personification and aim towards to purify the heart and mind of people and create a society free from all exploitation. According to Gandhiji empowerment of women can be possible by sharing resources such as material, financial, intellectual with every woman. This is called as the Gandhian formula (sharing and sacrifice). Gandhiji has done great revolution by bring out masses of illiterate women from the four walls of their houses during freedom struggle. His persistence on Women's education is

the first step towards to achieve esteemed goal to empower women in the country. The above principles of education are applicable for both the gender during their early childhood period. It enhances their physical, motor skill, cognitive, moral, social and personality development of the children irrespective of their gender for all-round development. Care should be taken about the gender stereotypes and breaking the traditional gender roles for gender empowerment during the formation stage of children. It will automatically help in reduce the gender gaps.

6.3. Gender Empowerment through Education

When all the women in the society are considered, the percentage of educated women is much less than men. The importance of female education is given following:

- Education helps women to raise her voice for own rights with the courage, which will help in mitigating gender inequality and social injustice.
- As long as they are backward, they will not get freedom, security and safety in life. Through education they can get better financial opportunities and employment opportunities.
- Education helps women to live a civilized life in the society and to understand about their social and cultural rights in the society and decrease the chances of gender discrimination. However, there is provision for women to lodge complaints against the different types of violence against women such as dowry, forced prostitution, female feticide, child marriage etc.
- Education helps women to understand the importance of health and wellness of the body and helps them to lead a quality healthy life. This will be helpful in gender mainstreaming.
- Education helps women to prove to be very successful in the area of life. Through equal opportunities she can get a better job of her choice.
- Right to education shows path to girls and women for their social and economic improvement.

7. Gender Empowerment through Agricultural Education: Role of ICAR

Agricultural Education is a continuous process undertaken by agricultural universities through imparting education and capacity building programmes for both the genders. Under ICAR, different State Agricultural Universities (SAUs) provide education in the various disciplines of agriculture and allied sectors. These impart education to students at the level of diploma, degree, masters and doctoral level. To ensure timely growth and achievement, the Indian Council of Agricultural Research (ICAR), this is the apex organization for coordinating, guiding, and managing research, extension and education in agriculture in country and took the lead and encouraged the setting up of exclusive State Agricultural Universities for the same services. The recent trends for the past four years showed an increasing percentage of enrolments of women in agricultural course than men. Girls' students showed higher percentage of academic achievement as compared to boys. It has been observed that the attitude of girl students towards higher agriculture education plays an important role in agricultural development process. It

can be seen that enrolment of girl students are more than boys in case of seeking admission in higher agriculture degree courses. The women research scholars in agricultural are considered as key constituent to carry out research in the agriculture and also involved in agricultural related occupations. The data has been revealed that about 15% of the world's extension agents are women in the area of Agricultural Extension services.

The Agricultural Education Division, ICAR is involved in imparting agricultural education and reformation higher agricultural education system to develop the excellence human resources in agriculture sector in the country. Recently, ICAR has recognized the Bachelor's degree of Agriculture as Professional Degree. The courses include Agriculture, Horticulture, Agriculture Engineering, Sericulture, Forestry, Food Technology, Biotechnology, Home or Community Science, Food Nutrition and Dietetics have been recognized as 'Professional Degrees'. These course curricula were planned by considering upcoming challenges in the agriculture and employment opportunities of passing out graduates in a holistic way for quality reassurance of agricultural education. These give indications for equality of women in agricultural education for development of the agricultural sector in country. These courses have reoriented to inculcate need based skills and entrepreneurial mindset among the agricultural graduates including both the gender initiating income generating activities which help in livelihood, food and nutrition security and sustainability of agriculture.

Gandhiji gave special importance to the requirement of mandatory education for girls. He emphasized the requirement of education, which would certainly support women to think on their own. He believed that in our society majority of women don't have much education and they don't aware what is going around the world which is the reason behind a good number of the evil practices persist against women. Hence education is essential for women. He undoubtedly understood that education is vital method to pronounce natural rights of gender especially of women to avail wisely and execute for their own development.

8. Conclusion

During the 20th century many significant changes have been observed in the status of women. They participate in social institutions to address the gender issues faced by women and bridge the gap created by society. This can be possible by achieving gender equality and gender equity. There are several factors responsible for creating obstacles to women education and participation in village level Institutions. Some cultures do not appreciate the education of women and girls, and they do not offer the opportunity and support to succeed. Women's contributions to society should not be ignored as she plays crucial role in the home considered as the primary social unit at village or society. So empowerment of gender should be brought out at each household level by giving equal opportunities to the gender. When the women become empowered, the whole family is empowered and this strengthens the entire community. Women should be encouraged in all spheres to promote women's education at all levels. This will help to improve the overall balance of women in the community and as well gender mainstreaming and gender empowerment in the society.

Chapter 15

Gandhian Philosophy of Self-reliance: Lab-to-Land Initiatives of ICAR

AK Singh, YG Prasad, VP Chahal, Randhir Singh and R Roy Burman

"I should like to slip out of the public gaze, to bury myself in the farm and devote my attention to farming."
MK Gandhi

1. Introduction

Gandhiji's profound love for the land and respect for the toiling rural people made him believe that India lives in its villages. He dreamt of self-sufficient and self-reliant villages and visualized that agricultural sector and household cottage industries may eradicate rural poverty and unemployment. Gandhi ji stressed upon the growth of agriculture based rural industries like khadi, handlooms, sericulture and handicrafts. As rural industries could operate successfully on family labour with less amount of capital and external inputs, the demand and supply could be addressed locally. Gandhi's political movements were aligned with social reforms. Mahatma would often turn to thoughts of village reconstruction to address unemployment and starvation in rural India (Bhuimali 2004).

The principle of Gandhian philosophy is regional self-sufficiency, or Gram Swaraj. He realised that to achieve Gram Swaraj, revival of village industries was absolutely essential. In 1934, the All-India Village Industries Association (AIVIA) was established for rural industrialisation.

2. Gram Swaraj

Mahatma Gandhi's concept of Gram Swaraj is rooted in his idea of self-reliance. The means of production of the basic necessities must be available locally. He supported the idea of decentralisation of production and emphasised on the idea of autonomous and self-contained villages through Panchayats having executive, legislative and judicial powers.

Gandhian philosophy advocated a labour-intensive policy against a capital-intensive one with decentralised system of planning, production and decision-making. The Gandhian philosophy highlights ownership, co-operation, equality, self-discipline, simplicity and limited wants. He believed in mobilizing people to produce locally to empower them and provide gainful employment to large section of society living in villages. The *Dandi March* of Gandhi in 1930 was phenomenal for signalling the importance of community participation in addressing local needs.

3. Sevagram experiment

This programme started under the guidance of Mahatma Gandhi in 1933 though its origin can be traced back to the 1920s with the establishment of the All India Spinners' Association. Self-contained and self-sufficient village life was the dream of Gandhiji. He was aware of the problems of rural India and wanted to solve these problems with the help of local resources. He advocated that upliftment of the common man is upliftment of the country and believed that cottage industries can salvage the rural economy. The objectives of the Sevagram experiment were to provide services to the under-privileged sections of the society, promote decentralized production, equal distribution of wealth and provide basic education to people. Self-sufficiency of Indian villages could be achieved by eradicating middlemen and giving remunerative price to the farmers for their produce (Mondal 2013). The project was implemented through establishment of several training centres for cottage industries, practicing communal harmony, education against taboos associated with caste and untouchability, and encouraging women's education. For the betterment of people, Gandhi ji formulated an 18-point programme, which included promotion of village industries apart from education.

4. Influence of Gandhian philosophy on the post-independence efforts

Organised extension services in India began with the initiation of Community Development Programme in 1952 based on the experiences gained through the Etawah pilot project experiment. The programme aimed at socio-economic transformation of rural people. In 1960, the government launched the Intensive Agricultural District Programme (IADP) initially in seven districts. In the third Five-Year Plan, Intensive Agricultural Area Programme (IAAP) was started covering 20 to 25 per cent of the cultivated area in the country (Randhawa 1982). High Yielding Varieties Program (HYVP) was launched in 1966-67 to enhance foodgrains production.

5. Frontline Extension Programmes of ICAR

Frontline extension entails a higher level of interaction by the scientists or faculties of the research and educational institution. It is presumed that the technology generator directly or through the domain expert scientist can demonstrate the technology much more efficiently in a farmer participatory mode. HYVP coincided with National Demonstration project launched in 1964 by the Indian Council of Agricultural Research (ICAR) and widespread demonstrations of high yielding varieties led to enhanced adoption resulting in the 'Green Revolution'. Later, ICAR started Operational Research and Lab-to-Land Projects. The Operational Research Project (ORP) initiated in 1974-75, aimed at dissemination of proven technologies among the farmers covering a cluster of villages, and analysing constraints (technological, extension or administrative) in the rapid spread of improved technical knowledge (Singh and Burman 2020).

5.1. Lab-to-Land Program (LLP)

The Lab-to-Land Program was launched in its golden jubilee year by ICAR in 1979 for transfer of viable technologies from laboratories to the farmers' fields. Under this program, 50,000 small and marginal farm households and landless agricultural labourers were adopted for their economic upliftment by the research institutes and agricultural universities. The activities under Lab-to-Land project included creation of a farm plan, training, demonstration, and field days. The programme also served as a feedback mechanism to the scientists and extension functionaries. The programme aimed at assisting selected farm families to develop individual farm plan for improving their whole farming system. The effort of the participating institutes in transfer of technology was expected to be accelerated and intensified through this programme without creating any additional infrastructure (Singh et al. 2006).

Over the years, ICAR evolved an effective and well-tested frontline extension system at the grass-root level, which is exemplary and admired all over the world. Mahatma's principle of cooperation and partnership is deeply embedded in the KVK scheme of ICAR. The first Krishi Vigyan Kendra (KVK) was established in Pondicherry in 1974. The earlier frontline extension programmes were merged into the Krishi Vigyan Kendra scheme in 1982.

5.2. National Agriculture Technology Project (NATP)

The National Agriculture Technology Project (NATP) was launched with financial support from the World Bank in 1998 to strengthen and complement the existing resources of National Agricultural Research System (NARS) and augment its output. Major objective of this project was to accelerate the flow of technology from research and extension to farmer, improve location specific and robust technology dissemination, decentralize decision making and strengthen the public extension system. Institute Village Linkage Programme (IVLP) enabled technology assessment and refinement in participatory mode with direct interaction of technology generators with the end users in villages (Sulaiman and Van den Ban 2000). The project helped to generate a basket of location specific and small production system-oriented technologies which are more productive, profitable and gender sensitive for drudgery reduction of farm women. Technology integration involves a set of activities that must happen when new scientific agricultural information is put to use in any farm production system (Singh et. al., 2003). The project served three distinct types of agriculture, namely, commercial, green revolution and Complex, Diverse and Risk prone (CDR) agriculture.

The Agricultural Technology Information Centre (ATIC) was started under NATP in 1999. The Centre provides diagnostic services, agro-advisory and inputs like seeds, plant materials, etc. through single window system. The ATICs were designed as demand-driven, financially viable models (Mondal 2013).

5.3. National Agricultural Innovation Project (NAIP)

Based on the experiences of NATP, ICAR introduced The National Agricultural Innovation Project (NAIP) in 2006 with the assistance of World Bank. The project focused on innovations

in agricultural technology and transforming Indian agriculture through poverty alleviation and income generation approach. Collaborative development and application of agricultural innovations with the active partnership of public organizations, farmers groups, private sector and other stakeholders was envisaged.

5.4. Krishi Vigyan Kendra (KVK) Scheme

Krishi Vigyan Kendra scheme of ICAR evolved over time for meeting the expectations and emerging challenges faced by the farming community. As of now, ICAR has established a total of 721 KVKs across the country. KVKs have emerged as the key institutional system at the district level for technological backstopping in agriculture and allied sectors. KVK is the fulcrum of the district level coordination between various implementing agencies and programmes like ATMA, line Departments, on-going schemes/ programs, Gram Sabha members, Panchayat institutions, other Government and NGO players in the field of extension. KVKs serve as a Knowledge and Resource Centre of agricultural technologies for supporting initiatives of public, private and voluntary sectors in improving the agricultural economy of the district.

The KVKs are funded by ICAR but the host institutions are State Agricultural Universities (SAUs) Central Agricultural Universities (CAUs), ICAR institutes, Deemed Universities (DUs), State Governments, Public Sector Undertakings (PSU), Non-Government Organizations (NGOs) and Other Educational Institutions (OEI). This cooperative endeavour embodies the coming together of various stakeholders and their approaches for delivery of frontline extension services at the grassroot level within the reach of farmers. The KVKs were established to improve the technical literacy of farmers including farm-women on the principle of 'learning by doing' and 'teaching by doing'. Also, the KVKs have been recognized as effective institutional links between agricultural research and development departments in the country. The KVKs carry out on-farm testing of technologies to identify its location specificity under various micro-farming situations; frontline demonstrations of well proven technologies for demonstrating production potential at the farmers' fields; training of farmers, farm women, rural youth and extension personnel for capacity development. The KVKs produce quality seed, planting material, bio-agents, livestock strains, organize various extension interventions, identify and document farm innovations. KVKs also generate awareness about improved technologies and developmental programmes by organising Kisan Mela (Farmers' Fair), field days, seminars, workshops, and farmers' exposure visits to different institutions. The KVKs have emerged as a unique institutional mechanism to function as a Knowledge and Resource Centre and address capacity development needs of stakeholders.

6. Mahatma's Vision for Self-reliance

India requires about 32 Mt of pulses by 2030 at an annual growth rate of 4.2% to meet the ICMR recommended per capita dietary intake. Large-scale

technology application by KVKs contributed to self-reliance in Pulses production. Pulses are climate sensitive crops predominantly grown under rainfed situations, in marginal soils under resource constraints. Ensuring recommended daily availability of pulses per capita has always remained a challenge. ICAR took up implementation of cluster frontline demonstrations (3.5 lakhs) in farmers' fields across the country through 590 KVKs. Improved high yielding, short duration, drought and pest/ disease tolerant cultivars of less than 8-10 year duration in all pulse crops coupled with seed treatment, *in situ* moisture conservation practices, weed management, crop protection, micro-irrigation and mechanized harvesting techniques were demonstrated to farmers in large clusters over three seasons at district level in all the states since 2015-16. Field days were conducted involving farmers from neighbouring villages and extension functionaries were also involved. Large-scale technology application by KVKs in farmers' fields under the National Food Security Mission (NFSM) resulted in productivity enhancement between 30-40% (2.2-3.9 q ha^{-1} in major pulse crops). The country's pulses production crossed the 25 Mt in a short period. Quality seed is key for achieving seed replacement for increasing productivity in pulses. Seed hubs were established in 97 KVKs and about 79725 q certified seed of high yielding pulses cultivars was produced during 2018-20.

7. Gandhiji's Vision of Trusteeship

7.1. Protecting indigenous varieties and land-races

Farmers over generations developed different varieties and land races under different agro-climatic and agro-ecosystems. Realizing the importance of conserving these varieties and land races, an institutional arrangement was developed with Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA) for identification and registration of farmers' varieties and organizing awareness campaigns by the KVKs. During the period of 2013-14 to 2016-17, as many as 7367 farmer's varieties have been identified for registration with PPV&FRA. Kadaknath poultry breed found in Jhabua and Dhar Districts of Western Madhya Pradesh and adjoining areas of Gujarat and Rajasthan is unique for its richness of protein and characteristic meat quality. KVKs in tribal dominated areas in Madhya Pradesh and Chhattisgarh established hatcheries for promoting scientific rearing of Kadaknath in the region which led to its further spread across 20 states. Promotion of better rearing practices in back yards as free-range poultry in existing orchards and commercial production for higher economic returns catapulted the indigenous breed to a well-recognized brand.

7.2. Farming as a way of life and livelihood

Organic way of farming is in tune with the vision of the Mahatma for self-sufficiency in the practice of agriculture utilizing the on-farm resources for promotion of soil health to improve farm output without much use of external inputs. KVKs enabled formation of 596 local groups in more than 400 districts and registered 13222 organic farmers covering 8135 ha area under the Traditional agriculture promotion scheme (PKVY).

Integrated Farming Systems (IFS) approach integrates, and links diversified farm enterprises like crops, horticulture, livestock, and fisheries for enhancing the livelihood security especially of small and marginal farmers. IFS symbolizes the traditional way of life of farmers combining various crop and livestock production systems for risk and cost reduction along with year round supply of farm inputs, outputs for household consumption and income from marketable surplus. IFS in homestead farms is quite common in the tribal North Eastern Region. KVKs established location-specific integrated farming system demonstration units of different sizes at instructional farms in more than 380 districts. KVKs also extended support for establishment of 13735 IFS units by farmers and farm women across 29 states.

In recent years, burning of paddy residue in Punjab, Haryana and Uttar Pradesh for sowing of succeeding wheat crop in the rabi season is in practice. This is not only responsible for environmental pollution but results in multiple ways of loss in terms of organic carbon, microbes and nutrients. The widespread, recurrent and unhealthy practice of stubble burning in the rice-wheat belt can only be combated with a massive campaign involving and educating all the stakeholders of society and creating an enabling environment to demonstrate alternatives for overcoming the problem of residue burning. To address this, a programme on Crop Residue Management (CRM) was initiated in these states through KVKs in collaboration with state departments of agriculture. KVKs took lead in building awareness against residue burning through the involvement of 60 KVKs in Punjab, Haryana and U.P. KVKs prepared robust action plans to create awareness among the farming community and also undertook capacity building of stakeholders and demonstration of suitable machines for in-situ management of paddy straw. A massive campaign against residue burning was launched by ICAR. An Information, Education and Communication (IEC) mechanism was built to reach out to farmers and farmers groups. KVK experts organized 525 hands-on training programs for 16,000 farmers, tractor owners and machine operators on management of crop residue. KVKs organized 24000 demonstrations on operating happy seeder machine and sowing wheat in standing stubbles. More than 400 field days and harvest days, 375 exposure visits to residue-burning free sites, 120 kisan melas covering a total of 6 lakh farmers were organized.

Hon'ble Prime Minister recognized the contribution of Sh. Gurbachan Singh, farmer from Punjab for his unique initiative against residue burning in *"Mann Ki Baat"* (Episode 49, 28 October 2018) programme. Kalar Majri village near Nabha, Patiala was also recognized as Zero Stubble Burning Village. Impact of the campaign against residue burning is seen in the drastic reduction of burning fire events by 31% in 2018-19 and 52% in 2019 as compared to

2016. Farmers hailing from the problem villages joined and led the campaign against residue burning, became champions of the cause and were recognized by the government.

Resource conservation technologies which can be easily adopted by farmers is the need of the hour to boost crop productivity and income of farmers. Soybean cultivated on raised beds showed increased yield in on-farm trials. Additionally, this land configuration has multiple benefits i.e., reduces tillage operation, seed rate and crop lodging; increases nutrient availability, enables management of weed and pests effectively over conventional flat-bed planting. Also, the raised bed planting is less susceptible to climate variability (excess rainfall) due to improved drainage in furrows. Raised bed planting of soybean is considered more appropriate in Vertisols (heavy soils) under rainfed condition for in-situ moisture conservation and yield improvement. Krishi Vigyan Kendras in Madhya Pradesh conducted on farm trials and cluster front line demonstrations on raised bed cultivation of soybean using bed planters for *in-situ* moisture conservation to realize higher productivity in rainfed areas and for resilience to climate risks in association with State department of agriculture. KVKs successfully demonstrated realization of average yield of 19.24 q ha^{-1} i.e., 21% higher than conventional flat-bed planting method.

7.3. Climate Resilient Villages (CRVs)

Over 80% of the operational land holdings are cultivated by small and marginal farmers owning <1 ha and 1-2 ha, respectively. Agriculture is a climate sensitive sector and is greatly influenced by climate change effect on distribution and quality of natural resources adversely affecting the livelihoods of millions of farmers. Building the adaptive capacity and coping ability of farmers is a priority in view of the increasing frequency of occurrence of extreme events such as drought, flood, cyclone, heat wave, cold wave and hailstorm. ICAR initiative on National Innovations for Climate Resilient agriculture (NICRA) project was re-oriented with the introduction of a cluster approach in 2018-19 enhancing the number of villages from 121 to 443 villages and scaling up from village to district level for development of district climate change adaption plans. All 121 NICRA KVKs demonstrated climate resilient practices and technologies tailored to context and location specific farming situations under four modules including natural resource management, crop, livestock, and fisheries production systems.

Evidences suggest that through location-specific natural resource management, improved resilience to drought was achieved through *in situ* soil moisture conservation practices and planting methods; higher benefit: cost ratio (>2.0) with *ex situ* rainwater harvesting and its efficient use and increased cropping intensity. Demonstration of drought and flood tolerant cultivars, short duration varieties, stress tolerant breeds of animals/ poultry resulted in yield advantages for farmers ranging from 15 to 50% and higher return on investment. Total 263 crop cultivars with demonstrated potential for climate resilience were integrated into the mainstream

seed production and supply chain. Interventions on stress tolerant breeds, feed and fodder management, health and shelter management in livestock, poultry and fisheries production systems were demonstrated to livestock/fisheries farmers.

Mahatma's vision of empowered community and village was realized through formation of Village Climate Risk Management Committee (VCRMC) comprising of 12-20 villagers. VCRMCs managed community assets and supported village level seed and fodder production and supply systems in the CRVs. Village level carbon balance was computed in NICRA villages using ex-ante analysis based on the extent of adoption of various climate resilient practices contributing to carbon sequestration such as land use change, cropping pattern change and extent of manures and fertilizer use etc. Carbon sink increased by 6 - 96% in the NICRA villages demonstrating the potential of carbon positive farming. Impact of the project is evident from up-scaling of the climate resilient villages model by state governments.

7.4. Doubling of Farmers Income (DFI) Villages

ICAR prepared state-wise strategic documents for doubling of farmers income by 2022. The aim is to enhance famers income in real terms compared to the baseline (2015-16) though productivity enhancement and reduction in cost of cultivation by increasing input use efficiency. KVKs across the country are implementing technology interventions at household level at 2 villages per KVK in more than 1400 villages. Location and context-specific technology demonstrations in agriculture, horticulture, livestock and fisheries are underway.

8. Reaching the Unreached and Empowering Women and Youth

8.1. Dissemination of agro-advisories to farmers

Information and Communication Technology and social media were employed to deliver need-based messages to farmers. Mobile apps, m-Kisan and KVK portal served as vehicle to reach out to farmers with much needed and timely farm extension advisories. Over 6700 WhatsApp groups were created by KVKs for regular two-way interface with farmers. KVKs have now been linked with 3.5 lakh Common Service Centres (CSCs) in all blocks so as to provide technological solutions to the farmers visiting CSCs with agriculture related problems.

8.2. Skill development of rural youth for self-employability

Skilling the manpower engaged in agriculture and allied sectors is imperative for boosting job-led growth in rural areas. KVKs offered skill training in job roles covering seed production, farm mechanization, dairy, poultry, horticulture, commodity management and agri-entrepreneurship. Skill development training programs were taken up by KVKs since 2016-17 through certified scientists having expertise in the respective job role. The outcome envisioned through these training programs is creation of non-farm jobs in allied activities, generating maximum number of entry level jobs, skilling and linking all stake holders to agriculture value chain, enhancing the economic value of time and labour of landless workforce and enabling youth as agri-

entrepreneurs. During 2018-20, KVK Scientists organized 1520 National Skill Qualification Framework (NSQF) aligned courses of skill development programmes of 200 h duration to 30814 rural youth.

8.3. Attracting and Retaining Youth in Agriculture (ARYA)

Youth play a vital role in transforming agriculture in India. Retaining youth in agriculture is a big challenge. At present, 35% of the total population are young as they are in the age group of 15-35 years and 75% of them live in rural areas. Continuous migration of rural youth to urban areas has been observed of late. Agriculture is to be made more profitable and remunerative for creating interest and confidence among rural youth. Fragmented land holdings are indeed a threat to food security for the burgeoning population. A need was felt for developing a comprehensive model of agriculture which is profitable for the rural youth. Attracting and Retaining Youth in Agriculture (ARYA) project was initiated in 2016-17, which is being implemented by KVKs in 100 rural districts. Skill training of 9900 youth was undertaken, and the trained youth were facilitated to start 2872 agricultural enterprises such as vermicomposting, mushroom production, bee keeping, nursery unit, IFS, processing and value addition.

8.4. Nutri-Sensitive Agri-Resources and Innovations (NARI)

Agriculture sector growth has contributed mainly to economic growth in India over the past several decades, but nutrition still remains a major concern. Increased crop and milk yields, increased overall food production as well as productivity have enabled the country to achieve food security. However, the issues like growing number of malnourished, underweight and stunted children, their vulnerability to the chronic and often irreversible effects of poor nutrition are serious challenges to be addressed.

Agriculture has a great potential to improve the food and nutritional requirements of vulnerable rural communities. Food security increases the food energy intake through increased production and consumption of major food grains, nutritional security can ensure the quality and diversity of food required for good health and nutrition. Nutritional security is a priority now where food security has been achieved. Nutrition sensitive agriculture is advocated under this programme with a focus on promoting family farming, linking agriculture to nutrition, need-based skill development among women and rural youth, involving school students to create interest and awareness, bio-fortification of locally available food, round-the-year dietary pattern, maintain dietary diversity, nutri-thali and establishing Nutri-Smart villages. Location specific Nutrition garden models were developed by KVKs in different agro-ecological zones to ensure access to locally available, healthy and diversified diet with adequate macro and micronutrients. A

nutrition campaign with the participation of 60000 Anganwadi workers and farm women was organised and Poshan Maah observed during September 2020.

8.5. Knowledge Systems and Homestead Agriculture Management in Tribal Areas (KSHAMTA)

ICAR implemented agricultural enterprise-based development of tribal agriculture through KVKs in 125 districts where the tribal population is >25% utilizing the funds under Tribal sub-plan. There is specific indigenous culture in tribal areas, but due to geographical conditions, the development of these areas and the socio-economic status of the people here have not improved considerably. Nevertheless, indigenous knowledge systems associated with agriculture in tribal areas are well developed that can address the issue of managing the natural environment through conservation and durable use of natural resources. In order to achieve balanced economic development in the country, it is necessary that concerted efforts should be made to bring these areas into the mainstream of the development process. KSHAMTA was started in the tribal dominated districts with the major objective of rapid agricultural development using indigenous knowledge system of these areas. The activities include collection, compilation and validation of prevailing indigenous technical knowledge (ITK); scientific intervention for development of environment friendly and durable production system; integration of ITKs in scientific research for livelihood and nutritional security of farmers in tribal areas; demonstration and training on bio-fortified nutrition rich crops/varieties in tribal areas; and demonstration and training on allied activities like fisheries and livestock. Under this initiative, technology assessment and demonstrations were organized through 6009 on farm trials and 34589 frontline demonstrations. Besides, training programmes and extension activities were carried out to benefit around 6 lakh tribal farmers. Similar programmes are being implemented for scheduled caste community through various initiatives including capacity building, technology adoption and establishment of micro-enterprises.

9. Enabling Scientists to Connect to Farmers

9.1. Mera Gaon Mera Gaurav (MGMG)

"*Mera Gaon Mera Gaurav*" programme initiated in August 2015 involves multi-disciplinary team of 3-4 scientists of ICAR Institutes and State Agricultural Universities connect to a cluster of five villages for giving suitable advice to the farmers on technical and other related aspects through regular visits or telephone. Scientists also create awareness among farmers about climate change, other customized technologies, protective measures, Swachh Bharat Abhiyan and other issues of local and national importance. During such interface, scientists also involve local Panchayats and stakeholders including development departments, NGOs and private organizations. There is no provision of any budget in this program and the Institutes/ universities provide facilities from their own resources. More than 13000 villages have been covered under this programme.

9.2. Farmer FIRST Program (FFP)

The Farmer FIRST programme initiated in 2016 aims at enriching Farmer-Scientist interface. It seeks to create linkages, technology adaptation and application, content mobilization, partnership building through active partnership with the farmers. The program moves beyond the production and productivity issues and addresses the complex, diverse and risk prone realities of majority of the farmers through this interface. Farmer FIRST interventions are applied as a community experimentation both at household and village levels. The project was initiated at 52 centres involving 114 villages and 50000 farm families across 20 states in problem solving mode with the participation of farmers' and scientists in broad areas such as NRM, crop, horticulture, animal husbandry and development of an institutional arrangement. The income of the households in these villages increased by 1.5 times in a span of three years.

10. Response to COVID 19 Pandemic

ICAR responded to the challenges posed by COVID-19 Pandemic to farmers and farming sector across the country in tune with the policy directions and guidelines issued by the Government of India to all the States and UTs during the lockdowns. Taking note of the occurrence of the Corona-19 pandemic to coincide with critical farm operations in agriculture and allied sectors, ICAR through its countrywide network of KVKs supported by Agricultural Universities and ICAR research institutes alerted the farmers and stakeholders across the country on the pre-cautions, safety measures and need for social distancing while carrying out the time bound field operations such as harvesting, post-harvest processing, storage and marketing of grains, fruits, vegetables, eggs, meat and fish.

ICAR issued national and state-specific advisory for farmers, translated into 15 regional languages and widely communicated through digital platforms. An e-book documenting the advisories at the national and state level was also released. The advisories received prime coverage in print, electronic and social media across the country including DD Kisan and other channels.

Kharif advisory for farmers was issued by ICAR for dissemination in 15 regional languages to farmers and farmer groups in 29 states through 718 KVKs along with state extension departments through print, electronic and social media and digital platforms. The kharif advisory covered better management practices to be adopted by farmers in all major kharif crops of paddy, maize, millets, pulses, soybean, sugarcane, vegetables and fruit crops; livestock, poultry and fisheries production systems during the ensuing kharif season to boost farm productivity and profitability.

Successful cases of agri-solutions to combat COVID 19 pandemic at farmer level were identified and documented. More than 100 best farm practices that helped farmers and farmers groups to cope with the lockdown by all KVKs across the country were documented for further dissemination. The practices covered innovative marketing linkages established, improved

storage, feed and fodder management, critical extension and advisory services, processing and value addition examples.

More than 8.0 crore messages were issued by KVKs to farmers through issue of 2044 advisories across the states through m-Kisan portal. Dissemination of advisory was also made through WhatsApp groups, newspapers, radio and TV channels, other social media and ICT platforms. Advisories were disseminated to 20.28 lakh farmers during the lockdown periods. Out of these, 9.37 lakh farmers were covered through 6711 KVK WhatsApp groups and 10.91 lakh farmers reached through other ICT platforms. News items on advisories issued by KVKs appeared in 1588 newspapers, messages were disseminated through broadcast of 395 radio talks and 92 TV programs besides attending 1.27 lakh calls from farmers. In addition, KVKs also disseminated the advisories to state department and private extension network for faster dissemination for rapid and wider coverage to their group members. Nearly 52003 q of improved seed of crops, 78.78 lakhs of planting material and 13.0 lakh fish fingerlings have been mobilized by KVKs for supply to farmers. The KVKs disseminated the message for use of Aarogya Setu mobile application to fight COVID 19 pandemic to 63.27 lakh farmers, which has been downloaded by 8.16 lakh farmers during lockdowns.

11. Convergence with the National Programmes

Integrated development of villages in aspirational districts was aimed with the launch of Krishi Kalyan Abhiyan (KKA) by Ministry of Agriculture and Farmers Welfare to intensify development work in 112 Aspirational districts of the country. In each district, 25 villages were selected for integrated development. KVKs organized training programmes on beekeeping, mushroom production and kitchen gardening for at least 50 farmers in each village. Besides, KVKs conducted one residential training of three days covering farmers from each of the 25 villages on integrated cropping practices and micro irrigation systems. Apart from organizing training programmes, KVKs coordinated the activities of the line departments in the district like distribution of soil health cards; mini kits of pulses and oilseeds; saplings of fruits, vegetables, agroforestry plants, bamboo plants; vaccination of bovines, sheep and goats; artificial insemination of cows and buffaloes; and distribution of agricultural implements and uploading the progress report of all the activities in the KVK Portal. KVKs organized 17810 training programmes imparting training to 642306 farmers, farm women and rural youth from 2745 villages in 112 Aspirational districts of the country. During the 2nd phase of KKA, 462901 farmers, farm women and rural youth were trained through 9089 training programmes in 2924 villages of 112 Aspirational districts of the country; 2633 demonstrations on integrated cropping practices were organized benefiting 10065 farmers; and 2390 demonstrations on micro irrigation were organized benefiting 9689 farmers, besides coordinating the activities of the line departments of the district. Under Jal Shakti Abhiyan, 334 KVKs organized 557 large Kisan

melas with participation of 314154 farmers and school children in identified water stressed blocks and districts across the country. KVKs created awareness among 133140 farmers in one day on vaccination, disease management and artificial insemination and productivity of livestock during the launch of the National Animal Disease Control program (NADCP).

12. Conclusion

The Gandhian thoughts and vision for rural transformation, community mobilization and participation, empowerment of women and youth from disadvantaged sections of the society, self-reliance of villages and holistic approach to agricultural development had a profound impact on shaping various ICAR frontline extension programs through KVKs for the betterment and economic wellbeing of farmers across the country. Gandhiji's principles of sustenance through resource conservation, adaptation to local farming situations, recognizing farm innovations, integration of farming enterprises for stable incomes and livelihood security have been the main stay behind the launch of many programs over the years. The KVK scheme of ICAR adopted a farmer centric and participatory approach with science and technology driven agricultural development at the district level. KVKs have partnered with all stakeholders for holistic development of self-reliant villages through convergence of efforts and resources. Armed with a multi-disciplinary team of experts and as a knowledge and resource centre, KVKs champion the cause of farmers at the grassroots, educating and empowering the small and marginal farmers, farm women and rural youth to make a difference in the life and livelihoods in the rural areas as envisioned by the Mahatma. The principle of trusteeship has been embedded through innovative programs of connecting research scientists for technology application in adopted villages with the active participation of farmers and creating opportunity for both self-evaluation by the scientist and valuable feedback by the farmer. ICT has been used as a force multiplier for timely dissemination of agro-advisories in local language for effective outreach. KVKs channelized innovative village level institutions with people's participation to promote conservation and harvesting of rainwater, resilient intercropping systems, sharing of community assets, seed and fodder resources for development of climate resilient villages.

The spirit of the historic 'salt satyagraha' spearheaded by the Mahatma to mobilize the community using salt as a powerful symbol to unite the Nation is to be imbibed and inculcated in our contemporary times as well for providing solutions to national challenges such as self-sufficiency in oilseeds, nutritional security of women and children, job led growth and empowerment of youth in agriculture and making our villages self-reliant and vibrant hubs for agri-based economic activity and wellbeing.

Chapter 16

Ethics in Agricultural Science: Gandhiji's Principles

K Alagusundaram

"Kings and their swords were inferior to the sword of ethics."
MK Gandhi

1. Introduction

Oxford English Dictionary defines ethics as *"principles that control or influence a person's behaviour"* in a plural form; and in a singular form it is *"a system of moral principles or rules of behaviour"*. Webster's Dictionary quotes ethics as *"the discipline dealing with what is good and bad and with moral duty and obligation"* or *"the principles of conduct governing an individual or a group"* and *"moral principles, one often sees it applied to questions of correct behaviour within a relatively narrow area of activity"*.

Ethics plays important and vital roles in our lives. In our everyday life we are forced to make choices on numerous things; starting from short term things such as buying materials like cloths and cosmetics to medium to long term things such as automobiles and houses and on life time things like partner selection and marriage and choosing the career paths. These choices are made based on needs, availability, and economics, influences of family and friends and societal influences at large. We must understand that our choices are not taken on random basis but are based on underlying and untold Ethical Principles. Many a times we take a choice that does not hurt others, particularly the ones near and dear to us, more importantly we feel happy if our choices help or make others happy. In the modern times we also consider the influences of our choices on the environment and society. Sustaining the happiness of the chooser and his family also plays important roles in major decisions. Happiness, sustainability, societal benefits and environmental safety are some of the important ethical principles on which our livelihood choices are made.

Agricultural Ethics involves a system of moral principles or rules to be followed for farming. This encompasses managing resources such as input resources like the land, water, energy, seeds, chemicals and non-chemicals for farm production; output resources such as the farm produce and the biomass generated as a result of farming; human resources like the farm workers, their families and other persons associated with the farming; animal resources used either for the farm energy inputs or for the manure, milk and meat; mechanical resources used for production systems; the ecosystem in which the production occurs; environmental impact and management; and sustainability of food production so the future generations do not

compromise for their food supplies and livelihoods. The Food and Agriculture Organization of the United Nations asserts that ethical values in agriculture determine the values for food, enhanced well-being of farming families, protecting human welfare, natural resources and the nature itself. The ultimate goal of agricultural ethics is to develop comprehensive and clear policies, creating standards for right farming activities for self-sufficiency and sustainability.

2. Gandhiji's Ethical Principles on Agriculture

2.1. Farmer the Pivotal Person of National Sustainability

Farmer is pivotal to agricultural production systems. Gandhiji, influenced by John Ruskin, had a strong opinion that the life of a farmer is the best compared with the lives of persons from other walks and professions of life, for he feeds the human kind through his untiring farming activities. He further reiterates that farmer is the central point of a sustainable rural society. Assembly of several farming families make a rural society; many rural societies make an agricultural ecosystem and numerous such ecosystems make a nation. So, in essence, a farmer is the central point of a nation and its sustainability. The 2000+ year old Tamil literature Thirukkural also has emphasized the importance of farmer as given below:

உழுவார் உலகத்தார்க்கு ஆணி அஃ தாற்றாது
எழுவாரை எல்லாம் பொறுத்து

Meaning: those who does farming are the pivotal to the human survival because they support the whole world from their hard produced foods.

The modern day concepts also emphasize the importance of farmer in sustaining the food production systems and thus the stability and sustainability of the current and future societies. The Government of India lays great emphasis in supporting famers and farming communities. Some of the schemes that were launched following the Gandhian Principles of 'Farmer is the Pivotal Person for a Society and the Country' are: PM-KISAN (Pradhan Mantri Kisan Samman Nidhi) Scheme which promises to pay all poor farmers (small and marginal farmers having lands up to 2 hectares) a sum of Rs. 6,000 each every year in 3 instalments through Direct Bank Transfer. It would reportedly benefit around 14.5 crore farmers all over India; Pradhan Mantri Kisan Pension Yojana which address the problems of farm sector distress and the government assures to provide small and marginal farmers in the age groups of 18 to 40 a minimum Rs. 3,000 per month fixed pension. If the beneficiary of the pension passes away, the spouse will be entitled to receive 50% of the original beneficiary's pension amount; and National Scheme on Welfare of Fishermen provides financial assistance to fishermen for construction of house, community hall for recreation and common working place. It also aims to install tube-wells for drinking water and assistance during lean periods through saving cum relief component.

The Farmer FIRST (Farm, Innovations, Resources, Science and Technology), a concept of ICAR, is developed keeping farmer in a centric role for research problem identification, prioritization and conduct of experiments and its management in farmers' conditions. The focus

is on farmer's Farm, Innovations, Resources, Science and Technology (FIRST). Launched in October, 2016 it provides a platform to farmers and scientists for creating linkages, capacity development, technology adaptation and application, on-site input management, feedback and institution building. It has benefitted about 45000 farmers so far.

Thus, the Gandhian Philosophy of Farmer the Pivotal Person for Sustainable Society has been fully recognized by the Government of India and ICAR and highly beneficial schemes to support the farmers have been launched and implemented successfully.

2.2. Gandhiji on Agrarian Economy

The agrarian systems can be classified into 3 categories based on their economies and the levels of operation: (i) subsistence agriculture; (ii) commercial agriculture and (iii) market agriculture. In a subsistence agriculture the farmers grow enough for themselves and their families with no marketable surpluses while in the commercial agricultural economy farmers produce enough crops for their uses and for local markets. In both cases the demand on the money for cultivation is minimum. In a market agriculture, on the other hand, the demand on money for cultivation is huge and the farmer is forced to borrow money from financial institutions and struck with huge debts. A small or marginal farmer can pay back his debts after realizing his harvests in the market. But when the crop fails due to poor rainfall or any other such uncontrollable reasons or when there are market surpluses and the demand is lower than the production in a community the net profit to the farmer gets reduced drastically and force his family to land in a great distress.

Due to the financial difficulties faced by small and marginal famers, who own the majority of land holdings in India, Gandhiji advocated and believed that subsistence and commercial agriculture are more viable than the market agriculture. According to his ethical principles a farmer should possess only so much land which is enough for cultivating crops for himself and his family and must be able to support the livestock and other support systems associated with the land. He further supported growing cash crops like cotton and castor because of a remunerative market these crops have.

Gandhian economic thought for a commercial farming is small scale and locally oriented production, using local resources and meeting local needs. This will make available employment opportunities everywhere, promoting the ideal of Sarvodaya. A concept of welfare of all, in contrast with the welfare of a few. This goes with a technology which is labour-using rather than labour-saving. Gandhian economy increases employment opportunities; it should not be labour displacing. Gandhiji had no absolute opposition to machinery; he welcomed it where it avoids drudgery. He also emphasized dignity of labour, and criticized the society's contemptuous attitude to manual labour.

The other principle of Gandhian economic thought, known as trusteeship principle, is that while an individual or group of individuals is free not only to make a decent living through an economic enterprise but also the accumulated surplus wealth should be used to form a trust for

the welfare of all, particularly of the poorest and the most deprived.

In the contemporary India, subsistence farming is practiced only in few pockets while commercial farming is a practice in substantial shares of marginal to small land holdings. In the changing scenario, due to the shrinking farming population and simultaneously rising urban population subsistence farming may not cater to the food needs of all. We must, however, work between a market agriculture and commercial agriculture. Commercial agriculture sustains the food supply in a block or a district level and does not cater to long distances. Market agriculture, on the other hand, supports the farm produce to be sold in distant markets. Fast transport systems and advancement of scientific food handling methods are added supports for such market agricultural economy. Government supports are essential for the success of market agriculture economies. Recently the Government Introduced Farmers' Produce Trade and Commerce (Promotion and Facilitation) Bill, 2020. This bill will help small farmers who do not have means to either bargain for their produce to get a better price or invest in technology to improve the productivity of farms. The bill, further, allows barrier free interstate or intra-state trading of farm produce. Farmers will get better prices through competition and cost-cutting on transportation. Government has also introduced a Kisan Credit Card scheme to save farmers from high-interest rates usually charged by money-lenders in the unorganized sector. The interest rate can be as low as 2% under this scheme. Moreover, the repayment period is based on the harvesting or marketing period of the crop for which the loan amount was taken.

2.3. Gandhian Principles on Organic Agriculture

"*The world has enough for everyone's needs, but not for everyone's greed*" is a famous Gandhiji's quote that promulgates ethical principles against overexploitation of the natural resources. We are the trustees of the natural resources available to us and not the owners. We need only to use the resources conservatively and effectively to satisfy our needs and not for accumulating wealth to quench our greed. He wanted the farmer to consider the earth as his mother. To protect the mother earth, he emphasized the extensive use of livestock and organic fertilizer for agricultural activities. He also explained the simple methods of producing organic fertilizers locally. We have realized, based on our experiences, the harmfulness of chemical fertilizers and over exploitation of soils and natural resources and their long lasting impacts on our production systems and sustainability in agriculture. This proved the worth of Gandhiji's vision and thoughts on organic agriculture several decades ago.

Non-organic crop and livestock production has great impacts on our environment at local national and global levels. Carbon dioxide and other greenhouse gas emissions, chemical residues on the food and the environment, pesticide exposure on workers, over exploitation of soil and water and land resources and unintentional but deleterious impacts on the production ecosystem and wildlife are of concern and needs attention. Food Safety is an issue for the consumer and the governments because the modern food production-transportation-processing-marketing chains expose consumers to chemical residues, additives, microbial pathogens and other such issues of great concern to human health. Traceability, quality inspection and

transparency are important in a food supply chain for safe food supply to the consumers.

Gandhiji advocated strongly that the agriculture in India should be organic. He emphasized that every farmer should make efforts to return to the mother earth of what has been used for growing the crop. This implies that continuously extracting the wealth from the soil will deplete its potential to produce crops with the same vigour season after season. Gandhiji also emphasized on appropriate and environment friendly agriculture and encouraged that the resources like the natural fertilizers, farm workers and sources of energy, tools and implements used for agriculture should all be derived locally.

Indian agricultural system is at the cross roads with respect to the input supplies to agriculture, the type of inputs to be used and the input use efficiencies. We cannot continue to unscrupulously use the external input resources, external to the farm, for the agricultural production. These external inputs include petrochemical based fertilizers, chemicals and energies from non-renewable sources. This is not because they are beginning to be expensive and non-affordable to small and marginal farmers, but more importantly because their reserves are depleting fast, faster than ever before, and are harmful to environment and our production systems. Furthermore, the huge biomass generated as a result of the farming is either wasted or underutilized. They also cause environmental damage. A typical example of environmental damage due to biomass is the pollution and smog caused because of crop residue burning, particularly in Punjab, Haryana and Western Uttar Pradesh.

Our research results emphasizes on Gandhian Ethics on Organic Agriculture and supports it with several facts: organic foods ensure better nutritional benefits and health safety; they have a protective role in environmental conservation; organically managed soils are of greater qualities and have better water retention capacities resulting in higher yields; requiring higher labour for the operations organic farming supports greater rural employment and income generation; due to the uses of locally produced bio-fertilizer the investments required for purchasing chemical fertilizers is reduced thus reducing the financial burden on the farmer; and the organic agriculture supports sustainable development goals.

Indian Council of Agricultural Research (ICAR) has been working extensively on application of organic agriculture in Indian farms for more than a decade. The All India Coordinated Research Project (AICRP) on Organic Farming is functioning from about 10 centers across the country. The research results from these centers are tested following the Front Line Demonstration (FLD) and Multi-Locational Trial (MLT) concepts across various agro-climatic zones. Sikkim is declared as an Organic State where the chemical based agriculture is strongly discouraged.

Due to the exploding population growth, huge animal populations and industrial advancements we are forced to produce very huge quantities of foods and fodders to meet the demands. The demands will continue to grow exponentially in the near future and organic farming may not solve the entire food and fodder demands. A combination of Gandhian Philosophy based organic farming to replenish our soil and water resources along with conventional modern day agriculture will help to sustain the production growth and will reduce the rate of degradation

of our natural resources. An intelligent and optimum combination of these two methods of farming will support the sustainable development goals without compromising on our current and future demands.

2.4. Gram Swaraj and Rural Industries

Gram Swaraj or village self-rule, was a pivotal concept of Gandhiji for creating a self-reliant farming families and self-reliant India. According to him every village should be a republic of its own and should be independent of its surrounding neighbours for its needs but interdependent on aspects of social and communal developments. A kind of selectively isolated ecosystem. A self-reliant village should possess all amenities of life like the food, clothing, clean water, sanitation, housing, education and other lively needs. It must further govern itself to solve local social and day to day problems.

Gandhiji was convinced that economic self-sufficiency is very important for a sustained living of a farmer and his family and for the peacefulness of a nation. Knowing very clearly that major portion of an individual life is spent in ensuring the economic wellbeing of his family, he emphasized and promulgated strong ethical principles for the economic activities and for sustaining societal harmony. He was against accumulation of wealth and hoarding by few individuals. He was propagating that economic development means the right for everyone in a society to survive comfortably and coexist harmoniously.

He administered "survodaya" which advocates that everyone should be given an opportunity to earn according to his capacity following just means. In this process the natural resources of the ecosystem should be preserved. He advocated the development of agriculture and village industries for uniform distribution of incomes with least efforts. Gandhiji's ethics on farm family sustenance further emphasizes that the crops produced must be processed in the villages and fosters establishment of rural processing industries. Such village based industries, according to him, not only improve upon the income levels of the farmer and his family but also will enhance the rural employment potentials and self-reliant rural societies.

During his periods nearly 80% Indian population were living in villages and so he believed that all the 80% of the population will get employment and livelihoods by this model. He was true. Even in the current days nearly 50% of Indian population lives in village and more than 80% of these are dependent on agriculture in some way or other. They are either cultivators or agricultural labours. By the model of Sarvodaya if all these villagers are offered good employment for a self-reliant living then the growth and development of India will be tremendous. He advocated for Khadi and all other village industries and worked hard in promoting them in the country till his last days.

The Government of India follows the concepts and ethics of Gandhiji and has launched many schemes for rural development and rural employment. Ministry of Rural Development, for example, is implementing Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), Deendayal Antyodaya Yojana – National Rural Livelihoods Mission (DAY-

NRLM), Deen Dayal Upadhyay – Gramin Kaushalya Yojana (DDU-GKY), Pradhan Mantri Awaas Yojana – Gramin (PMAY-G), Pradhan Mantri Gram Sadak Yojana (PMGSY), Shyama Prasad Mukherjee National RuRBAN Mission and National Social Assistance Programme (NSAP) to bring about overall improvement in the quality of life of the people in rural areas, through employment generation, strengthening of livelihood opportunities, promoting self-employment, skilling of rural youths, provision of social assistance and other basic amenities.

Gandhiji advocated that the agricultural produce must be processed in the villages before distribution and marketing. Continuous Government Interventions have resulted in nearly 25 lakhs units of unorganized food processing industries in rural India and about 80 percent of them are family-based enterprises supporting livelihood to rural households and minimising their migration to urban areas. These units largely fall within the category of micro enterprises. Unorganized food processing sector faced a number of challenges, which limit their performance and their growth. The challenges include lack of access to modern technology and equipment, training, access to institutional credit, lack of basic awareness on quality control of products; and lack of branding and marketing skills.

Government has initiated progressive steps to mitigate these problems. Recently Ministry of Food Processing Industries has launched a Centrally sponsored scheme, 'PM Formalisation of Micro Food Processing Enterprises' (PM FME) to provide financial, technical and business support for small and micro food processing enterprises. This scheme would generate total investment of Rs 35,000 crore and generate nine lakh skilled and semi-skilled employment and benefit 8 lakh units through access to information, training, better exposure and formalization.

Gandhiji's conception of Swaraj or complete independence is possible only through agricultural and ago-based industries development. According to him policies must support on-farm food production and off-farm cottage industries that uses agricultural produce as raw material and those generate rural employment. His was not a centralized mass production, but a concept of production by the masses and is based on private partnership mode supported by public interventions. The rural agro industries based projects must belong to the people and it would be run for the greater benefit of the society and nation at large. The role of the state would be to help in setting up the industry by giving finance, technical expertise and other needed supports. This is a very similar model that is being implemented by many government schemes. The financial support and technical guidance is offered by the government institutions while the people, either individuals or a group of people create and own the facility. The benefits of such a facility is enjoyed by all in the localised ecosystem. The accrued benefits include the employment generation, raw material cost realization for the agricultural produce and the profit sharing by the partners of the unit.

The custom hiring centers (CHCs) for farm machinery hiring purposes, the agro-clinics for input supplies to the farms and the Agro-Processing Centres (APCs) for processing a specific or group of agricultural commodities are the type of public-private partnership mode based successful models promoted and implemented by ICAR and other government agencies.

2.5. Gandhian Philosophy on Animal Husbandry

Animal Ethics, as proposed by world countries, focuses on the use of animals for the intensive production of milk and meat and eggs and poultry, extensive production of feedstuffs for animals, and impacts on the environment due to intensive and concentrated production. The welfare of animals is an important underlying concept and need to be addressed in an animal husbandry unit.

Gandhian philosophy on animal ethics is totally different from the normal animal ethics around the world. He spent nearly 30 years on elaborating an economically viable and religiously conforming animal husbandry system. He had a very strong conviction and ethical and moral principle that animals should never be slaughtered for meat purposes. He wanted that a scheme to recognize this on a national scale should be initiated. Gandhiji's critical interpretation of cow-protection, advocated by Hinduism, leads to a general reflection on the duty of non-violence. The approach, adopted by Gandhiji, in solving the problem of cow-protection focuses on its practical dimensions and is based primarily on reforming animal husbandry. Mother cow is, in many ways, better than the mother who gave us birth. Our mother gives us milk for a couple of years but cows offer milk to human kind year after year till near the end. Gandhiji further stated, *"I would not kill a human being for protection of a cow, as I will not kill a cow for saving a human life, be it ever so precious"*. In his total commitment to nonviolence, Gandhiji always included the animals, stating, *"The greatness of a nation and its moral progress can be judged by the way its animals are treated."*

2.6. Gandhiji on Cooperative Farming

Mahatma Gandhi's experiences with cooperative farming started during his stay in South Africa. The 'Phoenix Settlement' and the 'Tolstoy Farm' are the two of his early experiments. In the Phoenix Settlement each member of the society were to cultivate three acres of land given to his family. This concept was started to avoid uncultivable land due to absentee land-owners. Tolstoy Farm was a rehabilitation settlement of the families affected by the South African freedom struggle during that period and the method of operation was similar to the Phoenix Settlement. There were 77 multi-religious members in the Tolstoy Farm who were assigned jobs including farming, carpentry, manufacturing and other such activities. These experiences and experiments helped him to develop the model he adopted in Sabarmati Ashram at a later stage.

Observing the distress of small and marginal farmers due to poverty and debt, Gandhiji felt, *"cooperation among the peasants is an absolute necessity for their prosperity"*. Cooperatives, according to his philosophy, will help to battle against the difficulties faced due to capitalism and other common enemies for the betterment of the livelihood of its members. He believed also cooperation was one of the important means to empower people.

Cooperative farming is of two major types: (i) a collection of individual farmers and farming on their own holdings jointly with a common agency formed and governed by themselves for

collectively purchasing the inputs for farming and for selling the produce; and (ii) a farming operation carried out collectively merging small individual holdings into a common unit and managed cooperatively. The benefits, in either case, are shared based on the size and value of the plot and the individual's contribution.

Nearly 80% Indian farms are small and marginal and cultivation in such small-holdings is uneconomical and non-profitable. Under such a situation if these marginal and small holdings can be consolidated and if the small and marginal farmers pool their land, resources and other inputs and then start cultivating their land jointly by forming a co-operative, they can get the benefits of large scale farming. Gandhiji believed our farmers shall not derive the full benefit of farming unless they take up cooperative farming and he further observed that it is better for 100 families in a village to collect their lands and divide the benefits than dividing the lands and staying poor due to small outputs.

Government of India, following Gandhian Principles and Ethics on cooperative farming, had initiated formation of FPOs or Farmer Producer Organizations. There are farmers' collectives, with membership mainly comprising small and marginal farmers. Presently, around 5000 FPOs are in existence in the country, which were formed under various initiatives of the Government of India including Small Farmers Agri-Business Consortia (SFAC), State Governments, NABARD and other organizations. Government of India wants to create nearly 10000 FPOs over the next five years. NABARD, SFAC and National Cooperative Development Corporation are to be given the responsibility to execute the programme to form the targeted number of FPOs.

Government of India recently announced the following measures to promote FPOs for a prosperous and sustainable agriculture sector that enable farmers to enhance productivity through efficient, cost-effective and sustainable resource use and realize higher returns to the produce: (i) Launching of "Operation Greens" for onion, potato and tomato crops on the lines of Operation Flood with an allocation of Rs. 500 crores for promoting FPOs, agri-logistics, processing facilities and professional management; (ii) With a view to encouraging enabling environment for aggregation of farmers into FPOs and take advantage of economies of scale, the Government announced 100% tax deduction for FPOs with an annual turnover of up to Rs. 100 crores.

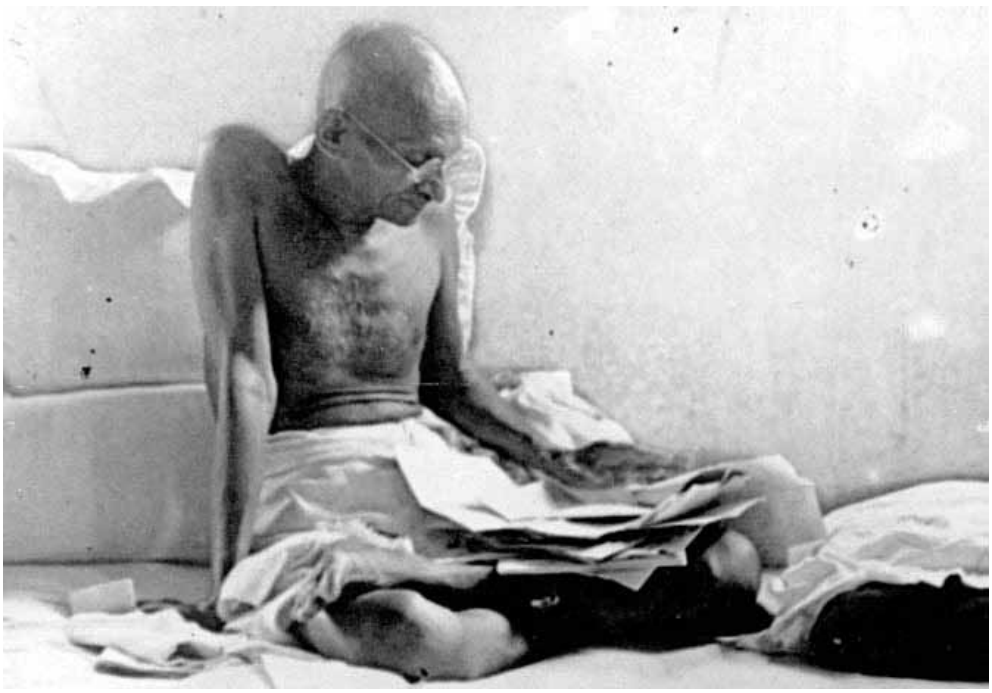
Equity Grant Scheme is a government initiative to support the equity base of Farmer Producer Companies (FPCs) by providing matching equity grants subject to maximum of Rs. 15.00 lakh per FPC in two installments with in a period of 3 years and to address nascent and emerging FPCs which have paid up capital not exceeding Rs. 30.00 lakhs.

3. Conclusion

Mahatma Gandhi had very valuable thoughts, observations, ethical principles and philosophies for agriculture, particularly Indian agriculture. According to him farmer is the pivotal person for the farm, village and the nation as a whole. The economic and social wellbeing of a

farming family is important for the harmony and happiness of a nation. Gandhiji believed that subsistence and commercial agriculture are viable options for a country like India because they not only sustain the needs of the farming families but also the needs of the neighbouring societies and ecosystems. In a modern day, an intelligent combination of commercial and market agriculture are essential for meeting the food supply needs and for safeguarding our natural resources. Gandhiji also advocated strongly for organic farming and discouraged use of petrochemicals and non-renewable energies. Our current focuses also aim at increased use of renewable sources of energy for farming and to have a mix of both organic and conventional farming systems.

Gandhiji advocated further on Gram Swaraj and Village Industries. He believed that the agricultural produce must be processed on the farm and sold at remunerative prices by the farmers. A similar model and pattern is also being advocated by ICAR and other Government Departments. On-farm primary processing industries are essential for doubling farmers' income and for reducing the post-production losses. Gandhiji emphasized non-violence to human and animals. He was totally against killing of animals for meat purposes. In this way his philosophies were totally opposite to the capitalistic philosophies. Gandhiji further recommends cooperative farming to realize full potentials and benefits of large farming situations. All the Gandhian Philosophies discussed in this article are true even to our modern day agriculture and numerous government schemes and ICAR initiatives have helped in realizing those philosophies for a better livelihood of Indian farmers.



Chapter 17

Gandhian Philosophy of Sustainable Agriculture: Path Ahead

AK Singh, RN Padaria and VK Singh

"If man is to survive, if civilization is to survive and flower in freedom, truth and decency, the remainder of twentieth century and what lies beyond must belong not to Lenin or Trotsky not to Marx or Mao or Ho or Che, but to Mahatma Gandhi."
Louis Fisher

1. Introduction

The impregnation of development and reform pathways with Gandhian philosophy has been local to global. His ideologies have been universally appreciated and adored despite its enigmatic features. His fundamental beliefs and ideologies have been instrumental in activating not only a person's endeavour towards self-actualization and salvation but also in a meliorist' s pursuit for social reforms as well as crusaders' fight for liberation and even a nations' constructive policies for development and welfare of people. Besides the principle of truthfulness to self, secularism, non-violence, and cleanliness; he laid emphasis upon equality and aspired for a classless society with no poverty, no hunger, no unemployment and education and health for all. He had a great concern for the poor and downtrodden. Mahatma had a clear vision of villages and gave a vehement declaration that *"India lives in her seven and half lakhs of villages"* (Young India, 1931) and asserted that *"If village perishes, India will perish too"* (Gandhi 1934). Gandhiji indicated that the country's success resided in the growth of the large proportion of its rural villages, while emphasizing the advancement of the rural economy, industry and the development of rural skills. Further, he asserted that placing 'village' as the focal point developmental programmes was the best way to give the rural people a decent living. He advocated sustainable model of development. His cautious observation "technologize and perish" indicated that over-consumption of natural resources recklessly would lead to indebting the future generations. He had rightly reminded that the Earth had enough for human needs but not for human greed. Gandhiji's ideas are relevant for protecting the environment and to preserve the carrying capacity of Mother Earth. Historically, the Indians regard the Earth as Dharti Mata (the Universal Mother) with her brood (Vasudhaiva-kutumbakam). Gandhiji coined the phrase – 'Economy of nature' in 1911, to express his sensitivity and profound understanding of human actions on the Earth. He also warned against the economic exploitation, which would destroy the resources, similar to the locusts' exploitation of crops. His statement encompasses for all the natural resources and relevant even now as we are struggling against the unprecedented effects of global warming and climate change.

2. Gandhian Model of Rural Development

Gandhian model of rural development comprises of following ideologies (Mishra 1977):

a) The heart of India lies in its villages. Revival of the village is the prime step towards development

b) The reconstruction of villages is only feasible if the rural people are no longer oppressed. The repression of villagers by urban dwellers was, in Gandhiji's view, 'violence'

c) He advocated 'simple living with high thinking', thus demanding a voluntary curtailment of worldly needs and pursuit of ethics and spiritual principles of life

d) Dignity of labour: Every individual should obtain their bread by manual labour and he who works should certainly have his earning.

e) Promoting the use of indigenous (Swadeshi) products, services and institutions

f) Balance of the ends and the means: Gandhiji insisted that non-violence and truth would not be preserved until a harmony was maintained between the goals and the means.

Rural development as evinced by Gandhiji included self sufficiency, co-existence and upliftment of rural industries. He aimed a rural reconstruction inculcating spiritual as well as scientific aspects. The rural reconstruction activities were successfully implemented by Gandhiji through his 18-point Constructive Programme in Sevagram near Wardha during 1935.

3. Gandhian Model of Indian Villages

He had a clear vision about ideal village, which was said in one of his letters to Jawaharlal Nehru (Gandhi 1934): *"My village will contain intelligent human beings. They will not live in dirt and darkness as animals. Men and women will be free and able to hold their own against anyone in the world. There will be neither plague nor cholera, nor small pox; no one will be idle, no one will wallow in luxury. It is possible to envisage railways, post and telegraph and the like"*

The perfect village of Gandhiji originally belonged to the pre-British era, when Indian settlements were pretty small republics untouched by the occasional visits of brutish hordes.

In 1942, after noticing the deterioration of the villages, Gandhiji exclaimed (Gandhi 1942), *"My idea of village swaraj is that it is a complete republic, independent of its neighbours for its own vital wants, and yet interdependent for many others in which dependence is a necessity. Thus every village's first concern will be to grow its own food crops and cotton for its cloth. It should have a reserve for its cattle, recreation and playground for adults and children. Then if there is more land available, it will grow useful money crops, thus excluding ganja, tobacco, opium and the like. The village will maintain a village theatre, school and public hall. It will have its own waterworks, ensuring clean water supply"*.

Gandhiji realised that the western influence of industrialization would undoubtedly wreck the structure of the village and the economy. He was completely aware that this wave would completely wipe out the village industries and would prevent its growth. The idea of rural reconstruction had focused on 'Village Swaraj and Swadeshi Movement' (Raman 1942). The core concepts of Village Swaraj as listed by Gandhiji were swadeshi, full employment, trusteeship, labour, bread, decentralization, self sufficiency, equality, Nai Talim and so on. Thus, the conception of the ideal village of Gandhiji's vision was a holistic one, comprising of physical, social, political, economic and educational aspects. The holistic ideas of Gandhiji for rural reconstruction are discussed below:

3.1. Trusteeship: Gandhiji said that rich would be the stewards of trusts who should take care of the needs of the community in general. Gandhiji was deeply moved by the hardship and wretched circumstances of the rural people, due to the centralization of wealth in the hands of the bourgeoisie class. In his words *"everything on this earth belongs to God and is from God. Therefore, it was for this people as a whole not for a particular individual. Everybody on this earth has a natural right to at least the basic necessities of life, just like the birds and the beasts have. If somehow, an individual had more than his proportionate share, he was a trustee of that portion for God's people"* (Gandhi 1947). He argued that the rich would not be able to amass the wealth without the support of the poor. Hence the poor must use the weapon of non-violence and non-cooperation to part the wealth equally, which in turn ensures prosperity.

3.2. Swadeshi: Swadeshi is the ethical principle underpinning an autonomous self-sufficient economic system. In Mahatma's words Swadeshi means "*spirit in us, which restrict us to the use and service of our immediate surroundings to the exclusion of the more remote*" (Gandhi 1942). From an economic point of view, conforming to Swadeshi doctrine creates the opportunity for a democratized self-sufficient economy. Buyers and sellers would have a stake for each other and collaborate each other in the upliftment of local areas by utilizing the local resources. He insisted that only those commodities that cannot be produced within a particular village should be brought from other village. This would create a strong love for local products and an altruistic behaviour towards the neighbours, which in turn would raise the standards of local farmers and artisans (Joshi 2002). Decentralized economic divisions would thereby make it simpler for the utilization of local resources such as raw materials, manpower, ensuring employment for all, thus creating a sustainable equilibrium and a cooperative living. Compliance to the doctrine of Swadeshi contributes to a proper economic order and peace.

3.3. Self-sufficiency: Self-sufficiency should be the primary objective of rural development according to Mahatma. In order to encourage this ideology, he tried to create a favourable attitude towards Swadeshi among the villagers. He promoted self-sufficiency as a foundational philosophy of life because dependency would lead to deprivation; the root cause of violence. He advocated that villages must be self-sufficient, i.e. cultivating their own crops, spinning own clothes, and other things required to satisfy their basic needs on a cooperative basis (for example, cooperative farming, spinners cooperative) for saving time, energy and resources

as well as protecting their own rights (Panda 1991). He focused on supporting village or cottage industry and crafts as they can generate jobs that are required to fulfil the villagers' daily requirements and also to promote self-sufficient villages.

As a part of this, he established Khadi making units in the villages, Khadi was considered as an instrument for Gandhiji to decentralize the development and distribution of the fundamental needs of life and to ensure jobs for everyone. Gandhiji regarded Khadi as an unavoidable means to the nation's overall growth and to banish pauperism. He said that Khadi ensured three basic necessities for poor: work, cloth and self-confidence (Tendulkar, 1951). He also prioritized the fostering of other sectors such as soap making, hand grinding and pounding, paper making, metal making, tanning, oil seed crushing etc. He supported manual work and criticized the implementation of automation, worrying that human labour would be replaced by the machines. But he welcomed and promoted the grass root innovations as it did not affect the employment opportunity and standard of living (Bora 1996). Gandhiji led the farmers of Champaran and Kheda in a satyagraha against the mill owners and landlords who were supported by the British government. He wanted to end oppressive taxation, and other policies that forced the farmers and workers and defend their economic rights. A major part of this rebellion was a commitment from the farmers to end caste discrimination and oppressive social practices against women. With that objective, he launched a cooperative effort to promote education, health care, and self-sufficiency by producing clothes and food that were made locally.

3.4. Bread Labour: Gandhiji was influenced by the works of Tolstoy and Ruskin, and urged that everyone should engage in physical labour irrespective of their designations. He named it as Bread Labour and told, *"God has given everyone the capacity to work and earn more than his daily bread and whatsoever is ready to use that capacity is sure to find work"*. He claimed that intellectual labour is for one's own fulfilment and one should not claim for its payment. Theory of Bread Labour ensured employment opportunity for all and guaranteed basic needs such as food, clothing and shelter. Physical labour would also keep people healthy and free of diseases. The dignity of labour would thus shape the economic basis of the modern nation (Gandhi 1946)

3.5. Gram Swaraj: The word Swaraj was used by Gandhiji with a distinct meaning and significance i.e., Self-rule and Self-restraint. He defined it in terms of individual and nation. Swaraj of citizens means the total aggregation of the individual's self-rule where as National Swaraj is the total sum of all efforts to create an ideal state on the basis of moral force. The citizens of such a state are aware of their moral power in its collectivity. Gandhiji was trying to identify the meaning of the Swaraj state with the Ramraj, the ideal state of Shri Rama. The Ramraj (the Enlightened Anarchy) of Gandhiji's vision was to be accomplished in three steps: Swaraj- Independence from British rule; Grama Swaraj-establishing a non-violent state by creating Village Republics; Ram Rajya-Kingdom of God on earth which would be devoid of violence and a completely democratic stateless society (Pandey 1989). Thus, Swaraj, Grama Swaraj and Ramraj are three critical elements in the pursuit of implementing the ideal social

order. However, it is hard to attain the Ram Rajya, Gandhiji stated that in its absence, the only feasible option was Grama Swaraj.

3.6. Decentralization: Gandhiji assumed that individual well-being with intellectual and emotional development must be the primary focus of society, and it should be accomplished by the decentralization of economic and political forces. He wanted the panchayat to execute the legislative, executive and judicial activities required for the effective functioning of the rural economy. Numerous developmental programmes, such as education, sanitation and hygiene, would also be performed by the village panchayat (Gandhi and Iyer 1986). Mahatma Gandhi's visits around the nation strengthened his belief that India might prosper if the villages were managed by the Village of Panchayats, based on the concept of "simple living and high thinking." It is in accordance with Gandhiji 's vision, that India has now enacted the Panchayati Raj Institutions by approving the 73rd (Constitution) Amendment Act, 1992.

3.7. Concepts of Austerity and Abstinence: Mahatma Gandhi said "*there is enough for everyone's need and but not for everyone's greed*" (Naryan 1970). He presumed that nature has balanced activities in a certain way that the eco-system would have an equilibrium and that everyone will get as much of what they require to have a happy life. Unsurprisingly, in order to satisfy his greed, man is selfish and ignores the law of nature and exploits resources for his gratification. Therefore, he pleaded to citizens to be austere and to pursue the concept of abstinence for the benefit of all (Naryan 1970).

3.8. Industrialization: Gandhiji was critical about industrialization and westernization, as he was afraid that it would affect the rural economy negatively. He was pretty sure that machines would occupy the position of human labour; thus increasing the unemployment and poverty rate. It would also lead to amassing of wealth by few, exploitation of villages and increase the suffering of destitute. He was in favour of grass root innovations and favoured machines if it fulfilled the criteria of providing employment to all and promoted self-sufficiency. Gandhiji opposed 'Industrial Civilization' but recommended 'Handicraft Civilization'.

3.9. Constructive Programme: Gandhiji began his rural reconstruction efforts in Sevagram during 1935 to execute the concept of 'Constructive Programme' that comprised of ideologies such as promotion of khadi, establishment of village industries, rural sanitation, basic and adult education, upliftment of backward classes, women empowerment, education in health and hygiene and propagation of mother tongue. He integrated all of these ideologies into his 18-point Constructive Programme and found as a non-violent way of achieving 'Poorna Swaraj'.

3.10. Gandhian Sarvodaya Plan Gandhiji was certain that the prosperity of the economy of India depended upon rural development. In his perspective, rural development relied on agricultural production, which in turn was the convergence of the farm and non-farm activities of the rural economy. He opposed the inherent inconsistency between economic and individual growth. Hence, he planned to integrate and create harmony between them by *Sarvodaya* and to achieve the aim of non-violent socialism; the Sarvodaya plan was proposed (Jan 2009).

It laid the foundation for the institutions that strive to achieve the philosophies of socialism. *Sarvodaya* meant all round development of citizens. He appealed for a balance of the pureness of the purpose and the nobleness of the process. The goal of the Sarvodaya plan was to create a social order of Sarvodaya based on the ideas of non-violence, honesty, harmony and cooperation. Sarvodaya plan comprised of Economic equality and communal harmony; Formation of cooperatives; Importance to farmers and landless labourers; Formation of labour unions; Technical and basic education for all and Hand spinning for all.

Gandhiji's Sarvodaya plan was vital in rural development and he said that rural development would happen only by rejuvenating the cottage industries and emphasised on the pivotal role of Khadi in fostering the other village industries. He made spinning and cotton cultivation compulsory, organised cooperative for weaving, regulated the price of handloom cloths, imposed ban on imported cloths. *Sarvodaya* was to be achieved in long run and the immediate goal was to set up *Sarvodaya* at village-grassroot level. Gandhian followers, such as Vinoba Bhave and Jayaprakash Narayan were actively engaged in Sarvodaya movement that sought to encourage self-sufficiency among the rural population of India by socio-economic reforms, promotion of land redistribution, and cottage industries. The movement aimed to tackle the issues of class tension, unemployment, and poverty at the same time sought to maintain the ways of living and traditions of rural Indians, that had been wiped out by industrialization and modernization. It also comprised of bhoodan, or the donation of land and agricultural assets by landowners (called zamindars) to their tenant farmers in an effort to put an end to the mediaeval zamindari system.

4. Gandhiji's Cooperative Movement and Progress of Cooperatives in India

After South African struggle for peasants, Gandhiji realized distress of Indian peasantry during his visit in the countryside of India due to oppression by illegal taxation and enforcement. After observation, he said, "*closest cooperation amongst the peasants is an absolute necessity*." According to him, cooperation can empower people in developing socialistic society and industry based on agricultural produce such as cotton, sugar, oil, seed etc. should rest on cooperative societies to avoid exploitation from corporate. This can safeguard the weaker section from industrialists and make village self-reliant (Debapriya 2006). According to United Nations (2012), "*A cooperative is an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically controlled enterprise*". Cooperative societies have potential to act not only as financing short term and medium term loans but also they can provide technical and vocational services to the small and marginal farmers to transform agriculture into agribusiness enterprise by pooling of the resource for realizing economies of scale (Sahoo et al. 2020).

There are several cooperative societies working successfully such as farmers' cooperative, consumer's cooperative, marketing cooperatives, processing cooperatives, service cooperatives,

etc. IFFCO and KRIBHCO are working successfully in input production distribution among the members as an enterprise. Dairy cooperatives like AMUL, sugar cooperatives, etc. are top most examples of agriculture based cooperatives in India. Gandhiji's Khadi and cottage industry is another cooperative which promoted production and value addition at houses of village and facilitated employment generation and self-sufficient small scale production units without any fear of establishment, storage, transportation, overproduction and marketing the produce (Sharma and Shikha 2016).

5. Contribution ICAR in Realizing Gandhiji's Dream of Rural Development:

Indian Council of Agricultural Research (ICAR) has made significant contribution in making India not only self-reliant on food front but also a food surplus country. Since its inception in pre-independence era; ICAR with its nation-wide network of research institutes, deemed universities and Krishi Vigyan Kendras; has been the most trusted and valued source for technological backstopping for the farmers. The Gandhian philosophy has been the driving force in devising pathways for technology development and dissemination. The development of appropriate and scale neutral technologies have been its core principle. The varieties and technologies of production and processing have penetrated among all categories and communities of farmers. ICAR is sensitive to the needs and aspiration of millions of small and marginal farmers and their resource endowments. It launched National Agricultural Research Project (NARP) in 1979 with assistance from the World Bank for conducting need-based, location-specific and production-oriented research with a mission-oriented problem-solving approach. It ensured generation of location specific and appropriate technologies. Earlier it had started Operation Research Project (1974) where scientists tested the potential of a technology among farmers on a watershed basis, covering whole village or cluster of villages involving allied agencies, and analyzed the technological and socio-economic constraints in spreading of technologies. The social audit component with the local people as active partner in the research program was in tune with Gram Swaraj by Gandhiji. Krishi Vigyan Kendra (KVK), the landmark effort of ICAR, was started in 1974 to impart vocational training in agriculture through experiential learning of farmers and rural youth for upgrading their knowledge and skill with improved technologies (Venkatasubramanian *et al*, 2009). Gandhiji's advocated '*Nai Talim'* and 'Vocational education to rural youth' and these ideas got fillip through ICAR's effort in establishing KVKs. Now a set of over 700 KVKs spread out through the length and breadth of the country are successfully conducting capacity building, extending hand holding support, and fostering linkages for rural youth and farmers and farm women to initiate agri-enterprises as well as start-ups for self-employment and creation of jobs in villages. KVKs also carry out on-farm testing of technologies. In 1994, ICAR started Institute Village Linkage Program (IVLP) to assess and refine the technologies in farmers' micro farming situations for generation of appropriate, eco-friendly and economically viable technologies through scientists-farmers participatory research. Such collaborative engagement of farmers and scientists facilitates a

sense of ownership among farmers towards technology development and validation. It also augments non- formal education among rural people as proposed by Gandhiji.

Based on Gandhiji's ideology of holistic development of a village, ICAR started outreach programs like Farmer FIRST and Mera Gaon Mera Gourav (MGMG) in 2015 to integrate the research-extension through scientists-farmers interface and participatory technology testing and dissemination processes. Farmer FIRST (Farm, Innovations, Resources, Science and Technology) aims at 'enriching knowledge' and 'integrating technology'. In first context, The research scientists and farmers learn from each other about the micro-farming situation and sub-systems of farming system (ICAR 2020). Technologies developed at research station may not be suitable at farmer's field, which need to be assessed, refined, validated, and adapted with active participation of farmers for their easy as well as speedy diffusion and adoption. The farmers are not mere the recipient of technologies rather they are experimenters too and often get engaged in technology refinement and development using their wisdom, knowledge and experience. The MGMG programme is an innovative initiative intended to speed up the transference of knowledge and innovations from lab to land through direct interface between scientists and farmers. About 6000 scientists from ICAR institutes and 15,000 scientists from state agricultural universities have been involved in this mega programme. A team of four multidisciplinary scientists at institute level adopt five (5) villages within a radius of 50-100 km from their place of work (PIB 2016) and work closely with farmers for technological and behavioral changes among the framers. The objective of such implementation strategy was to develop model villages, which would act as a catalyst for further development of the neighbouring villages in future (Som et al. 2019). The scientists and farmers together identify and prioritize the problems and decide for appropriate interventions for their solutions. Demonstrations and trainings are conducted for popularization of innovations. ICAR institutes also adopt villages for development as model villages, which act as the light houses for other surrounding villages in the hinterland of the institutes. Such initiatives of ICAR augment realization of Gandhian model villages.

6. Gandhian Philosophy: Effective Propellant for Sustainable Agriculture and Livelihoods

Given the agrarian crisis in modern India, it is highly imperative to incorporate the Gandhian ideologies while formulating the paradigm for future agriculture. Farmers' welfare has been the primary focus of government of India and accordingly, numerous schemes and programmes have been initiated to stimulate the growth in agricultural sector and to boost up the financial conditions of farmers. With growing concerns of climatic variations and dwindling availability of natural resources, there is a paradigm shift in development approaches across the globe. Gandhiji adequately laid emphasis upon soil and water conservation measures. There is a popular observation that soils are not only thirsty but hungry too. Injudicious use of inorganic fertilizers has made soils less fertile as well as deficient in micro-nutrients, while disturbing the microbial regime in soil. Similarly, the injudicious use of water for irrigation has led to

accelerated depletion of ground water resources and soil degradation. Gandhiji's ideologies indicated judicious use of naturally available resources, without disturbing the ecological balance. His thoughtful statements that "*To forget how to dig the Earth and tend the soil is to forget ourselves*" and "*Earth provides us enough for our needs but not for our greed*" are eternal in their impact on guiding the human philosophies and lives on this Earth. From the conservation point of view, the Dandi Satyagraha launched by him in 1930 was also about freeing humans from the greed, and about the need to use the natural resources cautiously. The burning issues of today about drought and water scarcity had been the concerns of Mahatma. The experiences of drought during the independence struggle at Kathiawar region in Gujarat led to Gandhiji creating awareness and appeal for afforestation on a large scale as an effective measure to contain water crisis. He emphasized the need for water harvesting in the prayer meeting in Delhi in 1947. His concerns about sanitation and Harijans (God's people) acknowledged the need for conserving water resources, the services rendered by, and the critical contributions to the society at large. Gandhian principles give us the confidence that a better world is possible.

Gandhiji stressed upon sustainable way of living and his idea of sustainable development has been duly recognized by the United Nations too. He was a big profounder of organic and natural farming based on permaculture or sustainable agricultural practices without dependence on external inputs. He emphasized that the farmers should stop using chemical fertilizers and begin to regenerate soil. To practice sustainable agriculture, he emphasized recycling of agricultural and food waste as animal feed and biogas production. Village can be sustainable with healthy food consumption and environment friendly agriculture which was concept of ecological regenerative agriculture (Annamalai 2015).

Gandhiji always stressed upon simple living with limited use of the resources as per our needs. National Mission on Sustainable Agriculture (NMSA) focuses mainly on conservation agriculture to make farm sector more productive, sustainable, remunerative and climate resilient by promoting location specific integrated/composite farming systems; soil and moisture conservation measures; comprehensive soil health management and mainstreaming rainfed technologies. Pradhan Mantri Krishi Sinchai Yojana was launched on 1 July 2015 with the motto '*Har Khet Ko Paani*' has led to augmentation of decentralized irrigation plan development, water sources development and efficient system of irrigation distribution network and farm level applications.

There is immense cognizance of the adverse impacts of the indiscriminate use of chemical fertilizers and pesticides on human health and environment. Gandhiji exhorted to give up chemical fertilizers and pesticides and substitute them with bio-manures and bio-pesticides. The Government of India has been striving to promote organic farming under the Paramparagat Krishi Vikas Yojana since 2015-16. *Jaivik Kheti Portal* will strengthen the online national organic products market.

Gandhiji's sustainable rural development can be achieved through Sarvodaya plan which focuses on agricultural and allied activities for holistic development of rural communities

by integrating social values in economic process. Sarvodaya plan basically consists of (a) economic equality and communal harmony (b) full attention to farmers and farming associates (c) all farmers having their committees (d) simple and compatible education for all (basic and technical) (e) hand spinning at every family as part of Khadi industry (Sharma and Shikha, 2016). Gandhiji's remarked on unemployment in rural India through his words "*Mechanization is good when the hands are too few for the work intended to be accomplished. It is an evil when there are more hands than required for the work, as is the case in India*." To contain a serious problem like rural unemployment, he advised for agricultural and allied activities such as village industries or cottage industries or cooperative societies because of labour intensive and capital saving in populated country like India for self-reliance (Gandhi 1934).

In the wake of COVID-19 pandemic, the Honourable Prime Minister of India announced *"Atmanirbhar Bharat*" (Self-reliant Indian Mission) to achieve economic self-reliance and to boost local industries and products which in turn would help in uplifting the rural poor. PM's announcement of self-reliant India is in resonance with Gandhian philosophy of Swadeshi , self-sufficiency and Swaraj. The drive for "*Atmanirbhar Bharat"* emphasizes upon local production and global presence of local brands. The innovative initiatives of *Kisan Rail* and *Krishi Udaan* launched by the Ministry of Civil Aviation will provide impetus to India's march towards self-reliance**.** One-Product One-District for better marketing and export in the Horticulture sector, while the Village Storage Scheme to be run by the SHGs will provide farmers a good holding capacity and reduce their logistics cost.

Collectivization has been effective in linking farmers to markets. Gandhiji too had emphasized upon cooperatives of farmers for safeguards against exploitation by the corporate. Of late, Farmer Producer Organization (FPO) has emerged as an effective institutional mechanism for promotion of agribusiness, where forward and backward linkage is strengthened through increased bargaining power and economies of scale. The farmers can become the owners of their farmers producers company where they can invest through shareholding and lend money from bank to expand their agri-enterprise. This can empower farmer producers to achieve higher share from consumers' rupee through direct marketing, while removing the middlemen or traders' higher share. The digital marketing platform e-NAM by Govt. of India (2016) also facilitated the Farmer Producer Companies to sell their produce to the buyers at a price where both producers and consumers get surplus through win-win situation. This can be a check to the irregularities by middlemen and traders and in Mandi system. Gandhiji's vision of unity of villagers making committee is achieved through FPOs like organization in current situation.

7. Path Ahead

a) Promotion of decentralized innovation hubs: Gandhiji believed in decentralized and bottom up planning and development process. Often the top-down approach in innovation generation and transfer has failed to meet the needs and aspiration of the people and thus the intended benefits have been overshadowed with losses in terms of ecological

degradation. Besides socio-economic considerations, emphasis upon forging communion with nature holds the key to realize the Gandhian dream of sustainable as well as inclusive development. This entails devising such strategies for development and dissemination of innovations which could ensure economic viability; social equality, and ecological compatibility in order to generate appropriate and effective solutions to the emerging challenges in agriculture and farmers' welfare. Therefore, besides collaborations of public-public and public-private institutions, emphasis must also be laid upon informal innovations systems (farmers' innovations). Promotion of decentralized innovation hubs will strengthen participatory process, where the innovative farmers and youth could contribute in mainstream research for generation of cost-effective and location specific technologies. Even the intellectual property of the local innovators could be protected and also upscaled with necessary support.

b) **Development of incubation/agri-business hubs:** Agrarian scenario has dampened the spirit of farmers and often there are criticisms that farming no more fascinates the rural youth. Unemployment and migration are common in rural areas. Farmers and rural youth need to be motivated and trained for entrepreneurship development. Entrepreneurial opportunities and special government provisions are helping agri-enterprises to be developed. Many farmers who have been entrepreneurial have become successful achievers. There is need to replicate these cases. Several schemes have been rolled out by the Govt. to promote local enterprises. Setting up incubation centres and agribusiness hubs at block level will not only promote household enterprises but will also check the migration and related problems. Initiation of research programme for evaluating successful models of incubation, entrepreneurial ventures, and commercialization of agricultural technologies will help in pragmatic policy advocacy.

c) **Promotion of integrated farming system:** Integrated farming systems are important for efficient management of available resources at the farm level, to generate adequate income and employment for the rural poor, for promotion of sustainable agriculture, for protection of the environment, and for livelihood security. The synergistic interactions of the components of farming systems need to be exploited to enhance resource-use efficiency and recycling of farm by-products. The IFS models for different classes of farm have the potential to generate additional income and employment than with rice-wheat or rice-rice alone, the system currently prevalent in major parts of the nation. Furthermore, these models may help resolve through diversification some of the existing land degradation and other agriculture-related problems, and also minimise risk to sustainability. The study illustrates the necessity to adopt an integrated approach, instead of a commodity- and disciplined-based one.

d) **Gender empowerment for food and nutritional security:** Hidden hunger continues to haunt a large section of Indian population. Capacity building for nutrition education should be promoted. Nutri Farming System or Nutri Farming model would help farmers to grow

and trade nuti-rich food and earn better remuneration and at the same time help in eradicating hidden hunger. Gender empowerment is essential to face the changing paradigm shifts in agriculture. Mainstreaming the gender perspective needs to be reflected in all our policies and programs. Promotion of employment opportunities for SHGs through financial support and technological backstopping could bring a sea change in rural livelihood systems. Gandhiji always emphasized upon upliftment of women for the welfare of society.

e) **Facilitation of institutional convergence:** Very often there remain gaps at planning or implementation levels and we witness the malaise of duplication of efforts, sporadic efforts or incoherent efforts. There should be activation of inter-departmental working groups at district and block levels for effective channelization of the schemes, provisions and welfare measures. Here there could be complementary arrangement of both top-down as well as bottom-up planning and engagement of public, private and farmers institutions/ organizations.

f) **Creation of custom hired services of farm machineries for efficiency** Today's agriculture needs precise as well as timely management of tillage, inputs, and inter-cultural as well as other farm operations. Mechanization is the need of the hour for time-, energy-, and cost-effective accomplishment of farm operations. Gandhiji is often criticized that he was against mechanization but in fact he only disfavoured mechanization which robed the hands of job. He did not criticize innovations for efficiency. He was the one who initiated crowd-funding for innovations in spinning wheel which could be efficient. Setting up new and strengthening of existing custom-hire centres with provision of more number of machines and better norms should be focused upon to enhance accessibility of farm machineries and reduction of drudgery.

g) **Water resource development:** Water will be crucial for not only agriculture but also for drinking and more importantly for hand wash and sanitization. The measures like roof water harvesting, community ponds and tanks, and on-farm water conservation will be critical. Support could be extended for such interventions. The Govt. has laid emphasis upon solar based water pumps as green way of farming. The grassroots organizations could take up the role of collective interventions in their areas for water harvesting through low cost structures. The *"Jal Saheli"* groups in Bundelkhand have done commendable work in augmentation of water security for the villages. Voluntary organizations and farmers organizations could also join hands in implementation as well as participatory monitoring of water related Govt. interventions. Emerging technologies including sensor based on-farm irrigation management need to be promoted for efficient water management and attainment of desired crop productivity.

h) **Linking farmers to markets:** Efforts need to be made towards devising gainful as well as trustworthy ecosystem and mechanism for linking farmers, particularly the small farmers, to markets. Recent farm bills amply stress upon market and income-oriented farming. Modified procedures have indicated ease of business in contract farming. However, there

is need for trust building as well as collective action. The farmer producer organizations (FPOs) and cooperatives could promote adoption of improved technologies by farmers and facilitate collective arrangement of input, credit and insurance services, besides having greater say in marketing of their produce. Organic farming has great potential for enhancing farmers' income, sustaining productivity and to promote residue free food products. There is a need for development of value chains for aggregation of organic produce, quality control, certification and branding, and marketing. Besides quality information, infrastructure support system for postharvest treatment and value addition will have to be ensured for prosperity of market-oriented farming.

8. Conclusion

Gandhiji's concept of rural development is a multidimensional process which includes *gram swaraj* (self rule), *atmanirbhar* (self-reliance), *ram rajya* (rule of law established by moral values), *panchayat raj* (decentralisation of power, economy, policies and decisions at panchayat), *ahimsha* (politics based on non-violence), *Satya* (administration based on truth and honesty), *sevabhaba* (service attitude), *Sahyog* (cooperation), and swabhiman (self-dignity of individual). Gandhian philosophy emphasizes upon upliftment of common man though enabling him to access the basic amenities such as food, cloth, shelter, health and education by earning locally with a dignity of life and livelihood. The poverty, superstition, exploitation in the caste system, concentration of power, violence, communality etc. have been the major negative factors in rural development. He always emphasized agriculture and allied activities to be the backbone of rural economy, which should be performed with least external inputs. The Khadi industry, cottage industry, rural crafts industry can be pivotal in reviving rural economy and self-dependent rural India in future. His sublime vision is all round development of rural India based on his ideas, principles, values and harmony with nature.

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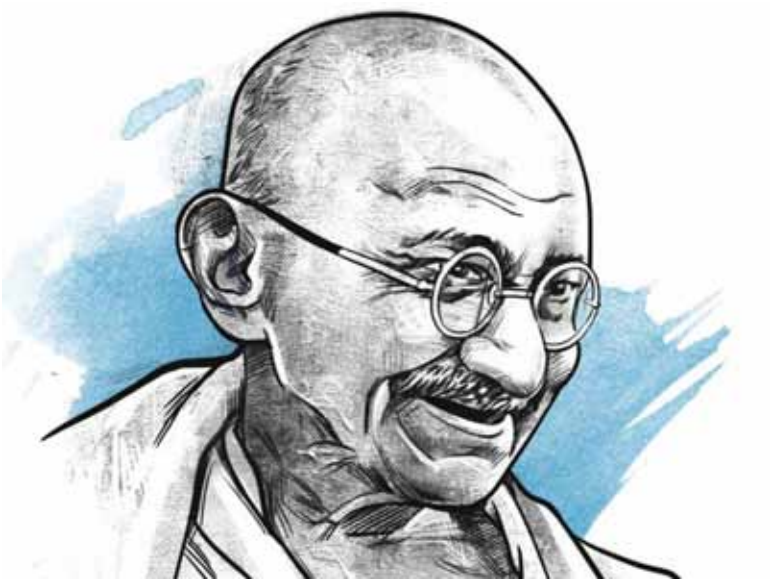

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