AGRI BASED TECHNOLOGICAL INTERVENTIONS FOR ENTREPRENEURSHIP DEVELOPMENT IN SEMI-ARID ZONE

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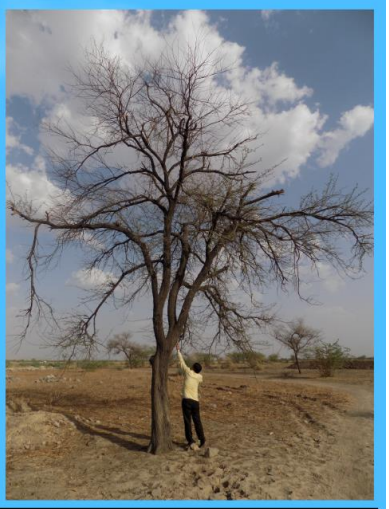

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&
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Agri-based Technological Interventions for Entrepreneurship Development in Semi-Arid Zone

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This book is a compilation of resource text obtained from various subject experts for MANAGE – ICAR-DRMR Baratput, Rajasthan collaborative training program on "Agri-based Technological Interventions for Entrepreneurship Development in Semi-Arid Zone" conducted during 22-26, August, 2022. This book is designed to educate extension workers, research scholars, and academicians about the promotion of entrepreneurship development through production and value addition in semi-arid zones in order to income enhancement. Neither the publisher nor the contributors, authors, and editors assume any liability for any damage or injury to persons or property from any use of methods, instructions, or ideas contained in the book. No part of this publication may be reproduced or transmitted without prior permission of the publisher/editor/authors. The publisher and editor do not give a warranty for any error or omissions regarding the materials in this book.

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FOREWORD

In India, agriculture and allied sectors provide employment to close to half of the workforce and contribute about 17% to the national income. Recently, innovative policy initiatives including Minimum Support Price (MSP), promoting village-level organizations (SHGs, FPOs, JLGs, PGs, etc.), contract farming, risk coverage, input subsidies, linking production to processing through corporate investment and market reforms are being implemented. Efforts of government in this direction are more inclined to encourage entrepreneurship development. In order to enable the unemployed workforce in the agriculture sector and overcome constraints of poor awareness, the scale of the economy, and low risk-taking ability, provisions have been created in law to facilitate the formation of Farmer's Producers Companies (FPC) to undertake agribusiness activities like other business entities. Recently, NABARD and other organizations have taken initiatives to establish the Farmer Producer Organizations with common agricultural as well commodity-specific targets. Commodity-specific FPOs are being registered either under the Cooperative Societies Act or Indian Companies Act.

The ICAR-Directorate of Rapeseed Mustard Research, Bharatpur, Rajasthan functions as a fulcrum to support the production system research for rapeseed (*Brown Sarson, Yellow Sarson, Toria, Taramira, Gobhi Sarson*) and mustard (*Black Mustard, Ethiopian Mustard and Indian Mustard*) group of crops through research, service and support units. ICAR also strengthened Institute Technology Management Units (ITMU) by establishing Agri-Business Incubation (ABI) Centers to facilitate the start-up in the agricultural sector. The semi-arid zones of the world are fragile ecosystems that are being substantially modified by the activities of mankind. Increasing human populations have resulted in greater demands on semi-arid zones for providing human sustenance. These zones are harsh habitats for humans. The occurrence of famines illustrated the unreliability of present agricultural systems in this zone. Large fluctuations in agricultural production have occurred in semi-arid zones of India.

Considering the key role played by technological interventions in the rain-fed farming systems, opportunities in the semi-arid zones is expanding as more soil, water, and energy-saving techniques are available for the growth of the country's agrarian economy as well as the need for entrepreneurship in agri sector.

In his context, I appreciate the effort of ICAR-DRMR and MANAGE to organize this collaborative training on "**Agri-based Technological Interventions for Entrepreneurship Development in Semi-Arid Zone"** to enlighten stakeholders with modern agri-based technologies for semi-arid zones of India. I further commend the organizers for choosing such an important topic for training, and I am confident that this compilation of resource material from the learned speakers will serve as a source of information and knowledge for stakeholders.

August 22, 2022

Dr. PK Rai, Director
ICAR- DRMR, Bharatpur, Rajasthan

PREFACE

Agriculture is the most important area to satisfy the food demand for the dramatically increasing world population. In this direction, India is required fast and reliable services without making dependencies on other countries however, it's also a good area for entrepreneurship. This e-Book will be helpful to instill agriculture technology foresight among extension functionaries for assisting new entrepreneurs in commercial activities conducted both on-farm as well as off-farm. On-farm activities include crop cultivation (oilseeds, pulses, seed spices, etc.), Vegetable production, arid & semi-arid horticulture, agroforestry models including natural gum tapping, livestock improvement (bovines and small ruminants), forages and grasslands for enhancing livestock productivity. Off-farm sectors like agro-processing & value addition, food manufacturing, and other critical farm support services. Information on improvement in crop productivity through agricultural mechanization, harnessing energy from renewable sources, efficient management of irrigation water, reduction in post-harvest losses, and promoting agri-business aimed to enhance income and generate employment in the rural sector. Brief outlines of the start-up agri-business incubation & agri-partnership programs; integrated solutions to address the challenges of poverty, climate change, nutrition, and sustainability of natural resources in the complex farming systems of the drylands; scaling climate-smart agriculture for enhancing resilience and profitability also discussed.

The editors felt that all the experience of resource persons of this training should be clubbed together to form a unique proposition on agriculture technology foresight. Agricultural science is subject that has different magnitudes, scales, and directions. The experts and resource persons in agricultural science contributed immensely and tirelessly to develop various chapters of this e-book in a very short span of time. They all deserve to applaud. The editors extend their sincere thanks to all the experts who have contributed valuable time and put sincere efforts to produce this e-book. The editors also thank MANAGE, Hyderabad for the financial support for the training program. The editors express gratitude towards the Director, ICAR-DRMR for the constant encouragement for this training and e-book creation for the participants. The editors hope that this e-book will help participants as well as other extension people across the country to gain valuable information on agricultural production, handling, storage, processing, and value addition for domestic and export markets

Editors

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Chapter-1

Technology Foresight: Anticipating Agricultural Applications

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Shaloo[3], Dr Shbana Begam[4] and Saravanakumar R[2]
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1. Introduction

The term "foresight" has long been used to describe readiness to deal with long-term issues (especially on the part of governments). The term "Technology Foresight" took off in the 1990s when countries sought new policy tools to deal with problems in their science, technology, and innovation systems. Technology Foresight (TF) refers to the process involved in systematically attempting to look into the long-term future of science, technology, the economy, and society to identify the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits (Pietrobelli and Puppato, 2016). Overall, TF studies provide strategic information for decision-making and long-term planning in science and technology, being used by governments, and organizations to prepare for the future. TF is different from technology forecasting. TF means a new future-oriented approach while Technology Forecasting is a traditional forward-looking approach developed in the 1950s in the USA. TF helps to shape the future of science and technology as well as society. TF is often seen as a set of tools for informing decisions about science, technology, and innovation (STI) priorities within established innovation systems (Miles et al., 2017). As the world faces a wide range of critical challenges, from conflicts and climate change to population growth, countries increasingly need to harness the right technologies to leverage comparative advantages, drive economic growth, and fulfil strategic needs. National-level TF is a vital tool for policymakers to identify domains of high importance or potential. This viewpoint outlines key imperatives for countries to ensure foresight best delivers value in a pragmatic, repeatable manner.

In this article, we elaborate on TF for agriculture in the next 25 years. The foresight is based on recent trends in research in developed and developing countries. In Section 2, we focus on the most prevalent technologies of the 21 century. We anticipate the present and future application of disruptive technologies in agriculture in Section 3. Section 4 briefs on the challenges and opportunities of these emerging applications. Finally, we conclude in Section 5.

2 Key Technologies

2.1 Biotechnology

Biotechnology is to modify the genetic structure in animals and plants to improve them in the desired way for getting beneficial products. Biotechnology is the use of an organism, or a component of an organism or other biological system, to make a product or process for benefiting human beings. It is a combination of various technologies, applied together to living cells, including not only biology but also subjects like mathematics, physics, chemistry, and engineering. Its application in agriculture includes Animal Husbandry, Cropping systems, Plant Physiology, Seed Technology, etc., and Crop Management. The diverse applications are possible with the help of gene editing i.e. by altering the harmful characteristics and inserting the desirable ones like fighting against disease – in humans, animals, and crops. The technology can provide (i) the use of food as a drug delivery system. (ii) Enhanced proteins, vitamins, and other nutrients in food (iii) production and development of a drug as a plant product. The delivery and production costs will be reduced as no separate refrigeration of food or vaccines will be needed (Newell-McGloughlin, 2008). Biotechnology provides farmers with tools that can make production cheaper and more manageable. For example, some biotechnology crops can be engineered to tolerate specific herbicides, which makes weed control simpler and more efficient.

Agriculture is the most important area to satisfy the food demand for the dramatically increasing world population. In this direction, India is required fast and reliable services without making dependencies on other countries however, it's also a good area for entrepreneurship such as (i) required chemical and lab material suppliers including gel-doc, PCR, laminar air flow, DNA kits (ii) generating different types of sequencing of plant samples which are presently imported (iii) Primer designing and supply (primer is a short single strand of DNA that serves as a starting point for DNA synthesis of a new DNA strand. It is required for DNA replication because the enzymes that catalyze this process, DNA polymerases, can only add new nucleotides to an existing fragment of DNA) (iv) Next Generation Sequencing (NGS) technologies which offer high-throughput, rapid and accurate methods of determining the precise order of nucleotides within DNA/RNA molecules.

2.2 Digital Agriculture

Digital Agriculture is "ICT and data ecosystems to support the development and delivery of timely, targeted information and services to make farming profitable and sustainable while delivering safe nutritious, and affordable food for all." The greatest need is to deliver targeted

and timely information to farmers based on their needs. The empowerment that comes from providing farmers with informed options is transformational, especially for women and youth. Enabling technologies for digital agriculture are shown in Figure 1. Cloud computing is the axle for the other enabling technologies and refers to the delivery of computing services—including servers, storage, databases, networking, software, analytics, and intelligence—over the Internet ("the cloud") to offer faster innovation, flexible resources, and economies of scale. In this figure, digital services promote rapid cycle innovation targeting farmer-preferred products and services with the help of mobile devices. Big data analytics turn vast amounts of collected data into actionable information and knowledge. Breeding informatics is the use of information for genetic improvement. AI/ML and the Internet of Things (IoT) is explained in detail in the next section. Geo-spatial technologies UAVs (Unmanned Aerial Vehicles) help to cover a large area of land in a short interval for monitoring and plant protection sprays. Mobile devices have become a useful tool in agriculture because the cost of the device is highly accessible, and their computing power allows a variety of practical applications to be created and deployed at the farm level.

2.3 AI and ML

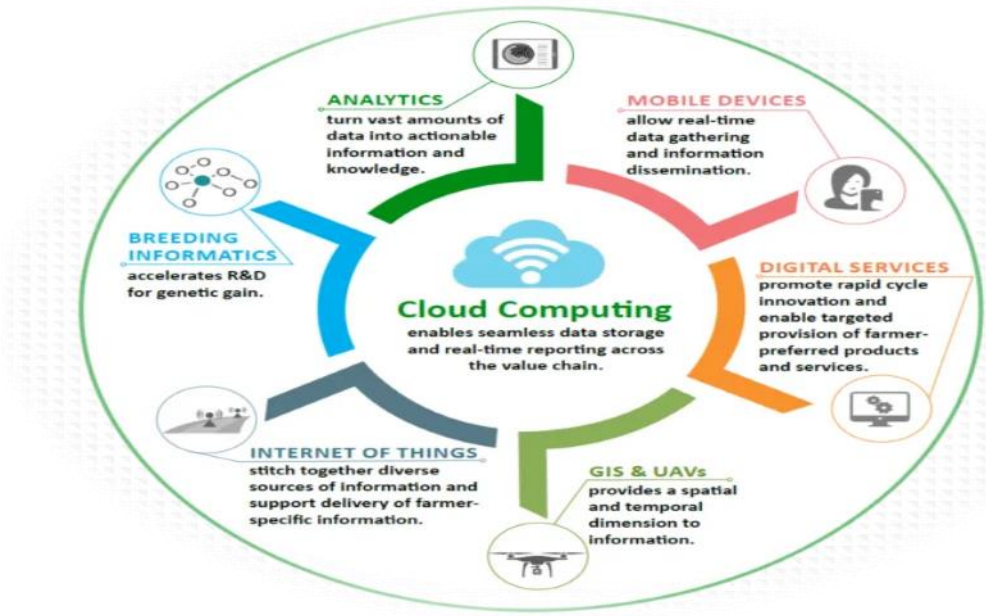
Artificial Intelligence (AI), and Machine Learning (ML) refer to the ability of machines to learn and act intelligently, meaning they can make decisions, carry out tasks, and even predict future outcomes based on what they learn from data. Machine learning teaches machines to learn from data and improve incrementally without being explicitly programmed. More precisely, ML is a discipline of AI that provides machines with the ability to automatically learn from data and past experiences while identifying patterns to make predictions with minimal human intervention. ML applications are fed with new data, and they can independently learn, grow, develop, and adapt. Machine learning derives insightful information from large volumes of data by leveraging algorithms to identify patterns and learn in an iterative process. ML algorithms use computation methods to learn directly from data instead of relying on any predetermined equation that may serve as a model. The performance of ML algorithms adaptively improves with an increase in the number of available samples during the 'learning' processes (Figure 2). For example, deep learning is a sub-domain of machine learning that trains computers to imitate natural human traits like learning from examples. It offers better performance parameters than conventional ML algorithms.

AI/ML plays a bigger role in everyday life e.g. Alexa, Siri, Amazon's product recommendations, Netflix's and Spotify's personalized recommendations, Google search, security checks for fraudulent credit card purchases, dating apps, fitness trackers, etc. are driven by AI. However, there are potentially huge risks for society and human life as we know it, particularly when you consider some countries are racing to develop AI-enabled autonomous weapons. AI and ML are the foundation on which many other technologies are built e.g. Internet of Things, virtual reality, chatbots, facial recognition, robotics, automation, and self-driving cars.

2.4 Internet of Things (IoT) and Sensor Technology

Sensors are used in the architecture of IoT devices and are useful for sensing things and devices etc. IoT is a device that provides a usable output in response to a specified measurement. The sensor attains a physical parameter and converts it into a signal suitable for processing (Figure 3). The processor further converts the signal to a human-readable form like changes in characteristics, changes in resistance, capacitance, impedance, etc. The converted signal is further received by the actuator and converted into a form that can automatically control some other machines. Resolution is an important specification for the selection of sensors. The higher the resolution, the better the precision. The Internet of things (IoT) describes physical objects (or groups of such objects) with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks. However, IoTs need not be connected to the public internet, they only need to be connected to a network and be individually addressable.

In the agriculture domain, the use of IoT technology is synonymous with the concept of smart farming or precision agriculture. There is a number of concerns about the risks in the growth of IoT technologies and products, especially in the areas of privacy and security, and consequently, industry and governmental moves to address these concerns have begun, including the development of international and local standards, guidelines, and regulatory frameworks (WIKI).



***Source**: ICRISAT*

Figure 1: Enabling Technologies for Digital Agriculture

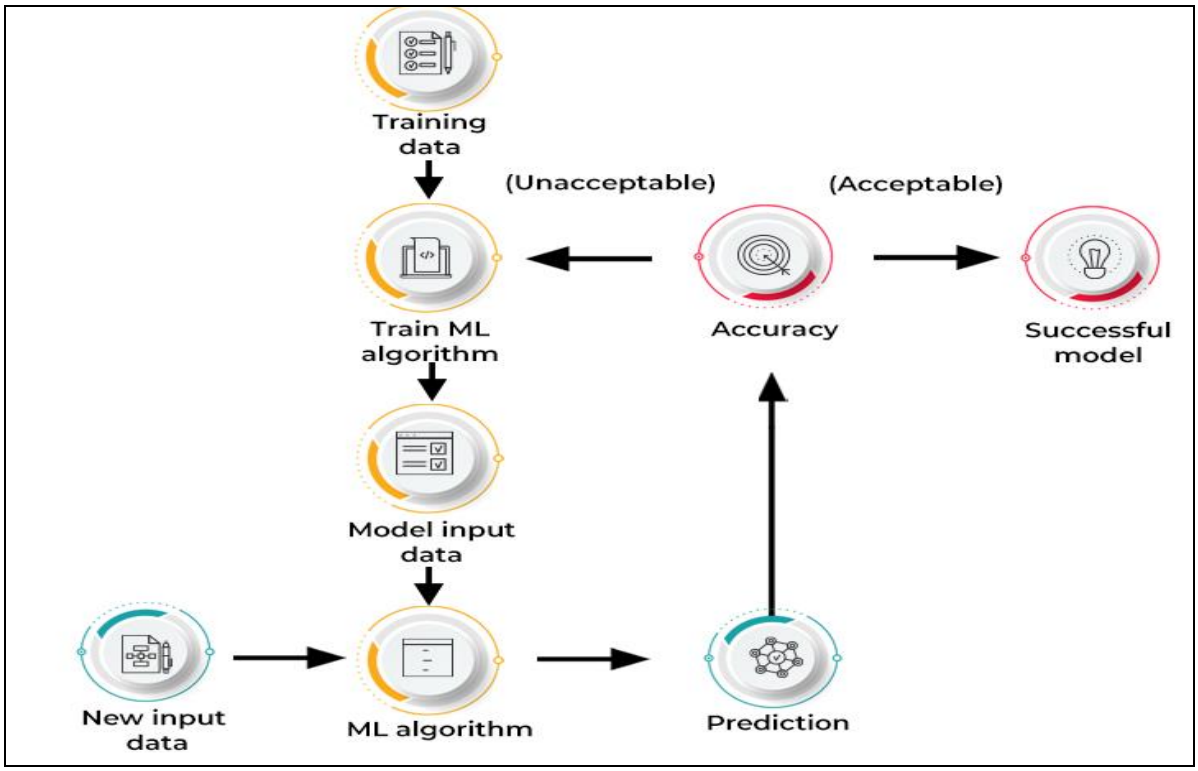


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Figure 2: Working of an ML Algorithm

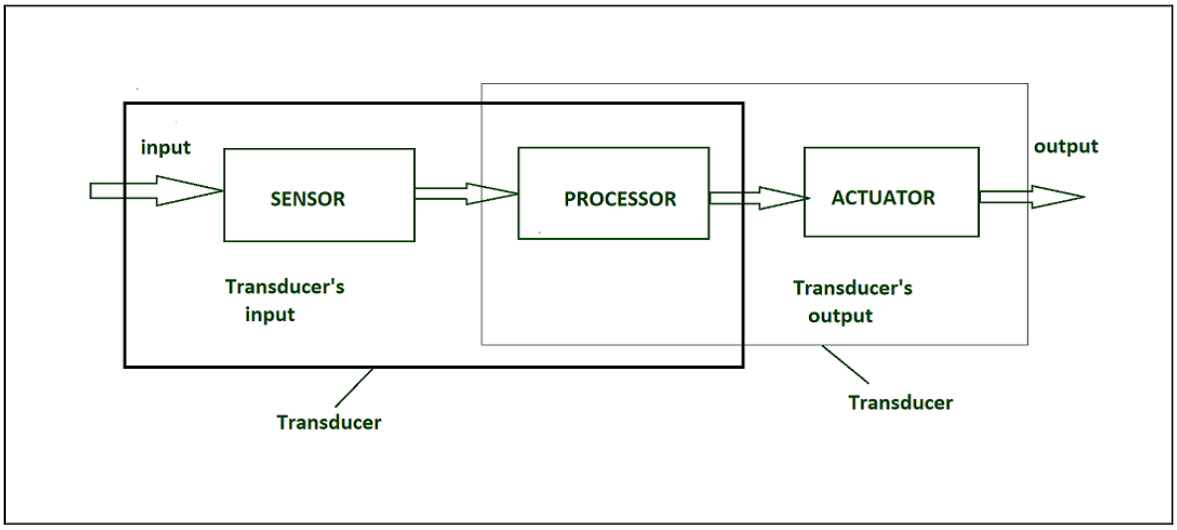

Figure 3: Architecture of an IoT

2.5 Block chain Technology for Digital Trust

Block chain-based technologies are introducing an important trust layer to the agriculture industry, ensuring that supply chain partners' claims cannot be tampered with starting from cultivation and harvesting data to transportation and storage (Bhushal, 2021). Block chain technology provides value to an industry that needs more trust as **it enables the storing of and access to information, which is immutable and timeless.** Block chain technology shows a promising approach to fostering a safer, better, more sustainable, and dependable agri-food system in the future. While the application of block chain in agriculture is in the initial phase and faces various issues like cost of implementation, privacy, security scalability, performance, and infancy, it can bring a revolution to the agriculture industry. Block chain Technology works on the principle of distributed ledger systems (Figure 4).

The main usage of block chain technology in agribusinesses focused on product traceability which involves capturing, storing, and transmitting product information in all stages of the agri-supply chain. Such information enables (1) building trust and transparency among different actors in agri-business, (2) checking product safety and quality, and (3) building customer confidence and trust (Bhusal, 2021). Some of the promising benefits of block chain adoption in agribusiness can be outlined as:

a. *Increase Trust:* Block chain due to its distributed nature and cryptography, the necessity of any central authority for information storage and security is eliminated hence restoring trust between producer and consumers.

b. *Improve Traceability:* The decentralized ledger that records each stage product's information enables connection inputs from suppliers, producers, buyers, and regulators who are relatively apart from each other, helping to enhance the traceability of the Agri-products.

c. *Improve product safety and quality:* Product information is recorded at every stage of the supply chain thus allowing all parties to ensure good hygienic conditions, and early identification of any contamination, risks, and frauds in products.

d. *The benefit to small farmers:* Small farmers can get a fair market price as they can track the status of the product and change market price using block chain technology without depending on the intermediates/middlemen.

e. *Improve consumer trust:* Consumers can access all the product's information at every stage of the supply chain hence increasing confidence and trust in the consumed product.

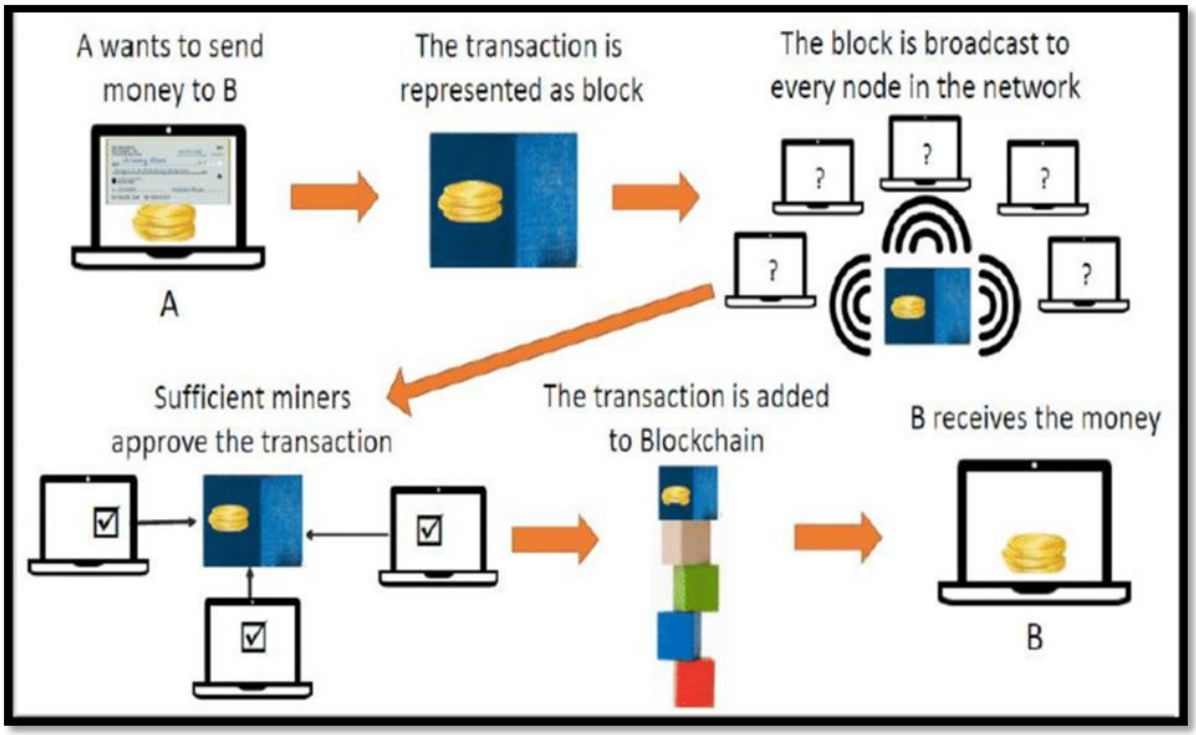

Figure 4: Distributed Ledger System in Block chain improves trust and traceability

2.6 Drone Technologies

Commercial drones are unmanned aircraft that are typically owned by corporations, universities, or entrepreneurs. Drone technology has a wide range of applications from monitoring coastal areas in defence to agricultural applications. Drones can capture aerial images, and motion sensor data, and storing it for analysis may be used for effective crop

management, disease control, or patrolling borders. A drone is an aircraft without a human pilot onboard. Instead, the UAV is either controlled by someone on the ground or autonomously via a computer program. The soaring popularity of drone technology is helping Indian start-ups create new businesses that range from aerial photography to crop monitoring, warehouse management, and surveillance. Revenue from business-to-business applications of drone technology is expected to grow more than fourfold over the next decade as the usage of drones expands across industries. More than 500 start-ups in India are racing to use drone technology to solve problems like helping farmers in monitoring crops, inspecting power lines and bridges, providing connectivity to rural areas, and monitoring construction sites (DRONE). For smart farming and Precision Agriculture (PA), aerial remote sensing is considered to be one of the most important technology. Aerial remote sensing, with the help of drones, utilizes images of different wavelengths and measures the vegetation indices to recognize the several conditions of crops. Analysis of soils and drainage, Crop health monitoring, Yield prediction, Pesticides, and fertilizer spot spraying are some important applications of drone technologies in agriculture.

3. Applications of Disruptive Technologies in Agriculture

3.1 Precision Agriculture

Precision agriculture is a management strategy that gathers, processes, and analyses temporal, spatial, and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability, and sustainability of agricultural production (Priya and Ramesh, 2020). Precision agriculture (PA) is the science of improving crop yields and assisting management decisions using high-technology sensors and analysis tools. PA is a new concept adopted throughout the world to increase production, reduce labor time, and ensure the effective management of fertilizers and irrigation processes. It uses a large amount of data and information to improve the use of agricultural resources, yields, and the quality of crops (Singh et al., 2020). Satellite and UAV-based applications of remote sensing in precision agriculture generally use multispectral measurements to estimate high-spatial resolution information related to soil properties, plant health, and crop yields. The recent development of precision application technology is now allowing for smaller treatment units by making applications according to site-specific demands. The automated systems of the future will have sensors and computer technologies that first categorize each plant in the field as either weed or crop and then identify the species of weed for further automated responses.

3.2 Inputs Management: Water, Machinery, Seeds, Transport

According to the United Nations World Water Development Report, by 2050 more than 50% of the world's population will be under high water scarcity. To avoid water stress, water resources are needed to be managed more securely. Smart water technology (SWT) has evolved for proper management and saving of water resources. Smart water system (SWS) uses sensor, information, and communication technology (ICT) to provide real-time monitoring of data such as pressure, water flow, water quality, moisture, etc. with the capability to detect any abnormalities such as non-revenue water (NRW) losses, water contamination in the water distribution system (WDS) (Gupta et al., 2020). Using ICT, researchers are coming up with self-learning systems known as Smart water systems (SWS), having the capability to manage water more efficiently.

Smart technologies can lead to better water resource management, which can lead to the reduction of water scarcity worldwide. High implementation costs may act as a barrier to the implementation of SWT in developing countries, whereas data security and its reliability along with the system's ability to give accurate results are some of the key challenges in its field implementation.

IoT applications can help farmers at any time during their farming activities and keep them updated with the latest crop and weather information to remotely monitor their fields. Utilizing IoT applications, farmers can make plans for the next season's harvest.

Indian agriculture is undergoing a gradual shift from dependence on human power and animal power to mechanical power because of the increasing cost of upkeep of animals and the growing scarcity of human labor Further, the use of mechanical power has a direct bearing

on the productivity of crops apart from reducing the drudgery and facilitating timeliness of agricultural operations. Drones are a recent addition to agricultural equipment. However, small and marginal farmers, under their economic conditions, are unable to own farm machinery on their own or through institutional credit. Therefore bringing the farm machinery available within the reach of small/marginal holdings, collective ownership or Custom Hiring Centres need to be promoted in a big way (Murugesan, 2019).

3.3 Plant Protection: Disease and Weed management

Plant Protection plays a significant role in achieving the targets of crop production. Plant protection at field-scale is critical for improving yield to address global food security, as providing enough food for the world's growing population has become a wicked problem for

both scientists and policymakers (Jain et al., 2021). AI-based equipment and machines like robots and drones have been designed for disease and weed detection. The detection, quantification, diagnosis, and identification of plant diseases and weeds are particularly crucial for precision agriculture. Over the last 20 years, researchers in the field of digital plant pathology have chased the goal to implement sensors, machine learning, and new technologies into knowledge-based methods for plant phenotyping and plant protection. The proper identification of the signs of major crop diseases is a serious challenge for agriculture and disease management along with control procedures that must be carried out effectively to reduce output losses and ensure crop sustainability (Nigam et al., 2021[1]). Computer Vision, along with AI and deep learning, has taken a major step in creating systems and methods for detecting and classifying images. In this approach, features are extracted automatically and learned from the data in the training phase (Nigam et al., 2021[2]). Nigam and Jain have reviewed both small and large dataset studies containing 500 to 87848 images and confirmed the superiority of deep learning models over other Machine Learning approaches (Nigam and Jain, 2019). Agricultural IoT apps play a major role in increasing agricultural production and decreasing crop losses due to diseases.

Modern AI methods are being applied to minimize herbicide application through proper and precise weed management. ML for weed detection can enable the development of tools and robots to destroy weeds, which minimizes the need for herbicides (Jain et al., 2021; Westwood et al., 2018). Specific algorithms can be trained to manage weed removal by Autonomous Weeding Robot systems via herbicide spray or mechanical procedures. With these high-performing algorithms UAVs can help with integrated weed management by identifying weed patches and lowering selection pressure against herbicide-resistant weeds and herbicide diffusion in the environment.

The integration of drones, artificial intelligence, and various sensors, which include hyperspectral, multi-spectral, and RGB (red-green-blue), ensure the possibility of a better outcome in managing weed problems (Bouguettaya et al., 2022).

3.4 Post-Harvest Management

3.4.1 Grading of Crop Output

A tremendous scope has arisen for grading the vegetables and fruits from farms, dispatch, and to consumers. More sophisticated robotic manipulator grading systems are needed for fruit and vegetables that are kept in piles and stock houses. Primarily based

on the optical characteristics at near Infra-Red levels sensors are preferred for the grading of fruits and vegetables. Sensors-assessed readings are utilized for algorithms and image processing. Advanced sensing technologies need to be addressed; some of these sensing systems are magnetic resonance, spectroscopy, chemical sensing, x-rays, wireless sensor networks (WSN), computer vision, mechanical contact, and radio-frequency identification sensors (Sharif et al., 2020). The sensors can be created based on various sensor types, designs, and constructions for ripeness monitoring of fruits and vegetables that reflects food quality in term of ripeness level, freshness, and consumer preferences, e.g., crunchiness, firmness, juiciness, aroma, etc., which are discussed with the addition of RFID and Nanosensors as the emerging technology in this field (Kuswandi et al., 2020). Non-destructive monitoring methods used in commercial applications include mechanical methods like impact, vibration analysis, and electronic nose; optical methods like visible/near-infrared spectroscopy, time and space resolved spectroscopy, and electronic eye; magnetic methods like magnetic resonance imaging and electrical conductivity method; acoustic methods like ultrasonics and impulse response method; and other dynamic methods like X-ray and CT scan (Bashir et al., 2020).

3.4.2 Packaging and Storage

On the other hand, active packaging maintains fruits in an appropriate condition by influencing the various physiological processes (respiration and transpiration), chemical processes (lipid oxidation), preventing insect infestation, and microbial spoilage. Active packaging methods include oxygen scavengers, ethylene scavengers, carbon dioxide emitters, humidity controllers, ethanol emitters, odour absorbers, and antimicrobial food packaging. In terms of storage, recommended CA storage conditions vary among fruits even for different species and cultivars of the same fruits. A new generation of edible coatings for climacteric and perishable fruits and vegetables is under development, with the aim of allowing the incorporation and/or controlled release of functional compounds using micro-level and Nano technological solutions such as Nano encapsulation and multi-layered coatings**,** thus enhancing their viability and stability (Bhardwaj et al., 2021).

3.4.3 Mobile Apps for Marketing and Transport

In India, there are enormous opportunities for utilizing smartphones as a part of agribusiness improvement. Its utilization is vital for quick growth and easy access to information for Indian agriculturists, farmers, and growers. National Agriculture Market (eNAM) promotes uniformity in agriculture marketing by streamlining procedures across the integrated markets,

removing information asymmetry between buyers and sellers, and promoting real-time price discovery based on actual demand and supply. It also promotes better marketing opportunities for farmers/sellers through online access to more buyers/markets, removal of information asymmetry between farmer and trader, better and real-time price discovery based on actual demand and supply of agri-commodities, transparency in an auction process, prices commensurate with the quality of produce, online payment, etc. that contribute to marketing efficiency. It helps in providing stable prices and the availability of quality products to consumers (Reddy, 2018). KISAN RATH Mobile App facilitates the farmers and traders across the country for transportation of agri-produce by connecting them with the transporters. The app interfaces with leading transport aggregators and individual transporters for providing a wide range of transport vehicles at the required date and place, quickly and easily (Shalendra et al., 2020).

4. Challenges and Opportunities for Implementation of Disruptive Technologies

4.1 Protection of the crop from weeds and pests

A large number of plants are affected by various pests and weeds. The pesticides applied to the plant check the growth of pests; however, it also harms the crop, the people consuming the crop as food, and also the environment. By early detection of the weed and pests' growing conditions, pesticide use can be reduced. AI and IoT-enabled models for plant protection need to be scaled up.

4.2 Monitoring the soil quality

The crop yield is very much dependent on the soil type and soil health. Models must be developed to find the soil nutrient content, soil texture, microbial growth and density, soil aridity, carbon and oxygen content in the soil, and soil pH value. Knowing these values will further help in finding other derived values like water retention capacity. It would also help in finding the best crop to be grown according to the resources available. Studying soil properties can further help in forecasting droughts and soil erosion. Analyzing the soil can also help in understanding the category and amount of fertilizers to be applied. IoT, ML, and Big data available for soil health can help the farmers in maintaining soil health, reducing the cost, and cultivating sustainable crops on respective farms.

4.3 Optimization of predictive models

Numerous researches have been conducted for building hybrid models by incorporating and assembling more than one machine learning. The simple models are efficient but can address

only one or two problems. There is a need to integrate multiple predictive models for easier management and adoption.

4.4 Supply chain management

The machine learning models can help identify the most demanded food items, supply and shortage, and the nearest area where it is available. This would help the consumer to buy things according to their needs. Also, a model must be built, that can show similar food items according to the customer's needs. This will not only help consumers and retailers but also farmers would be benefitted.

4.5 Reduction in drudgery

Different elements affected agriculture development; however, the most essential bottlenecks are lack of instant information and drudgery involved in farming practices.

Better awareness among farmers' groups may enhance the usages of Kisan Rath, e-NAM, timely supply of inputs at the doorstep, irrigation scheduling, and farm management using mobile apps. The states practicing diversified agriculture and even allied enterprises have more potential to transport the produce to distant markets using ICT.

4.6 Extension Strengthening

All farmers do not have access to agricultural extension services. Mobile apps have the potential to fill this gap. Poor use of application may be due to farmers having low ICT literacy leading to an inability to understand the full benefits of the service. IT infrastructure may also need strengthening as internet connectivity has been suggested as one of the major limiting factors. The unavailability of wireless, broadband coverage and energy in a rural area along with the high cost of these devices makes it harder for field implementation in developing countries.

4.7 Traceability using Blockchain

Block chain technology helps to improve organic or fair-trade food traceability from “Farm to Fork” in light of European regulations. Organic food supply chain companies aiming to improve food traceability via block chain face two key decisions - (1) optimizing chain partner collaboration and (2) the selection of which data to capture in the block chain. Other challenges were data confidentiality, validation of data inputs, and interoperability. Easy

verification of certification data, accountability, improved risk management, insight into trade transactions, simplified data collection and exchange, and improved communication account for the benefits. Block chain enables faster food traceability which in turn earns greater customer satisfaction

5 Conclusions

Smart farming is an upcoming concept that deploys disruptive technologies like the Internet of Things (IoT), computer vision, and artificial intelligence (AI) for farming. Robots and drones may replace traditional farm operations such as picking fruits, killing weeds, or spraying water or fertilizer on crops. Further, IoT devices, powered by sensor technology, collect real-time field data that allow farmers to make data-driven decisions. In addition, the widespread popularity and adoption of precision agriculture fuel IoT growth in farming. Machine learning models provide a great way to analyze the data collected on a large scale and help in acquiring the information gathered to generate a progressive and important process. These technologies are an ideal way to develop different profound models to introspect the relation between various factors and their influence. Hence, they can be used for multiple forecasts and predictions depending on the particular conditions. Smartphone penetration enhances the multi-dimensional positive impact on sustainable poverty reduction and identifies accessibility as the main challenge in harnessing the full potential in agricultural space.

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Chapter-2

Natural Resins and Gums Based Technological Intervention for Entrepreneurship Development in Semi-Arid Zone

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1. Natural Gums and Resins

Natural gums come out as exudates from the trunk of a gum producing tree as a response to injury. Gums are also extracted from seeds, seed coats, micro-organisms etc. They are generally insoluble in oils or organic solvents like alcohols, ether, hydrocarbons etc. However, they are soluble in water or at least become soft and swollen when mixed with water forming sticky substances. All the natural resins are of vegetable origin with the exception of lac and similar insect exudations which harden on exposure to air. They are insoluble in water but usually dissolve readily in alcohol, ether, carbon bi-sulphite and certain other solvents. Natural gum-resins, as the name implies, consist of natural mixtures of gums and resins in variable proportions and therefore partly soluble in water and have a penetrating and characteristics odour and taste. Certain gum-resins contain small amount of essential oil. They are called oleo gum-resins e.g. *Asafoetida*.

2. Classification

Natural resins, gums and gum-resin can be broadly grouped into five types, based on origin Table 1).

Table 1. Types of Natural resins, gums and gum-resins

Source	Location of the product	Examples
Seed	Derived from specific portions of the seed	Gums: Guar gum, tamarind gum, psyllium gum
Plant exudate	Derived from the exudates, due to injury, from trees and other plants	Gums: Gum arabic, gum karaya, gum ghatti, babul gum Resin: Rosin, dammar Gum-resins: guggul, salai, asafoetida
Sea weed	Derived from mostly cell-wall of the plant	Gums: Agar, alginic acid, carrageenans
Microorganism	Derived from bacterial fermentation; extracellular	Xanthan gum, gellan gum, pullalan
Insect	Derived from the secretions of lac insect (*Kerria* spp.)	Lac resin (shellac)

3. Production and Demand

Indonesia, India and China are amongst the World's major producers of gums and resins. India is traditionally largest producer of Lac, Guar gum and Karaya gum. In recent years, due to back to the nature trend there has been a revival of interest in natural resins and gums extracted from forests by rural and tribal people who depend on these resources to sustain their livelihood. Two-fold increase in demand is expected due to realization for eco-friendly and safe natural materials for human contact and consumption.

4. Role in National Economy and Livelihood Support

The gross value of goods and services provided by the forestry sector is estimated at an average of ₹26,330 crores i.e. about 2.37 % of GDP. Of this recorded forest revenue about 60% comes from minor forest products including gums and resins. The sector supports about 50 million population inhabiting forests and sub-forest areas and 70% of employment in the sector is in minor forest produce (about 1.6 million mandays). It is an admitted fact that neither the forests nor the tribals and poor inhabiting these should be removed for environmental protection. The only approach appears to be developing minor forest products like natural resins and gums based economic activities in these areas to uplift the poor and maintain required forest cover or vegetation. There is scope of developing gum tree based plantation or planting gum trees on field boundaries for enhancing gum production and providing livelihood option for farmers. The expected income from different gum tree plantations have been worked out and presented in Table 2. Similarly, expected income form planting gum trees on field boundaries calculated are presented in Table 3.

Table 2. Scope of raising plantation of natural gum producing tree and expected income

Natural gum producing trees	Spacing for plantation raising	No. of tree /ha	Expected gum yield(Average), kg/tree/season	Gum production /ha	Approx. assumed Price of gum, Rs./kg	Estimated Income from gum production, Rs./ha
Acacia senegal	5 x 5m	400	0.1-0.5(0.3)	120	400	48000
Acacia nilotica	5 x 5m	400	0.1-0.5(0.3)	120	300	36000
Anogeissus latifolia	10 x 10m	100	1.0-2.0(1.5)	150	300	45000
Sterculia urens	10 x 10m	100	0.5-4.5(2.5)	250	200	50000
Butea monosperma	5 x 5m	400	0.1-0.5(0.3)	120	150	18000
Buchanania Lanzan	6 x 6m	256	0.5-1.0(0.75)	192	150	28800

Table 3. Scope of raising natural gum producing tree on field boundary and expected income

Natural gum producing trees	Spacing for raising gum yielding tree on field boundary, m	No. of tree /ha*	Expected gum yield(Average), kg/tree/season	Gum production /ha	Approx. assumed Price of gum, Rs./kg	Estimated Income from gum production, Rs./ha
Acacia senegal	5	80	0.1-0.5(0.3)	24	400	9600
Acacia nilotica	5	80	0.1-0.5(0.3)	24	300	7200
Anogeissus latifolia	10	40	1.0-2.0(1.5)	60	300	18000
Sterculia urens	10	40	0.5-4.5(2.5)	100	200	20000
Butea monosperma	5	80	0.1-0.5(0.3)	24	150	3600
Buchanania Lanzan	6	64	0.5-1.0(0.75)	48	150	7200
**Assuming field is square in shape*						

5. Ecological Approach for Economic Development

Forests are not only important source of subsistence, employment, revenue earnings, raw material to a number of industries but also play pivotal role in ecological balance, environmental stability, bio-diversity conservation, food security and sustainable development. Extensive tree wealth exists outside continuous forested areas. Vegetation plays the most critical role in maintaining and regulating the living as also the non-living components of any eco-system. Besides this, there is revival of interest in natural resins and gums due to increasing recognition of their immense social, environmental and industrial development possibilities. For sustained economic development in and outside forest areas as also deserts and degraded lands, human intervention for plantations of economic value is essential. The interventions so far, largely focused on exploitation of these resources and plantations, if any, of less-economic value trees such as fast growing trees. Plantation of economic value is expected to ensure sustained development with stable environment.

6. Export and Import — India

Total export of natural resins, gums and gum-resins during the year 2019-20 was 2.81 lakh tons valued ₹3283.41 crores and total import was 1.03 lakh tons valued ₹1665.32 crores. Major export items are Lac, Guar, Karaya, *Asafoetida* and major import items are Rosins, gum-Arabic, *Asafoetida* and *Olibanum*.

7. Application Areas

Resins are largely used in surface coating formulations for several applications like wood furniture polishes/varnishes, paints, lacquers, food and pharmaceuticals, adhesives, insulations, cosmetics, handicrafts, jewellery etc. Some of the resins like lac are very good source of several bio-active compounds of various uses. The gums and gum-resins are mostly used in food (thickening/ gelling agents, stabilizers, emulsifiers), pharmaceuticals, cosmetics, textiles, chemical industries. In several application areas there are no substitutes for these natural products while in some, synthetic alternatives are available and used.

Lac based technologies for entrepreneurship development

Lac and lac based processes and products have immense potential for development of small and cottage industries for value addition. Some of the processes and products have potential for entrepreneurship specially in rural areas through development of cottage industries. The farmers/rural youth can be empowered with desired skill for making these products and running these lac based units. A little investment is required for establishing processing facilities and making products in terms of equipment, facility and skill. ICAR-IINRG, Ranchi has developed different types of process and product technologies for which, technologies are transferred through licensing or training programme depending on type of technology. Many technologies related to lac processing and products has been already commercialized in past and still in demand. Some new technologies have been recently developed. These different important commercializable technologies available at Institute for entrepreneurship are listed below.

Lac processing

- Small scale lac processing unit for seedlac
- Integrated small lac processing unit

Lac based process

- Process of making Dewaxed decolourised lac
- Process of making bleached lac
- Process of making aleuritic acid
- Recovery of lac dye
- Process of making isoambrettolide

Lac based products

- Fruit coating formulation for fruits & spices

- Lac dye based natural Alta
- Lac wood shine
- Non-spirit lac based wood varnish
- Lac Glaze
- Lac based Nail polish
- Aqueous Lac Varnishes for Earthenware and Bamboo based Articles
- Shellac based dental plates
- Shellac Gasket compound
- Shellac Emulsion paint for Internal Coating
- Air-drying and baking type insulating varnishes

8. Processing, Value Addition and Marketing—An Opportunity for Enhanced Income and Livelihood Support

Gums and resins are low volume, high value produce. These can be processed to add value in quality for higher returns. In some products value addition through primary processing alone results in 3 times higher returns. Developing products of commercial use would further augment returns, employment and export earnings. To achieve this an organized marketing support would be crucial. In India Lac and Guar gum are processed but for most of other resins and gums processing and value addition is meager.

9. Growth Perspective

Job led inclusive agricultural growth even in disadvantaged regions and situations is possible by ensuring much needed processing, value addition, diversified product development or applications and ensuring effective marketing through production to consumption value chain. Such a venture would help the primary producer as well to realize enhanced worth of his produce and hence trigger the growth further. Since gums and resins cannot be used fresh, primary processing and value addition are of paramount importance. There was a need to formalize the research mechanism and system to develop the sub-sector in right earnest to promote commerce in agriculture through its diversification besides augmenting climate moderation.

10. Research Support

Keeping in view the immense potential of these natural, non-toxic and bio-degradable products, the ICAR decided to include these as part of the regular research programmes at Indian Institute of Natural Resins and Gums, Ranchi. The Institute with new mandate undertakes research on various aspects of production, processing, product development and value addition of all plant resins, gums and gum-resins. The research is emphasized to enhance the quantity and quality as also on developing and standardizing techniques to increase the harvest of gums and resins, and their handling and storage. Identification and process development for the isolation of potential phytochemicals from gums and resins for use in nutraceuticals, functional foods and as an antioxidant are priority areas of reseach. In order to address the tapping and primary processing of region - specific gums and resins an outreach programme in a network mode was sanctioned during XIth Plan and is continuing. The efforts through research are likely to boost sustainable development in disadvantaged areas.

Indian Institute of Natural Resins and Gums, Ranchi is coordinating and networking research activities pertaining to Harvesting, Processing and Value Addition of Natural Resins, Gums and Gum-resins. The project activities focus research on Rosin (*Pinus roxburghii*), Guar Gum (*Cyamopsis tetragonoloba*), Karaya Gum (*Sterculia urens*), Gum Arabic (*Acacia senegal*), Guggul (*Commiphora mukul*), Tamarind (*Tamarindus indica*) seed gum, Dammar, *Pinus kesiya* resin and agroforestry models based on Resins and Gums. There are 10 centres including lead centre at IINRG, Ranchi.

Chapter-3

Potential of Custom Hiring Services of Farm Implements for Agri-entrepreneurship Development in Semi-arid Areas

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Introduction

The trend towards over-capitalisation in agriculture and the increasing cost of production are becoming the new challenges for competitive production. The basic requirement to meet this competition is to reduce the unit cost of production and maximize resource productivity which depends greatly on the availability and judicious use of mechanization means by the farmers. Custom Hiring of Agricultural Machinery is one of the best institutional innovations established in recent years as a panacea for all these problems. Pace of mechanization of agriculture in Madhya Pradesh has not been at par with the developed states like Punjab and Haryana. To increase the availability and adoption of agricultural machines and thereby increase the level of mechanization, 'Custom hiring model and skill development for improving farm mechanization level in Madhya Pradesh', in association with Directorate of Agricultural Engineering, Govt. of MP, was launched to help the farmers to raise the farm productivity through custom hiring of machines and introduction of improved farm machinery and equipment.

The Model

To ensure that the benefits of the mechanization aptly reach the farmers, it is vital to make appropriate machines accessible to the farmers along with professional services at affordable cost and time. One of the ways of doing so is creation of bank of high capacity – high efficiency machines along with suitable prime mover and then making them available to farmers with trained operator. Selection of machines vis-à-vis utility, demand, cost and market availability is vital and so is awareness about operation, adjustment, repair and maintenance for optimal performance of machinery. ICAR-CIAE, Bhopal already engaged in development of machines and protocols for different farming operations, besides a two pronged approach – developing skills in farm-machinery management and creating awareness of availability of machines across the country – was implemented in collaboration with Directorate of Agricultural Engineering, Govt. of MP.

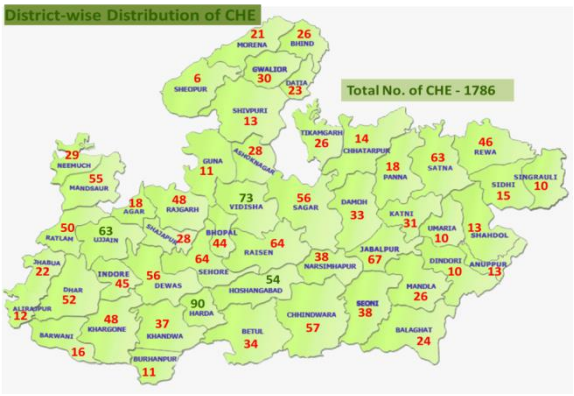
While implementing the custom hiring model and skill development for improving farm mechanization level in Madhya Pradesh, entrepreneurs were given one-two weeks training at CIAE, Bhopal by scientists and technical officers, who educated them about the usage and benefits of advanced agricultural techniques. These trainings were provided without any gender bias. The skill development programme included classroom field practical sessions (20 % classroom & 80 % practical) and exposure visits to other organizations. Each programme essentially included exposure to all the agricultural machines required for carrying out tillage operations, seedbed preparation, sowing-planting and transplanting, weeding & plant protection, harvesting, threshing, straw management and selected post-harvest operations, besides technically correct and safe operation of tractors and its maintenance. Thus a number of Technological Agents of Farm Machinery have been produced through this model.

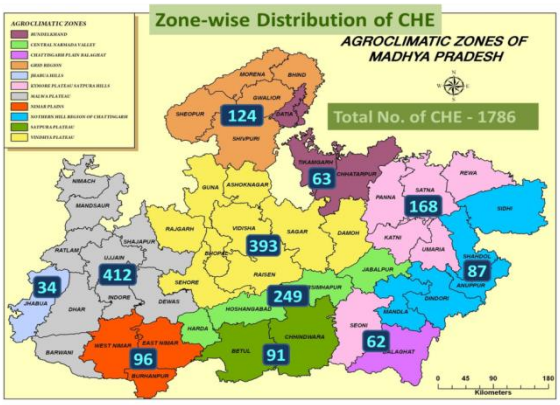
Scheme Details:

The scheme has been introduced for providing mechanization solutions to small farm holders who cannot afford to have their own machines, and that way to increase the mechanization of agriculture in the state. In order to ensure the availability of complete package of farm machines to the small farmers, the scheme has been introduced with certain **measures** as following:

- Eligibility: Persons below 40 years of age belonging to all categories. An applicant must be a graduate. (Preference to Agricultural Graduates).
- Custom hiring centres costing ₹10 - 25 lakh
- Subsidy - 40-50 percent subsidy upto to maximum ₹10 lakh. Subsidy only on loans obtained from banks. "Back Ended Subsidy“ (4-years lock-in period).
- Each unit should have at least one tractor, plough, rotavator, cultivator, disc harrow, seed-cum-fert drill and one thresher. Besides, selection of other suitable implements can be made on the basis of additional area and crops.
- Under the scheme tractors of 35 to 55 horsepower can be obtained.
- A centre will have to give tractor and agricultural implements on custom hiring for minimum ten years.
- Even if bank loan is repaid within this period, custom hiring services will have to be provided to farmers upto stipulated period. Sanctioned loan will be recovered in maximum 9 years.

During 2012-13 to 2016-17, 1786 enterprises have been established, out of which 55% (986 participants) were trained at ICAR-CIAE. The scenario of of these enterprises across the state has been as following:





Out of those participants who have established and running there custom hiring centres for more than a year (Sample size (110 No. entrepreneurs and 330 beneficiary farmers) were surveyed through personal visit. The data collected from various custom hiring enterprises and famers broadly include the financial details of the enterprise, machines owned, crops and operations for which custom hiring services being offered, custom hiring rates etc. and feedback, future requirements and constraints faced by entrepreneurs and farmers both.

Few meaningful observations have been highlighted as following:

Availability of Machinery through Custom Hiring Entrepreneurs

All custom hiring entrepreneurs are providing the general purpose farm machines to the small farmers and the machines available on rental basis contains complete package to serve the need of various field operations from Tillage to Threshing, as following:

Tillage: Reversible MB Plough, Rotavator, Cultivator

Sowing: Seed Drill, Seed-cum-Fertilizer Drill,

Intercultural: Narrow Tyre Tractors & Small Tractors

Plant Protection: High Capacity Boom Sprayers

Harvesting: Reaper and Reaper Binder

Threshing: High Capacity Thresher

Straw management: Straw Reaper

Few custom hiring entrepreneurs are providing special purpose farm machines also to the small farmers on rental basis, as following:

- **Front Dozer , Zero-till Drill, Rice Transplanter, Garlic Planter, Disk Harrow**
- **Raised-Bed Planter, Potato-Planter, Sugarcane cutter planter**

Rates of custom hiring

The rental charges of various agricultural machines have been found to be slightly varying depending on the area and demand during the season. The average custom hiring charges have been recorded as following:

Name of the equipment	Average Rate for CH (Rs./h)	Name of the equipment	Average Rate for CH (Rs./h)
Rev. MB Plough	677	Front dozer	683
Rotavator	775	Reaper Binder	1163 with rope
Cultivator	600	Straw Reaper	1252 per tank
SD/SFD/ZTD	611	Combine Harvester	1500 – 1800 per acre
Thresher	775	Spray Pump	500/h
Trolley	15-50 per km	Laser Leveller	900/h

Overall Business-Service Scenario of Custom Hiring Centres

Data from Custom hiring service centres was also collected for profitability and the services they are providing in terms of area coverage and number of families being served, which has been summarized as following:

Particulars	Annual Profit (₹Lakh)	No. of Families Served	Area Covered-Annual (ha)
Average	2.50	103	153.2
Min.*	0.40	6	20.0
Max.	7.00	400	414.0

*** Exceptional cases.**

Constraints faced by Entrepreneurs

During survey, opinion of the entrepreneurs was also collected for the constraints being faced by them. The analysis of the same is as following:

i. **Availability of Repair-Maintenance facility:** 65.5% told that adequate repair and maintenance facility was available in their area for the machines available with them. While,

33.6% showed concern about timely availability of the facility even when adequate Repair-Maintenance facilities are available within the vicinity.

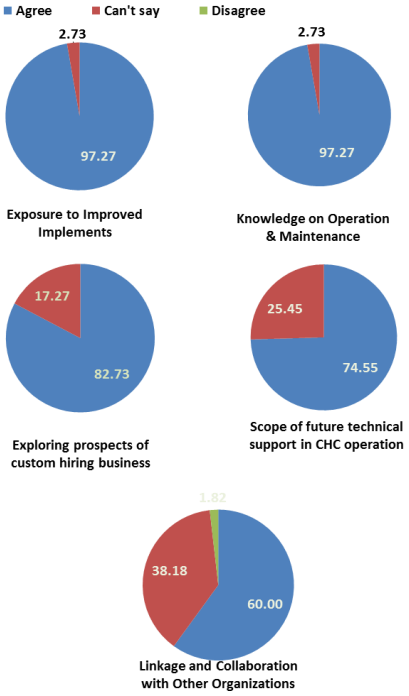
ii. Delay in Payment: This has been observed as the biggest constraint, as almost 90% entrepreneurs told that they worked on credit basis and sometimes they received the payment from season to season. Only 10.9% didn't have any problem related to payments from the farmers.

iii**. Availability of Driver/Operator:** Approx. 28% entrepreneurs are facing problem in availability of experienced operator. 72% didn't face any problem at all in this matter.

Benefits of Training at ICAR-CIAE, as perceived by Entrepreneurs

The entrepreneurs trained at CIAE also shared their opinion about the way they have been benefited with training at ICAR-CIAE.

- 97% of the custom hiring entrepreneurs said that they got wide exposure to advanced agricultural machinery during the training at ICAR-CIAE which has been immensely helpful to them in selection of quality machines for their enterprise and also for future planning and expansion.
- As far as knowledge on optimal operation and maintenance of machinery is concerned, 97% said that because of the practical knowledge and tips they got during the training, they have been able to minimize the operational expenses.
- 82 % of the entrepreneurs also agreed that they learned about the further prospects in the field of custom hiring so as to maximize the annual use of machinery being owned by them and increase the profitability.
- 75 % of the entrepreneurs are willing to receive support and guidance from ICAR-CIAE, in future too on technical aspects.
- 60 % of the entrepreneurs realized that the training at ICAR-CIAE has also been helpful for them in developing linkages and collaboration.



Benefits to Farmers

Besides survey of entrepreneurs, the associated/client farmers, who have been availing the custom hiring services form the entrepreneurs were also surveyed for the benefits realized

from them. A total of 330 farmers (3-4 farmers associated with each entrepreneur) were interviewed and it was observed that the small farmers have been getting the machines for various operations timely from these entrepreneurs, which has precisely been the objective of the scheme i.e. to ensure the availability of complete package of farm machines to the small farmers. 32% of the farmers availing the facility are those who have a loan holding of 1-2 ha only. Land holding wise distribution of farmers availing custom hiring services is tabulated as following:

Land holding wise Client Farmers	
Marginal (< 1 ha)	10.8 %
Small (1-2 ha)	21.0 %
Semi-medium (2-4 ha)	26.9 %
Medium (4 - 10 ha)	28.7 %
Large (> 10 ha)	12.6 %

Client Farmers' Opinion about benefits: The opinion of farmers was collected about the following:

- Increase in Production
- Saving in Input
- Saving in Time
- Reduction in Losses
- Reduction in Cost of Production

Data collected from client farmers during survey have been analysed and tabulated as following:

Values (%)	Production	Losses	Input	Time	Cost
AVG	26.1	21.1	28.4	51.0	33.2
Max	40.0	50.0	60.0	80.0	50.0
Min	10.0	0.0	5.0	15.0	15.0

Due to increased mechanization level and easy availability of improved machinery through custom hiring entrepreneurship, even small farmers are now getting encouraged to replace their traditional and time consuming farming practices with improved and mechanized protocols.

Comparison of farming practices before and after introduction of Custom Hiring Facility

Due to increased mechanization level and easy availability of improved machinery through custom hiring entrepreneurship, even small farmers are now getting encouraged to replace their traditional and time consuming farming practices with improved and mechanized protocols. The table below gives a snapshot of change in various farming practices before and after increase in the mechanization level:

Farming/ Agricultural Operation	Old Practice	New Practice
Ploughing and seedbed preparation	B/D ploughs and T/D cultivators were used. It ploughs the land to shallow depth only did not pulverize and invert the soil that well. The land retained less water & land was not flattened after sowing.	T/D reversible MB ploughs and rotavators are used for ploughing and seedbed preparation, which ploughs the land deep, mixes the soil better, allowing it to retain more water and give smooth and flattened seedbed facilitating higher germination.
Seed grading	Infected or spoilt seeds were not separated and sown along with Good quality seeds.	Seeds are properly separated using graders and only good quality seeds are used for sowing.
Seed treatment	Treatment of seeds and mixing with fertilizers were done by hands.	Seed treatment drums are used for chemical treatment and proper mixing of seeds with fertilizer.
Sowing	Manual broadcasting of seed and fertilizer or B/D, T/D seed drills (with fertilizer mixed) were used.	Sowing is done using seed cum fertilizer drill, allowing separate placement of seed and fertilizer. Modern techniques like raised bed planting & ridge-furrow sowing are also used.
Weeding & interculture	Manual weeding with hand held khurpi or chemical weeding with shoulder mounted sprayer, which is highly time consuming because of very low field capacity.	Chemical weeding is done using Tractor mounted sprayer pumps which gives very high field capacity. Small tractors (15-20 hp) having narrow tyres are used for mechanical weeding.
Harvesting	Manual harvesting. Highly labour intensive, time and cost consuming.	Self-propelled reapers and reaper-binders cuts and bundles crops. It saves time and there is less wastage.

Farming/ Agricultural Operation	Old Practice	New Practice
Threshing	Manual threshing devices and Small power threshers. Much dependency on availability of electricity and weather uncertainty too. Also labour intensive, time and cost consuming.	Tractor drawn Mechanized multi crop threshers are used. It reduces time and cost and also reduces dependency on availability of electricity and weather uncertainty is also minimized with timeliness in threshing operation. Accidents have also reduced due to use of safe and automatic feeding type threshers.
Straw management	Crop/Straw stubbles were burnt to prepare the field for subsequent crops and operations	Straw is fully recovered from the field using straw reapers which fetches extra income to the farmers. Instead of burning, crop stubbles, it is buried well into the soil using rotavator, which improves the soil health

B/D – Bullock drawn; T/D – Tractor Drawn

Outcome

Until so far, the growth of these custom hiring centres has not only contributed in increasing farm productivity but also in improving rural employment generation. It is raising the self-esteem of the youths associated with it and discouraging the rural migration as well. On the basis of a survey of farmers hiring various machines, major impact of "Custom Hiring Entrepreneurship Development" scheme on farmers and farming practices in Madhya Pradesh are as following:

- Increase in average productivity of major crops
- Increased availability of improved agricultural machines.
- Easy availability of machinery at affordable rates, especially to small and marginal farmers unable to own machine(s).
- Increase in cropping intensity.
- Increase (25-35 %) in overall production due to high productivity and higher cropping intensity, as reported by farmers.
- Timely completion of operations, thus reducing losses.
- Saving in costly inputs.
- Saving in time.
- Reduced cost of cultivation (25-45% as reported by farmers)
- Empowerment of the farming community.

Major Crops for which Custom Hiring Services Utilized	Average Yield of crop before intervention (kg/ha)#	Average yield / Expected yield after intervention (kg/ha)#
Soybean Wheat Gram Paddy Pulses & Lentil*	Soybean – 1450 Wheat – 2800 Gram – 1110 Paddy – 1950 Lentil – 620	Soybean – 2580 Wheat – 4600 Gram – 2025 Paddy – 3500 Lentil – 1460
*Contributed to significant increase in **Cropping Intensity** as Pulses family crops (Black gram, Green Gram etc.) are being taken as **Third Crop** in Many areas, which could become possible only because of ***Increase in Mechanization Level.***		

 # Source: Data made available by Directorate of Ag. Engg., Govt. of MP

Suggested Strategic Interventions for further Improvement of Scheme

- New Custom hiring centres be opened in areas, having less number of CH centres.
- Income slab and land limit ceiling be introduced to extend the benefit to real needy and to fulfil the scheme objectives.
- Technical scrutiny of Tractor & Implement combination and approval by a competent committee, involving Scientists from CIAE, before sanction.
- Training be conducted before preparing and submitting the project proposal to the bank for financing.
- Uniform Interest rates, repayment plan and other Terms & Conditions across various banks.
- Project proposals with min 80% investment only be considered, so as to ensure availability of complete package of agricultural machinery.
- Preference be given to those residing in rural area.
- The improved prototypes developed by ICAR Institutes and SAUs, despite being efficient in performance, have not become common among the farmers. Few improved farm equipment which have done well in the field may be included in the list of options in the future.

Case Study-1

Shri Anil Pratap Singh is a resident of village Semariya of Rewa district. His family owns about 2 ha land in Rewa district. To augment his net income, he became interested in custom hiring business of agricultural machinery in his village and received training from ICAR-CIAE, Bhopal after enrolling in entrepreneurship development programme of Directorate of Agricultural Engineering, Government of M.P. which is funded by Department of Agriculture, Cooperation and Farmers' Welfare, Government of India.

After successfully completing the training, he established his custom hiring business centre at Semariya village naming it as 'Shiv Mahima Custom Hiring Centre', with an investment of ₹21.00 lakhs in March 2014. His venture was financed by Allahabad Bank, Rewa. In the beginning, he bought two tractors (48 and 55 hp) along with one reversible MB plough (2 bottom), front dozer (width 8 feet), two rotavators (1.8 and 2 m) two cultivators (both 11 tynes), seed-cum-fertilizer drill (11 rows), and tractor operated paddy thresher. He already had one 35 hp tractor, one 11-rows zero till drill and one self-propelled walk behind reaper under his possession. Gradually, he expanded his business by purchasing raised bed maker-cum-seeder (6 rows on 3 beds), self-propelled walk-behind type paddy transplanter (4 rows) and straw reaper.

With his entrepreneurial skill, zeal to adopt new technology and wide range of farm machinery inventory, he specialized in complete mechanization of paddy-wheat cropping system for the farmers in his area and also promoting raised bed cultivation for kharif crops. He rents out these machines to many farmers of his village and also surrounding villages of Rewa block for cultivation of field crops like paddy, soybean, wheat, and chickpea. He generated gross revenue of around 11 lakhs with a net profit of about ₹5.00 lakhs in 2015-16. With technical guidance from CIAE scientists, He is also planning to procure LASER guided land leveller to offer the complete mechanization package starting from land preparation and levelling to residue management to his clients for paddy-wheat cropping system.

Case Study-2

M/s Renu Tomar D/o Shri Shakti Singh Tomar is a resident of village Sayar, block Vidisha of Vidisha district. After completion of her post-graduation in chemistry, she became interested in custom hiring business of agricultural machinery in her village and enrolled in entrepreneurship development programme. She received training from CIAE, Bhopal in January 2013. After successfully completing the training, she established her custom hiring

business centre in April 2013 naming it as ‘Renu Custom Hiring Centre’, with an investment of ₹18.00 lakhs out of which ₹9.0 lakhs was given to her as subsidy from Government. In the beginning, she bought a tractor of 55 hp along with one reversible MB plough (2 bottoms), front dozer blade (6 feet), rotavator (1.2 m) cultivator (7 tynes), seed drill (11 rows), multi-crop thresher (25 hp), straw reaper, spray pump (700 l) and trolley (2 wheels).

With active help from her father Mr. Shakti Singh Tomar in running day-to-day business of the custom hiring centre, she rented out these machines to many farmers for 1030 hours in 2013-14 and 1320 hours in 2014-15 hrs of his village and also surrounding villages for cultivation of field crops like soybean, wheat, gram as well as vegetable crops. The custom hiring centre generated an annual net profit of about ₹5.00 lakhs in 2013-14 and ₹7.87 lakhs in 2014-15. Gradually, a few more machines were added to her inventory like bhusa shifting pump, winnower, spiral grader etc. with the surplus profit made from custom hiring centre and two small tractors of 15 & 18 hp for horticultural works with 50% subsidy provided by Department of Horticulture, Government of Madhya Pradesh.

Case Study-3

Shri Anil Pratap Singh is a resident of village Semariya of Rewa district. His family owns about 2 ha land in Betul district. To augment his net income, he became interested in custom hiring business of agricultural machinery in his village and received training from ICAR-CIAE, Bhopal in August 2013. After successfully completing the training, he established his custom hiring business centre at Bajpur Chakora village naming it as 'Devendra Rathore Custom Hiring Centre', with an investment of ₹18.00 lakhs in December 2013. In the beginning, he bought one tractor of 60 hp along with one reversible MB plough (2 bottom), front dozer, rotavator (2.1 m) cultivator (9 tynes), seed-cum-fertilizer drill (13 rows), raised bed maker-cum-seeder (4 rows – 2 beds), multi-crop hadamba thresher (35 hp), sugarcane cutter planter (2 rows) and hydraulic trolley (4 wheel). With his entrepreneurial skill and zeal to adopt new technology, he procured the sugarcane cutter planter from Shahabad in Haryana for providing service to sugarcane farmers in his area and also promoting raised bed cultivation for kharif crops.

He rents out these machines to many farmers of his village and also surrounding villages of Betul block for cultivation of field crops like soybean, wheat, maize, chickpea and sugarcane. He generated income of around 6.5 lakhs in a year with a net profit of about ₹3.00 lakhs. With technical guidance from CIAE scientists, He is planning to add two more machines in his inventory in near future namely, reaper-cum-binder and sugarcane bud chipping machine for growing sugarcane settlings in portray to further diversify the business of his custom hiring centre.

Case Study-4

Shri Rahul Dhoot is a resident of village Berkheda Hassan, tehsil Shyampur of Sehore district. He owns only 1.25 ha land. To augment his net income, he became interested in custom hiring business of agricultural machinery in his village and received training from CIAE, Bhopal in January 2014. After successfully completing the training, he established his custom hiring business centre in April 2014 naming it as 'Balaji Custom Hiring Centre', with an investment of ₹21.50 lakhs. In the beginning, ha bought two tractors of 50 & 55 hp along with one reversible MB plough (2 bottom), front dozer, rotavator (1.8 m) cultivator (9 tynes), seed drill (11 rows), multi-crop *hadamba* thresher (35 hp), straw reaper (56") and trolley (2 wheel).

With active help from his father and elder brother in running day-to-day business of the custom hiring centre, he rented out these machines to around 100 farmers for about 1100 hrs of his village and also surrounding villages for cultivation of field crops like soybean, wheat, chickpea as well as vegetables like onion, garlic, chilli etc. He generated income of around 8.0 lakhs in a year with a net profit of about ₹2.50 lakhs. He added two more machines in his inventory in April 2015 namely combine harvester and *bhusa* shifting pump with the surplus profit made from custom hiring centre.

Chapter-4

Agro-voltaic system: Suitability for Rain-fed Farming

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1. Introduction

Two key resources for the development of human civilization are food and energy, and their demand is increasing day by day. With the advancement of the food production system from agrarian to a futuristic technology-driven system, there has been a rapid increase in energy use in agriculture. The rise in energy use has adverse effects on climate due to the burning of fast depleting fossil fuels and thus emitting greenhouse gasses. In this context, we need to harness and use more renewable energy, especially solar energy, which is plentiful in most of the country. PV-based electricity generation has been encouraged due to its high modularity, no need for movability, and low maintenance cost. India has been rapidly increasing solar power generation capacity over the last decade, partially to mitigate the impacts of climate change but more importantly to participate in the global energy transition to prepare its energy systems for the future. As a result, India registered the second-highest growth in the renewable energy sector after China. India's power generation from renewable energy sources (10.3 billion units) is 9.11% of total power generation (113.2 billion units). Among renewable sources, solar power accounts for 36.3%.

The Govt. of India has set an ambitious target of achieving 175GW of solar photovoltaic (PV) based power generation capacity in the country and doubling the farmer's income by the year 2022, which has been further revised with 450 GW by 2030. It has been envisaged that following these targets, about 40% and 60% of India's total electric power generation capacity will be met from renewable sources by 2022 and 2030, respectively. Further, the Govt of India has committed to a 100% renewable power system target by 2050 and a net-zero carbon emission target by 2070, declared at COP 26 climate meeting in Glasgow in November 2021. In India, the availability of solar radiation is around 3-6 kW h m^{-2} day^{-1}, making them one of the potential contributors to energy generation from photovoltaic (PV) technologies. On the other hand, the hot arid region of India is blessed with abundant solar resource availability and clear sunny weather for more than 300 days a year. For example, the annual average availability of solar irradiation in arid western Rajasthan is about 5.6-6.0 kW h m^{-2} day^{-1}.

The concept of integrating food production and energy generation through an agri-voltaic system has recently evolved due to ever-increasing land resource demands. Both food production and PV-based renewable energy generation need solar irradiation. Food production occurs by converting solar energy to food through a photosynthetic process with an efficiency of ~3%. In contrast, PV-based energy generation occurs through the conversion of solar energy to electric energy through a photovoltaic process with an efficiency of ~15%. Both these processes require land as a basic natural resource. Therefore, it is thought of producing both simultaneously from a single land unit through an agri-voltaic system. Agriculture sector has great scope in meeting this renewable energy target of the country through two major ways. First is replacing fossil fuel-based farm operations with renewable energy sources. Second is the contribution of renewable energy generation from the agriculture sector. The first approach includes replacing diesel-operated or grid-tied electric pumps with solar photovoltaic (PV) pumping systems, use of solar devices for processing and value addition of foods, increasing the use of solar PV-driven tools and implements etc. The second approach is contributing to renewable energy generation, which may be achieved through the cogeneration of food and energy using an agri-voltaic system.

Agri-voltaic system, which is an integration of PV generation and crop production, has the potential to achieve the above said two targets by 2030. Installation of solar power plants requires about 2 ha MW^{-1}; however, due to ever-increasing pressure on land requirements, there is a need for their optimum and judicious use by integrating cropping practices with the erection of PV arrays. Moreover, the problems of dust deposition on solar panels require regular washing with water, which is again a scarce resource in the arid region. In addition, extending electric grids in isolated hamlets and farm fields is not economical and poses practical problems. In view of these identified problems, the concept of integrating solar power generation and agricultural farming for both grid-connected and off-grid electricity generation may be introduced into the agri-voltaic system.

There are several ecosystems benefits of installing AVS in a farmers field and these are (i) increase in land equivalent ration, (ii) reduction in dust load of the top of PV panel and thus reduces the cleaning operation for optimum PV generation, (iii) improves soil moisture regime at interspace and below panel area of ABS systems, (iv) improves microclimate (temperature, humidity, etc) surrounding the AVS environment and thus helps to maintain/improve the performance ratio (PR) factor of PV generation, (v) reduces carbon footprint at a rate of about 498 t ha^{-1} y^{-1}, (vi) reduces erosion of soil due to wind and water action etc.

2. Design of agri-voltaic system

2.1 PV Module Installation

Installation of solar power plants of 1 MW capacity requires about 2 ha of area. Design parameters for erecting solar panels in AVS are slightly different from that in a conventional solar power plant. At ICAR-CAZRI, Jodhpur, India an AV systems of 105 kW capacity has been established with three experimental designs in three separate blocks. The size of the experimental farm was 68 m × 68 m and the size of each block is 28 m × 28 m (Fig. 1). PV modules were arranged in the East-West direction and inclined southward with a tilt angle of 26^{o}. To avoid shade effect on the PV panel on the leeward side an inter-row spacing of 3.2, 6.4 and 9.6 m was maintained in one, two and three-row PV array, respectively in the North-South direction (Fig. 2). In all these blocks, two different designs were followed: few arrays with gap in between PV modules and few arrays covered fully with PV module which allows receiving different amount of intercepted solar irradiation on ground surface, which is required for crop cultivation in between PV arrays and also below PV panel areas. The shading from the PV module varied according to the time of year and height of the crops planted between the module rows. This AVS system was established with five designs in three separate blocks. The AVS system consisted of five designs and these are: AVS (i) AVS-1 having one row PV array with 100% PV density, (ii) AVS-2 having one row PV array with 50% PV density, (iii) AVS-3 having double row PV array with 100% PV density at bottom row and 60% density at top row (iv) AVS-4 having triple row PV array with 100% PV density at bottom two rows and 60% PV density at top row and (v) AVS-5 having triple row PV array with 100% PV density at bottom row and 60% PV density at top two rows. Different PV density in arrays were designed to allow photosynthetic photon flux density (PPFD) in interspace of PV installation area, which is essential for crop production.

2.2 Crop production in agri-voltaic system

In the present AV system, the PV modules created shade on ground surface on leeward side as per the movement of sun. To avoid the shade of one PV array on the next array, a separation distance between two arrays is maintained. This interspaced area between two PV arrays was utilized to grow suitable crops. Moreover, area below the PV module was also used to grow crops since PV modules are fixed over mounting structures at a certain height from ground surface. However, growing crops in between the arrays of PV modules

requires selection of suitable crops that have certain degree of shade tolerance and are shorter in height to avoid shade on PV panels.

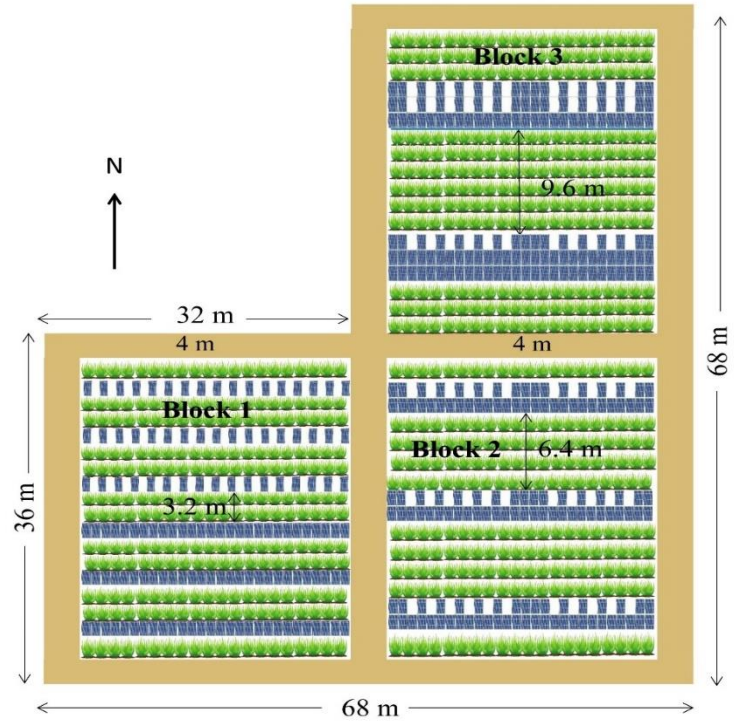

Fig. 1. Schematic design of PV module installations for AVS

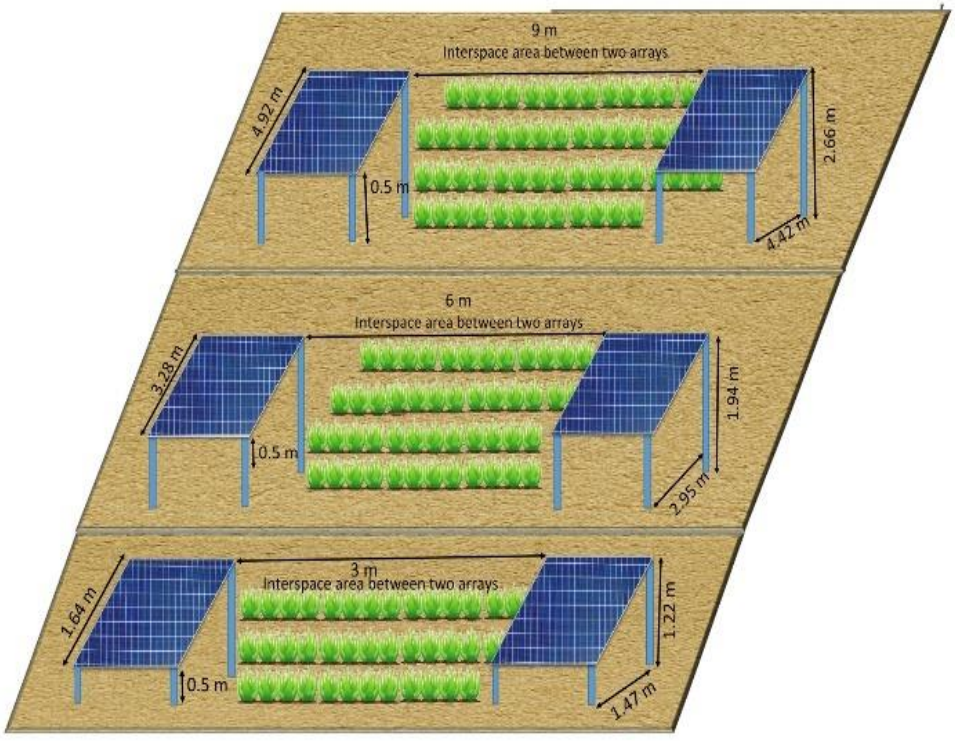

Fig. 2. The installed agri-voltaic system at ICAR-CAZRI, Jodhpur, India

The shaded portion at interspaces area varies from morning to evening as per the zenith angle and azimuth angle of Sun's position. The available amount of solar irradiation both under direct (open sun) and diffused conditions govern plant growth because the amount of photosynthetically active radiation (PAR) is different under both these conditions. The height of crops is a key parameter for selection of crops for AVS because high crops may create shade on PV modules and thus reduce the PV generation. Therefore, crops with low height (preferably shorter than 50 cm) which can tolerate certain degree of shade and require less amount of water are most suitable for AVS in an arid ecosystem. Following crops are chosen to grow in agri-voltaic system. Under rainfed situation, moong bean (*Vigna radiata*), moth bean (*Vigna aconitifolia*), and cluster bean (*Cyamopsis tetragonoloba*) have been selected as arable crop, whereas under irrigated situation during *Rabi* season isabgol (*Plantago ovata*), cumin (*Cuminum cyminum*) and chickpea (*Cicer arietinum*) have been selected. Apart from these arable crops, medicinal plant, e.g. *Aloe vera* and *Solanum melongena* (brinjal) have been selected as perennial *Spinacia oleracea* (spinach) and snapmelon (*Cucumis melo* L. Momordica group) as vegetables crop as annual components. For cultivation in areas below PV modules, aromatic grasses viz. *Cymbopogan citrates* (lemon grass) and *Cymbopogan martini* (palmarosa) have been selected. These crops are expected to modify the microclimates below PV modules and thus help in optimum PV generation in arid ecosystem. Moreover, the coverage of crops on soil surface in between PV arrays will also check the erosion of soil by wind action and thus will reduce the dust load on PV module. A field view of different *kharif* and *rabi* crops grown in the AVS is shown in Fig. 3-5.

2.3 PV based electricity generation from agri-voltaic system

Solar PV generation and solar irradiation has been regularly monitored through SCADA (Supervisory Control and Data Acquisition) facility and automatic weather station. The installed AVS has been connected to local electricity grid through net metering system. Therefore, the generated electricity is directly sold to state electricity board at a fixed tariff which varies across different states of India. The average tariff rate of Rs 5 per kWh may be considered to calculate the income from PV-generated electricity. The schematic diagram of the PV based electricity generation from the installed AVS and its supply to grid is depicted in Fig. 6. At Jodhpur, India effective solar irradiation to generate electricity is available for an average of 4–5 h in a day. Therefore, 1 kW PV system is expected to generate 4–5 kWh unit of electricity per day. Thus, 100 kW AVS in Jodhpur will generate at least 400 kWh unit of

electricity in a clear sunny day. During the year 2021, month wise, highest PV generation was observed during April 2021 (Fig. 7).

Fig. 3. Installed agri-voltaic system at ICAR-CAZRI, Jodhpur, India

Fig. 4. Field view of different *Kharif* and *Rabi* crops grown in AV system during 2019-20

Fig. 5. Field view of different vegetables and aromatic grasses in AV system

Average PV generation from the 100 kW_p agri-voltaic system attached to the grid through a bi-directional energy meter or net meter has been about 342 kWh day^{-1}. As a result, the annual power output generated by the AV system was 1,24,823 kWh, and the total revenue generated was ₹6,24,115 during the year 2021.

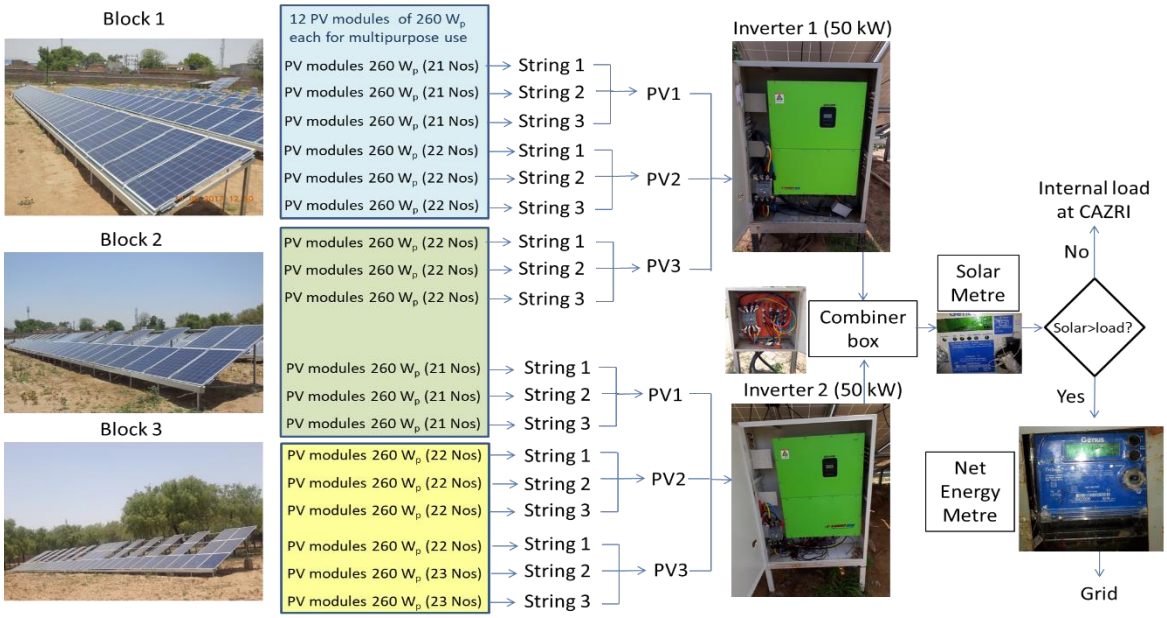

Fig. 6. Schematic diagram of PV based electricity generation in AVS and its supply to local grid.

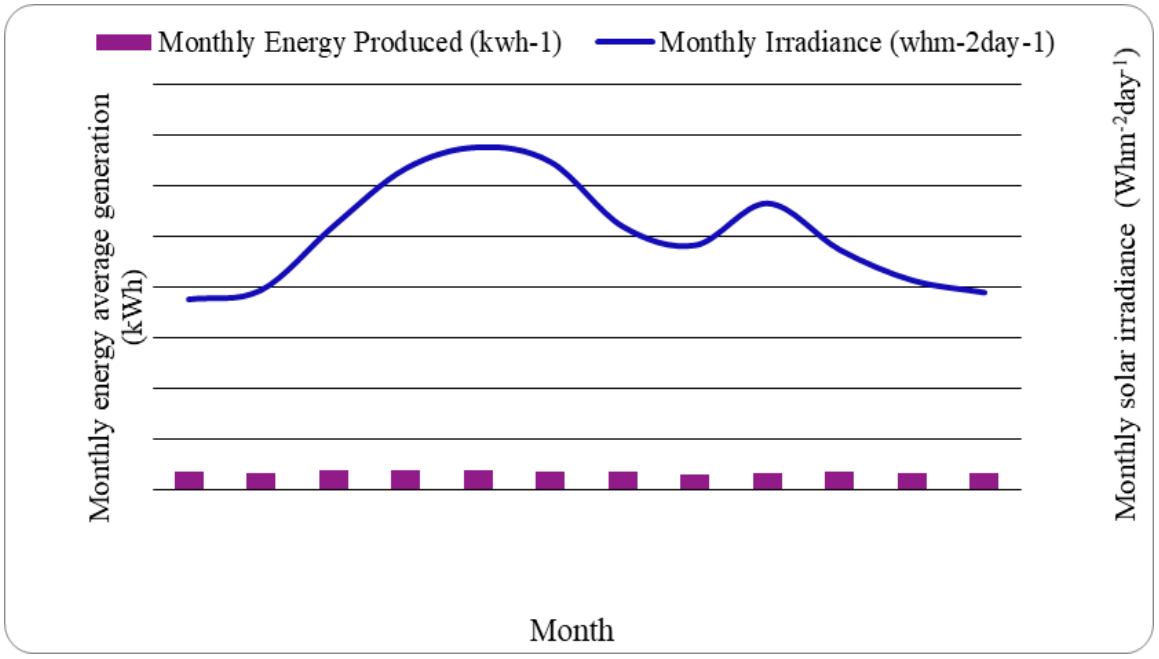

Fig. 7. Solar PV generation and solar radiation in different months during the year 2021

2.4 Rainwater harvesting system in agri-voltaic system

For optimum PV generation, regular cleaning of deposited dust from PV module surface is essential and requires about 20-40 litre month^{-1} kW^{-1} of water. The rainwater harvesting system from top surface of PV modules in agri-photovoltaic system can provide water for cleaning purpose and to recycle it. Apart from cleaning, harvested rainwater may provide irrigation of about 40 mm during rabi season. Potential capacity of harvested rainwater from agri-voltaic system covering 1 ha area is about 3.75-4 lakh litre at Jodhpur. It is possible to collect and store rain water from the top surface of PV modules in AVS. Therefore, in this AVS rainwater harvesting system was also designed and developed by rectangular MS sheet as water collection channels (Fig. 8), underground water conveying PVC pipes of 4″diameter and an underground water storage tank of 1 lakh litre capacity. Surface area of a solar PV module of 260 W capacity is 1.64 m × 0.992 m. Thus, total surface area of 105 kW capacity agri-voltaic system is about 651 m. The total quantity of water received as rain cannot be harvested from PV module surface because of splash loss, evaporation loss, etc. Therefore, a factor of 0.8 may be considered to estimate the total harvested water from rainfall amount. Again, 10% conveyance loss of the collected water to rainwater storage reservoir needs to be considered. Therefore, about 72% of annual rainfall is expected to be collected in water reservoir. Thus, about 180,000 litre of water can be harvested from 105 kW agri-voltaic system. Field observations revealed that solar PV top

area harvested 93.3 m^3 of water against a rainfall of about 221.2 mm during the period from June 1- 31 July 2019 with an efficiency of 65.8%. Hence in arid region with severe challenge of water scarcity for agriculture, the agri-voltaic system is a feasible and sustainable option for meeting both food and energy demand in future.

Fig. 8. Rain water harvesting system from top surface of PV module

2.5 Environmental parameters monitoring

The performance of PV systems is highly affected by internal and external factors such as the structural features, aging, radiation, shading, temperature, wind, dust load on PV plates. Any type of climatic change causes changes in the solar radiations and in the ambient temperature, hence causing changes in the solar PV output performance. The J-type thermocouple with 32 channel data logger was used to measure ambient temperature and PV module temperature at 10 minute interval. Different types of probes were set in the shade of panel at full and half density treatment, bottom of panel as well as soil temperature at different depth of the panel. During daytime, micro-climatic parameters viz. net radiation (NR) and photo synthetically active radiation (PAR) were measured in shaded areas under solar PV modules and at open sun condition in the AVS. Both NR and PAR were measured at one-hour interval from morning to evening during clear days. The NR was measured by net radiometer at crop canopy during peak summer and winter season, whereas PAR was measured by line quantum sensor at crop canopy. Deposition of dust has also a negative role on solar PV generation since it reduces the transparency of the top glass surface of solar PV

module. Cleaning of PV modules is, therefore, a regular management practice to get optimum PV generation. Dust deposition of solar PV module was measured during cleaning operation in each block.

The ambient temperature varied from 2.7°C to 48.6°C. Air temperatures increase sharply from March onward and stand highest during June till pre-monsoon showers set in the area. The temperature of shade of PV panel areas vary between 3.0°C to 49.6°C with peak values as high as 50°C in June 2020. During summer days, average temperature of PV module reached up to 60-65°C whereas during winter season it reached up to 40-45°C with peak values 71°C during June 2020. It has been observed that PV module temperature was always about 15-20°C higher than ambient temperature during day time and thus reduces the solar PV generation. It is to be noted here that solar PV module performs optimally at 25°C and each degree increase in temperature from this optimum value decreases the voltage output and hence negatively affect the PV generation. Diurnal variation in temperature of PV module, shade of PV panel areas and ambient temperature during a typical summer day and winter day is shown in Fig. 9.

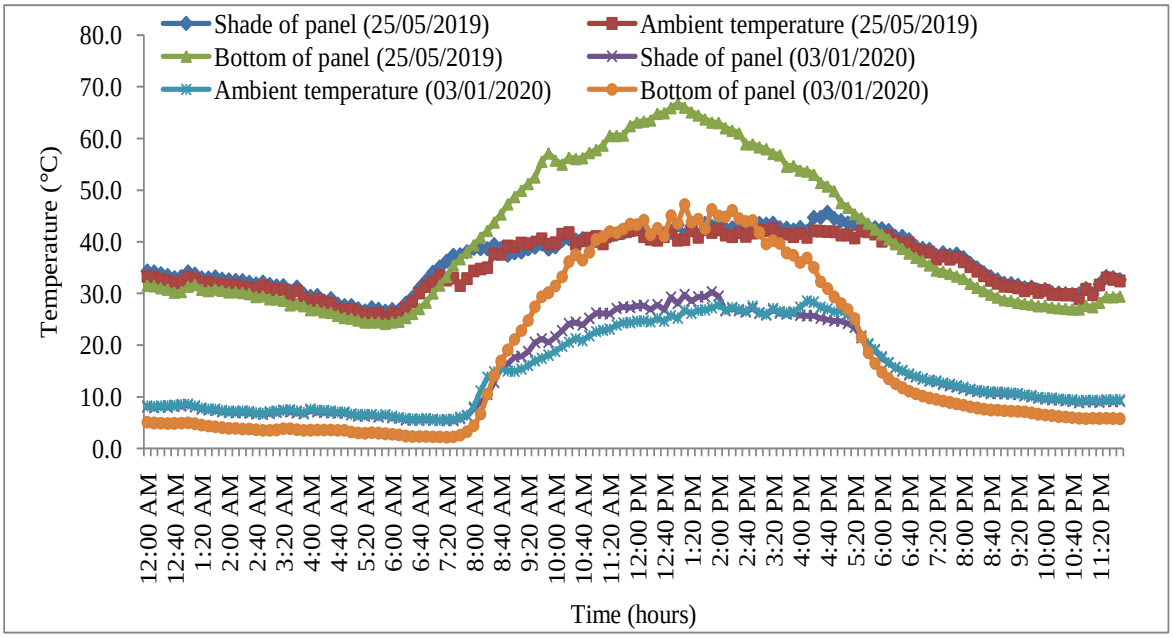

Fig. 9. Variation in temperature of solar PV module and the ambient condition during summer and winter season in the agri-voltaic system

2.6 Dust deposition on solar PV module

Deposition of dust has also a negative role on solar PV generation since it reduces the transparency of the top glass surface of solar PV module. Cleaning of PV modules is therefore a regular management practice to get optimum PV generation. Cleaning with water soaked wiper once in a week during summer months and once in a fortnight during winter

months has been followed. Dust load on the PV module was observed slightly higher in block 2 with double-row PV array than block-3 with triple-row PV array and single-row PV array. Average dust load on PV module was quantified as 1.98 g m^{-2}, 2.35 g m^{-2} and 2.17 g m^{-2} respectively in single-row, double-row and triple-row PV array in the agri-voltaic system.

3. Potential areas for establishing agri-voltaic system in India

The agri-voltaic system has very good potential in those portions of the country where solar irradiation is available in plenty. Arid western Rajasthan and Gujarat receives higher amount of solar irradiation (5.3-6.0 kWh m^{-2} day^{-1}) as compared to rest portion of the country (<5.5 kWh m^{-2} day^{-1}) except Ladakh. Apart from western India, southern tip of India covering Tamilnadu and Kerala also receives considerable amount of solar irradiation and thus there is scope of installation of agri-voltaic system in the region. Among twelve districts of western Rajasthan, availability of solar irradiation is high in Jaisalmer, Barmer and Jodhpur (>5.7 kWh m^{-2} day^{-1}) whereas comparatively low in Ganganagar, Hanumangarh, Churu and Jhunjhunu (5.3-5.5 kWh m^{-2} day^{-1}). In arid Gujarat, the Kachch district has vast potential to harness solar energy. In contrast to it, low availability of water in these arid districts is a limiting factor to achieve potential crop yield. Therefore, water harvesting system from top surface of PV modules in the agri-voltaic will help in conserving rain water and to use it in crop production system and also in cleaning the PV modules.

4. Possible way to install agri-voltaic system in farmer's field?

Initial investment for establishment of agri-voltaic system is about Rs 250 lakhs for 1 ha. High cost of investment is a major hindrance for its adoption in farmers' field. Therefore, policy supports and guidelines are necessary for establishment of agri-voltaic system in farmers' field. Very recently Ministry of New and Renewable Energy (MNRE), Govt. of India has taken a plan under '*Kisan Urja Suraksha Utthan Mahaabhiyan* (KUSUM)' yojana. Under component-A of KUSUM scheme, a total of 10 GW of decentralized ground mounted grid connected solar power plants are planned with an individual plant size ranging from 500 kW to 2 MW. Considering the potential of the technology such plant can increase the income of farmers by simultaneously generating electricity and growing cash crops.

Conclusion

Agri-voltaic system has been shown as a potential option to grow crops and generate renewable energy from a single land unit. The system is best suitable for those areas where

solar irradiation is available in plenty and land productivity potential is comparatively low. Additional advantage of agri-voltaic system is its ability to harvest rainwater from the top of PV modules. The harvested rainwater can be used for cleaning of deposited dust on PV modules and to provide supplemental irrigation to crops. The agri-voltaic system can be connected to grid through net metering system to supply the PV generated electricity and earn an income of Rs 7.5 lakhs $acre^{-1}$ $year^{-1}$. Otherwise, the off-grid agri-voltaic system can be used to operate solar PV pumping system in farmers' field. Apart from income by selling the PV generated electricity, farmers can also earn income from crop production. Overall, the land equivalent ration can be improved by installation of agri-voltaic system in farmers' field.

Chapter-5

Employment Opportunities under Start-up Agri-Business Incubation and Agripreneurship Programs

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Introduction

India is an agrarian economy where nearly 43% workforce is dependent on agriculture for their livelihood with the agriculture sector contributing 17% to the country's GDP. There is increased need of innovative agricultural innovations catering to different agriculture and allied sectors but farmers often lack access to market relevant technologies, products and services. Agri Startups have bridged this gap by revolutionizing the Indian agribusiness sector by providing innovative solutions to different challenges faced by agriculture and allied sectors, create newer livelihood opportunities and promote socio-economic development. Agribusiness incubation centres have been identified as successful facilitators of entrepreneurship development, startup growth and promote local economy. The incremental support provided by the Indian Government by implementation of different schemes like Start-up India, Atal Innovation Mission, NAIF-ABICs, RKVY-RAFTAAR ABIs etc. in combination with enabling environment provided by different other organization and institutions has enabled transformation of agriculture into agribusiness.

Different Govt. of India Schemes & Programmes promoting Start-ups

The Government of India has implemented many schemes to nurture, promote and support growth of Agri startups in the country *viz.*, *Rashtriya Krishi Vikas Yojana* - Remunerative Approaches for Agriculture and Allied sector Rejuvenation; Start Up India Program; Atal Innovation Mission (AIM); New Gen Innovation and Entrepreneurship Development Centre (New Gen IEDC) under National Science & Technology Entrepreneurship Development Board (NSTEDB); Dairy Entrepreneurship Development Scheme promoted by National Bank for Agriculture and Rural Development (NABARD);

Venture Capital Finance Assistance (VCA) Scheme promoted by Small Farmers' Agri-Business Consortium and Aspire (MSME) to name a few.

Similarly, many accelerators/incubators/mentors are also functioning in the food and agritech chain in India are promoting growth of agri startups namely AGRI UDAAN – Food and Agribusiness Accelerator 2.0, 3.0, 4.0; Centre for Innovation, Incubation & Entrepreneurship (CIIE); Agri-Tech Startup Accelerator, CIE, Hyderabad and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Food Processing Business Incubator/ Agribusiness Incubator (ABIO). These programs and policies aim to support existing and budding ventures, enterprises and start-ups in agriculture by training, mentoring and financing.

Rashtriya Krishi Vikas Yojana

Remunerative Approaches for Agriculture and Allied sector Rejuvenation (RKVY RAFTAAR): The *Rashtriya Krishi Vikas Yojna* (RKVY) is an important scheme of the Government of India, Ministry of Agriculture and Farmers' Welfare (MoA&FW), aimed at strengthening infrastructure in agriculture and allied areas In order to promote agri-preneurship and agribusiness by providing financial support and nurturing the incubation ecosystem, a new component under the revamped scheme RKVYRAFTAAR has been launched in 2018-19 with 10% of annual outlay inclusive of 2% administrative cost.

RKVY-RAFTAAR supports agribusiness incubation by tapping innovations and technologies for venture creation in agriculture. In this process, incubation facilities and expertise already available with participating academic, technical, management and R&D institutions in the country shall be utilized on an individual or collective basis to harness synergies. The existing institutional agribusiness incubators would be strengthened on a need basis by providing grants-in-aid. Agribusiness Incubation is in its early stages in the Indian agricultural landscape. Though a good number of agribusiness incubators have been started since the establishment of first country's agribusiness incubator by ICRISAT in the year 2003, yet the success rate of such incubators has not been high. The existing institutional agribusiness incubators were, therefore, envisaged to be strengthened on a need basis and new ones to be set up by providing grants-in-aid under the scheme.

The *Rashtriya Krishi Vikas Yojana* - Remunerative Approaches for Agriculture and Allied sector Rejuvenation **(**RKVY-RAFTAAR) scheme was launched in 2018-19 by the Ministry of Agriculture and Farmers' Welfare (MoA&FW), Govt. of India to strengthen infrastructure in the Agriculture and Allied sectors, promote Agripreneurship and Agribusinesses by providing financial support, nurture the incubation ecosystem and promote Agri-Business Startups in the country. The RKVY RAFTAAR Division of Ministry of Agriculture &

Farmers Welfare, Govt. of India established twenty four RKVY-RAFTAAR Agri Business Incubators (R-ABIs) and five Knowledge Partners (KPs) across different states of India in 2018-19.

The CCS NIAM Centre for Innovation Entrepreneurship and Skill Development established NIAM Agri-Business Incubator (NABI) in 2018. CCS NIAM hosts Agri Business Incubator (NABI) and also functions as RKVY RAFTAAR Knowledge Partner for four partner RABIs. NABI hosts two funding programmes namely Agripreneurship Orientation Programme (AOP) & Startup Agri Business Incubation Programme (SABIP). CCS NIAM is also the Knowledge Partner to five RKVY-RAFTAAR Agri-business Incubators (R-ABIs) spread across the country viz. Rajasthan, Bihar, Orissa, Jharkhand & West Bengal viz., Sri Karan Narendra Agriculture University (SKNU), Jobner, Rajasthan; Bihar Agricultural University (BAU), Sabour, Bhagalpur, Bihar; National Rice Research Institute (NRRI), Cuttack, Odisha and Indian Institute of Technology (IIT), Kharagpur, West Bengal.

Agri-Startups are nurtured through countrywide Incubation Centers under:

i. Agripreneurship Orientation Programme (Pre-Seed) – Rs.5 Lakhs Grant-in-Aid support
ii. Startup Agri-Business Incubation Program (Seed) – ₹25 lakhs Grant-in-Aid support

i. Agripreneurship Orientation Programme (Pre-Seed Stage Funding):

The Agripreneurship Orientation Programme aims to develop an innovative idea based on technology, service, business platforms etc. into prototype/ product, services/ platforms etc. and launching of a business based on that, provide an opportunity to budding agripreneurs/students for venturing into the agribusiness arena as well as for minimizing risks involved in businesses based on innovation; attract and retain a large number of enthusiastic and skilled youth in agriculture and create a pipeline of innovative startups for incubators. Under this programme, subsistence grants of a maximum of ₹5.00 lakhs will be provided to interns who have successfully completed the initial two months of agripreneurship orientation program and are aspiring to convert their innovative idea based on technology, service, business platforms etc. into a prototype/ product. Startups supported for idea/pre-seed stage funding will be eligible for obtaining next stage of Seed Stage Funding after evaluation.

ii. Startup Agri-Business Incubation Programme (Seed Stage Funding):

The Startup Agri-Business Incubation Programme aims to ensure timely seed support to deserving incubatees, enable translation of Minimum Viable Product (MVP) to marketable stage and scale up the product and business, provide a platform for faster experimentation

and modification in their approaches or Minimum Viable Product (MVP) based on innovative solutions/processes/products/services/business models etc. for scaling up.

The Programme Highlights include:

a) Startup Agri-Businesses eager to get integrated incubation support
b) Two Months Training Cum Internship.
c) Grant-in-aid upto ₹25 lakhs

NIAM Initiatives for startups for promotion of Agri Business Incubation & Agripreneurship

NABI has incubated 172 innovative Agri-Business Startups, organized more than 300 outreach events to enhance the entrepreneurial ecosystem, facilitated filing of 19 Patents by Startups for protecting their innovations, benefited nearly 10 lakhs farmers, provided full-time employment opportunities through incubated companies to more than 1500 people and supported more than 25 innovations through mentoring, technical guidance & financial assistance.

NIAM Agri Business Incubator also provides different services/benefits to agri startups namely:

i. Mentoring: Mentoring by domain and functional experts
ii. Business Coaching and Training: Business coaching and training by qualified professionals
iii. Technology Commercialization and Pilot Support: Hands-on support in technology validation and piloting
iv. Business and Financial Model Development: Assistance in building robust business and financial model by experts
v. Funding: Funding of up to ₹5.00 lakhs & ₹25.00 lakhs for selected startups under the program
vi. Pitch Deck Preparation: Support in preparation of attractive, striking and eye-catching pitch deck
vii. Networking and Investor Connect: Organization of Demo day to network and connect with different stakeholders of ecosystem
viii. Infrastructure Support: State of art facilities for startups to in upcoming incubation building
ix. Intellectual Property Development: Assistance from qualified professionals in IP development and documentation

x. Branding and PR: Support in branding and PR of startups through vast network of CCS NIAM and its publications.

Some of the innovative agri startups nurtured and supported by NABI are mentioned below:

1. **Electrostatic Sprayer developed by M/s. Aigret Pvt. Ltd., Pune Maharashtra:** Conventional sprayers are highly drift prone causing pesticide spillage on soil/ground leading to environmental damage. Very poor spray coverage and deposition efficiency, non-uniformity of droplet size causes product quality loss and ultimately heavy revenue loss to farmers. Agri startup M/s. Aigret Pvt. Ltd., Pune Maharashtra has developed electrostatic sprayer with smaller droplets of 40 to 50 microns charged using high voltage electrostatic field. Electrostatically charged droplets provide 360 degree wrap around effect and better coverage thus reducing drift, and 35 to 40% savings on pesticide usage. This low-cost patented technology is useful for Grapes and Pomegranate Crop. The equipment results in spraying of uniform droplet size resulting in better coverage results in higher yield and quality product, higher revenue. There is low drift, no spillage of pesticides on ground resulting in environment protection, less contamination of drinking water and 35 to 40% savings in pesticides usage.

2. **Low cost warehousing developed by M/s. Singodwala Warehousing and Logistics Private Limited, Jaipur:** Farmers/sellers/village level aggregators in remote areas do not have access to warehouses, commodity finance and market linkage which impacts their business volume and economic loss due to poor post-harvest storage. M/s. Singodwala Warehousing and Logistics Private Limited, Jaipur developed Android

based Super App for farmers, addressing all post-harvest needs of Non- Horticultural commodities by providing Warehousing, Commodity Finance, Online Trade and Logistics services. Using their app they are converting idle properties in rural areas or near farm-gate in warehouses and envisage to ensure that every farmer gets warehousing, commodity finance and e-mandi facility within 5 kms of their farm. The benefits of this app are availability of Post-Harvest Solutions in one Application; Linkage of Warehousing-Commodity Finance-Market; Price Discovery Algorithm and Online selling of pledged stock.

3. **Technology titled Internet of Groundwater developed by M/s. Aumsat Technologies LLP, Mumbai:** The exploration and location of a potential source of underground good quality water, without a technology driven approach is a challenging task. The conventional methods of ground water detection rely on expensive, time consuming, pseudoscientific 'water dowsing' resulting in higher chances of predicted searches ending up in dry well. The startup has developed satellite imagery based technology for detection, prediction and forecasting of underground water resources without physically being present on the field. The advantages of the technology are Scientific and cost effective method for groundwater discovery, precise location of potable groundwater source in drought-hit areas and affordable for small farmers.

4. **Grain Assaying Device developed by M/s. 3Stake Labs Pvt. Ltd., Bengaluru:** Traditional grain assaying is time-consuming, use destructive methods which causes potential loss to the farmers and hence, need highly trained assayers. M/s. 3Stake

Labs Pvt. Ltd. has developed Hy-Greev, A Smart grain Analyser. This hand-held device uses high precision and artificial intelligence based system for grain assay. It tests 5 essential parameters like foreign matter, moisture, contaminants, weevil, immature grains and assay them according to government standards within 2 minutes. The benefits of this device are direct data transfer to the customer, assaying parameters conducted for 6 commodities namely Paddy, Ragi, Green Gram, Black Gram, Bengal Gram, Tur Dal, better prices for commodities, use of Artificial Intelligence for better accuracy, technical benchmark and farmers friendly approach.

5. **Natural Polymer for Water Retention developed by M/s. EF Polymer Pvt. Ltd. Udaipur, Rajasthan:** The agri startup has developed an ecofriendly water retention polymer (organic and biodegradable hydrogel) made from bio-waste (fruit peels, vegetable trims) from juice vendors, farmers market, restaurants, hotels, and universities' food counter which can be used as fertilizer. The collected raw material is dried in the solar tunnel dryers and then ground to powder form. The powder of fruit and vegetable is processed to extract pectin and cellulose which is used as main raw material for polymerization. This hydrogel can minimize the irrigation requirement, retaining water for a longer period of time in the soil.

   This 100% Biodegradable Hydrogel is certified organic, minimizes irrigation requirement by increased water retention, increases soil moisture and improves soil health and promotes efficient waste management practices.

6. **Arecanut Dehusking Machine developed by M/s. Bi-Sons Private Ltd., Aizawl, Mizoram:** Arecanut is an important cash crop of Mizoram and it is also widely grown and consumed in a large scale across the country. Arecanut processing involves removal of outer fibre and cleaning of inner nuts. This manual process involves use of sharp tools and is labour intensive, time consuming and dangerous often leading to injury. M/s. Bi-Sons Private Ltd., Aizawl, Mizoram has developed a novel arecanut dehusking machine for separating husk from the nuts. This machine low cost and

affordable with output capacity is 400 nuts per hour.

7. **Water Level Monitoring app. developed by M/s. Waterlab Solutions Pvt. Ltd., Pune, Maharashtra:** NABI supported agri startup M/s. Waterlab Solutions Pvt Ltd, Pune, Maharashtra has developed an android based multilingual mobile application (Bhujal) to monitor water levels in shallow and deep borewells/boreholes. Bhujal helps users to manage their borewells efficiently and encourages responsive use of precious ground water. The feature of geotagging of borewells offers online digital platform supported with data analytics and presentations for critical decision making for users for individual or collective monitoring of borewells and their regulation. The app is simple, scalable, cost effective and user friendly, based on non-invasive way of measuring water level in borewells and leads to better water management.

8. **Vegan Leather developed by M/s. Bhoomi Agri Ventures, Shivamogga, Karnataka:** The spreading of shredded areca leaves across the farm land is the major problem to areca palm, coffee and cardamom farmers. Taking out these leaves from the farm land is a big task which requires huge labor. M/s. Bhoomi Agri Ventures, Shivamogga, Karnataka has developed biological solution to convert Areca Leafs into

Areca Palmleather. This 100% natural, ecofriendly and biodegradable vegan leather is better alternative to animal leather and plastic products available in markets. The various products developed by them using areca leather are bags, folders and shoes.

9. **Processing Minor Forest Produce developed by M/s. Jovaki Agrofood India Pvt. Ltd. Udaipur, Rajasthan**: The agri startup is providing avenues for sourcing, processing and marketing of minor forest fruits (Jamun and Custrad Apple) with involvement of tribal women in remote areas of Rajasthan thereby increasing their income by employment generation. Their products have shelf life upto 12 months. They are currently working in Rajasthan with more than1800 tribal women with the help of network of SHGs, NGOs and FPOs. The different custard apple and jamun based products are in the purest form, contain no harmful chemicals, added sugar or preservatives. These products also provide health benefits and help prevent diseases like diabetes and hypertension.

10. **Virtual delivery of aquaculture advisory, IIFSA-Information and Inputs for Sustainable Aquaculture LLP, Nellore, Andhra Pradesh:** The lack of real-time information, problem identification and absence of timely technical support in aquaculture sector leads to mortality, morbidity, low productivity of water bodies used for commercial aquaculture operations. The agri startup is providing virtual delivery of aquaculture advisory using pond data management software. They provide GPS Location based pond enrollment, lab tests, water testing kits, prebiotic culture, water sanitizer, water detox, oxidizer and water treatment products. Their services include 24x7 support to enrolled farmers by system approach, remote management of ponds with real-time parameters, Pond Specific Solution, Early Detection and control of diseases. The different innovative products developed and commercialized by the startup are namely; E-buffer, E-Sack, E-Glue, E-Detox, E- Plus and Water Testing Kits.

11. **Farm-Let Model developed by M/s. KisanTreat Agritech India Pvt. Ltd., Jaipur, Rajasthan (Jaipur, Kotputli, Hanumangarh and Ganganagar) and Haryana (Gurugram):** The startup is working on digital platform based on "Soil2Sell" model providing on ground assistance and transparent market linkage to farmers. Using their model customers can rent their own miniature farm and grow the things they like, organically. The farm input and output is managed by the start-up after classifying the land as per customer need. The model provides year round utilization of land resources for growing diverse crops. The benefits of technology are production customizable as per the customers' family requirement, cost effective, resource use efficient model, controlled use of farm inputs, production and doorstep delivery of high quality organic produce, quality driven vegetable production, ecological farming, environment friendly, promotes growing of indigenous crops and enhancement of soil health.

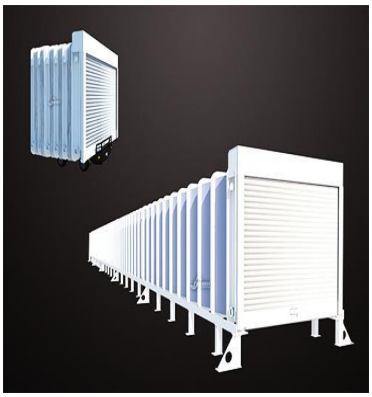
12. **Comb Honey developed by M/s. Bee's World India, Betul, Madhya Pradesh:** The Comb honey is honey which is still contained within its original hexagonal shaped beeswax cells, called honeycomb. Apiculture, allied enterprise which can be done in innovative way, by focusing the value added products like royal jelly and its venom too. The benefits of this product are availability of Pure and Hygienic, Adulteration free honey in innovative form (comb honey). The product leads to increased Pollination and crop productivity due to less or no harm to honey bees and promotes viability of ecosystem.

13. **Farm Gate Fruit Processing developed by M/s. SNL Innovations Pvt. Ltd., Jaipur, Rajasthan:** The startup has developed movable or mobile fruit processing machine which can do value addition to fruits at farm-gate. The machine provides a 'caring integrated ecosystem' which benefits farmers, processors, and consumers. Fruit and vegetable pulp, processed directly at farm using an in-house developed mono-block fruit processing platform (on-wheels) to convert fruits to pulp with shelf life of up to 1 year, with complete traceability from farm to customer. The advantages of the machine are portable machine which can be moved from one place to another, leads to better post-harvest management, better prices for low-grade fruits by value addition, increased shelf life, income and employment generation, saving in transportation cost, platform for back tracing and traceability. This machine is beneficial for farmers group, SHGs, FPOs and FPCs.

14. **Foldable Warehouse developed by M/s. BMH TRANSMOTION INDIA PVT. LTD, Nagpur, Maharashtra:** There exists huge supply and demand gap in warehousing sector. Also, the warehouses are structured in a way that it they not only get folds and but also moved from one location to other as required. M/s. BMH Transmotion India Private Limited has developed a foldable & portable grain storage system with any fumigation which reduce grain losses. It stores grain of all types in a portable foldable storage system, which aims to reduce grain losses, without any fumigation. The storage structure has an aeration system, which regulates temperature and moisture levels. The structure is outlined with specially developed fabric, keeping in mind the factors required for good quality grain storage. The advantages of using the foldable warehouse are easier farm-gate storage, reduced grain losses at farm level and better post-harvest management of food grains by providing bulk food storage systems to farmers.

Comb Honey

Farm Gate Fruit Processing



Foldable Warehouse

Virtual Veterinary Consultancy

15. **Virtual Veterinary Consultancy, M/s. Paravet India Pvt. Ltd., Jaipur, Rajasthan:** M/s. Paravet India Pvt. Ltd., Jaipur, Rajasthan provides consultancy services to livestock owners through virtual platform thus reducing their need to visit a veterinarian every time. They provide valuable digitally accessible data on-farm animal level for all animals

and necessary for prescribing medicines. The digitization of farm animal data contributes to efficient veterinary and animal health research, surveillance of drug efficacy by pharmaceutical industry, monitoring of medicine levels in supply chain by agri-food processors, tracking and benchmarking of herd/flock/farm performance by farmers and their vets. The different unique features of their services include provision of providing digital solution in vernacular language, Convenient services, provision of Chat, Audio-Video consultation through wide range of animal specialists and optimum Resource use efficiency.

Till date 172 agri business startups have been incubated at NABI under six cohorts and to facilitate their business growth. NABI has facilitated grant-in-aid support to the tune of ₹8.5 crores for 73 agri startups under five cohorts. These novel startups have developed and commercialized 350 different innovative products & services with diverse business models in over eleven different thrust areas, provided livelihood opportunities to more than 10,000 people directly and indirectly and benefitted over 10 Lakh farmers so far. NABI also provides marketing assistance to agri startups through buyer-seller meets, national & international exhibitions, facilitate access to different growth avenues for agri startups, Investor meets for channelizing the funding opportunities for incubated startups, exposure visits to National Innovation Foundation, Agri Universities, R&D Institutions, Tech Developers and other incubators are also arranged for incubatees. Various outreach activities are organized by NABI on regular basis and more than 300 outreach programmes have been organized so far in partnership with different Universities, Krishi Vigyan Kendras (KVKs), Incubation Centres, Colleges, Business Schools, etc. The initiatives undertaken by NABI has been recognized and rewarded with awards and accolades from various renowned organizations as Best Agri-Incubation Centre in India Award by MIT World Peace University, Pune; India Smart Grid Forum (ISGF) - Innovation Awards, 2022 as “Smart Incubator of the Year 2022” by India Smart Grid Forum under “Gold Category”.

CCS NIAM is also the Knowledge Partner to RKVY-RAFTAAR Agri-business Incubators (R-ABIs) spread across the country covering 5 states viz. Rajasthan, Bihar, Orissa, Jharkhand & West Bengal namely Sri Karan Narendra Agriculture University (SKNU), Jobner, Rajasthan; Bihar Agricultural University (BAU), Sabour, Bhagalpur, Bihar; National Rice Research Institute (NRRI), Cuttack, Odisha and Indian Institute of Technology (IIT), Kharagpur, West Bengal. The roles & responsibilities disbursed by NABI as Knowledge Partner include handholding R-ABIs in all their operations as mentor, organize review

meeting of R-ABI on frequent intervals (Monthly & Quarterly), handholding in capacity building, outreach, networking. NABI has also facilitated sanctioning of grant-in-aid funding to four partner R-ABIs to the tune of ₹7 Crores for 93 incubated startups.

Conclusion: NABI is promoting, nurturing and facilitating funding support to agribusiness startups by providing much needed social and economic benefits to various stakeholders across the country. NABI is contributing in growth of agri graduates, startups, farmers and relevant stakeholders by Entrepreneurship Development, Skill enhancement, Technological Mentoring, Funding support, IP facilitation, Market Connect, Business Model Canvas, Product Validation, etc. In the last three years of its operation, NABI has trained and funded agri-startups and also created a safe haven for innovative agri-business ideas to grow and establish themselves as successful agri-ventures. NABI is putting in its concerted efforts towards strengthening of the Agri business startup ecosystem in the country and contributing in faster evolution of agri startups and innovators into successful businesses.

Chapter-6

Development and Design of Improved Animal Shelter for Livestock Production in Arid Regions

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Livestock sector is a source of livelihood and economic sustenance for majority of farmers in larger part of country under difficult geographical regions. As the ecosystems are sensitive to change in climate, it is essential to assess the possible impact of extremes of climate on animal production system (Sejian et al. 2011 a). The rise in temperature due to global warming became apparent since 1990. This century is going to witness soaring temperature, erratic weather pattern with more intense monsoons, increased cyclonic activities, severe droughts, floods, melting glaciers etc. (Singh and Shinde 2006). Majority of livestock in arid, semi-arid, hilly & mountains areas are maintained in extensive management systems, although the breeds of livestock in these regions are well acclimatized in different environmental conditions but their production potential is undeniably influenced by the extremes of climatic conditions of the regions. Besides higher temperatures and higher humidity, there may be increasing health risk and decreasing product quality. However heat or cold stress does occur in these animals when they exposed to ambient temperature above and below critical temperature zone.

The fetal growth (Ocfemia et al.,1993) and post weaning growth in kids (Patel, et al., 2007) are affected by heat stress particularly at high ambient temperature. Apart from decreased growth rate in young, Heat stress affects production and reproduction in high yielding dairy cows, the conception rate has been reported to be significantly reduced in summer from 5 to 20% (Flamenbaum, 1998). Extremes in the environmental conditions can have enormous effects on the productivity of farm animals (Burke, 1998). Thus, all livestock need protection from climatic extremes even in moderate climatic regions, primarily to ensure survival of animals for continued production and reproduction. Animal housing helps in moderating the range of micro-environment to which the animals are exposed and optimizes their production by protecting them from extremes climates. Numerous studies indicate that the provision of proper shelter improves livestock performance through moderation of environmental factors (Patel, et. al., 2001, Singh, et. al., 2003 and Patel, et al.,

2007). The main aim of the shelter is to provide comfort and a sense of wellbeing to animals so that they can produce to their maximum genetic potential.

Effect of environment stress on animal physiology and productivity

1. Animal physiology: A major part of dry region is characterized by harsh environmental conditions, poor quality of water and forage, higher variation in air temperature etc. Small ruminants of this region are mostly maintained on extensive grazing, where these animals were not provided any kind of shelter during the grazing, but in extremes of summer and winter animals seek shelter and physical protection. Extremes in the environmental conditions can have enormous effects on physiology and productivity of farm animals (Singh, et al., 2001 and Singh and Upadhyay, 2009). Patel et al. (2009) analyzed the stressful and comfortable period based on weekly Temperature Humidity Index (THI) values for Central Farm of CAZRI, Jodhpur, the stressful period for animals starts from May to Ist week of October, where THI ranged from 79 to 83 and the comfortable period was found to start from IInd week of October to March (THI vale equal or below 74). The cold stress period was also observed in this region from IInd week of December to IIIrd week of February during night when there were cold waves. A long period of summer, monsoon and post monsoon are stressful seasons in arid and semi-arid regions. Animals should be protected from direct solar radiation during the hottest hours of the day to ameliorate the effect of heat stress (Shinde, et. al., 2002).Some physiological adaptations are also developed in the sheep of this region. Since water is a precious element in arid and semi-arid regions, so ruminants of these regions show some adaptive mechanisms to conserve water during heat and drought. They reduce urine volume as well as faecal moisture.

Malpura sheep has been studied extensively for effect of multiple stresses. Heat stress is a major limitation to reproductive function of sheep because it has deleterious effect on estrus incidences, estrus intensity and embryo production, which finally affects their productivity. Heat stress delayed the onset of estrus, sexual behaviour, conception and lambing rates of Malpura ewes (Maurya *et al*., 2005). In another study when Malpura sheep were exposed to multiple stresses, impact was severe on reproductive functions of the animals such as reduction in conception rate. Stress-induced increase in plasma progesterone is an established fact (Sejian *et al*., 2011). Thus, it is pertinent that the sheep surviving in the arid and semi-arid regions undergo all stresses and still serve as the sustainable livelihood option for the rural poor.

2. Milk production performance: The milk yield of all mammalian species undergoes seasonal variation. The optimum environmental temperature for lactation depends

on the species, breed and degree of tolerance to heat or cold. The milk yield of Holstein cattle declines at temperature above 21^{o}C, in case of Brown Swiss and Jersey cattle it declines at about 24 to 27 ^{o}C whereas milk yield of Zebu cattle declines only above 34 °C. Observations in India on cross-bred cows has shown that the productivity of cross-bred of exotic with indigenous breeds were not seriously affected by the hot dry climate in north western parts.

Sinde et al. (1990) observed that milk yield per day decreased with simultaneous increase in ambient temperature and humidity. Dutta et al. (1995) reported that temperature and humidity together explained 62.75% of variation in milk yield/cow/day, which was higher than that explained either temperature or humidity alone. In a study of thermal stress and milk production in half-bred Holstein crosses (Karan Fries) and zebu cattle Sahiwal, the Karan Fries showed higher sensitivity for temperature rise (Singh and Upadhyay, 2009). When THI crosses the index value of 72 impacted milk production negatively, the average milk production of Karan Fries and Sahiwal animals was 13.4 and 6.6 litre/day at around THI of 72. The respective milk production was decreased to around 9 and 5 litre/day in Karan Fries and Sahiwal cows at around THI of 82. The increase in each unit THI impacted in reducing the milk production by 0.43 and 0.16 litre/day/animal, respectively in the range of 72-82 THI. The 305 days lactation yield was influenced by season of calving in Tharparkar cattle, it was higher in winter season calvers (1438.8 litre) than summer season (1274.9 litre) in arid condition (Patel et al. 2000). But the milk fat content of Tharparkar cattle was found to be lowered in both hot dry (4.30%) and hot humid season (4.64%) in arid zone whereas, higher percentage of fat was observed during autumn (5.24%) and winter season (5.25%) (Patel et al., 1994). Though the Marwari goat breed of Thar Desert are well adapted against desert vagaries, but the productivity of these animals affected adversely due to extremes of climatic conditions. Marwari goats yielded lower lactation yield during winter when housed in open type house (thatched roof animal shelter) in comparison to closed type pucca animal shelter in arid region. These goats yielded 38 lit more milk in a lactation period of 154 days with higher milk fat 4.77 % (Patel et. al., 2001). In a another study they found 22% more lactation yield in Marwari goats when these were housed in closed type Improved Animal Shelter than open type Tradition Animal Shelter during winter season (Patel et al., 2007). The reason for higher milk yield in Marwari goats under Improved Animal Shelter might be due to protection of goats against cold weather in winter season.

In a field study in rural areas of Goa (Das et al., 2015) it was observed that house with proper orientation, ventilation, floor space and cooling arrangement had a significant effect on average daily milk yield and microenvironment of dairy shed. Significantly higher

milk yield and lesser heat stress were observed in east – west orientation, good ventilation and standard floor space of minimum 5 square m per cattle. Further cooling arrangement in cattle shed had a highly significant ($P < 0.01$) effect on average daily milk yield and microenvironmental parameters revealing that if false ceiling is made inside cattle shed besides manual and mechanical cooling animals would feel more comfort resulting in higher milk production. In cross bred Karan-Fries cows, the higher average daily milk yield and dry matter intake was recorded during hot humid seasons when animals were housed in modified shed as compared to existing shed (Sinha et al., 2018).

3. Reproductive performance: Heat stress affects the reproductive physiology in farm animal. In a study of effect of thermal stress on superovulatory response, the occurrence of estrus was late (30.6+1.2 h) with shorter estrus period (31.7+3.6 h) in a group of ewes exposed to thermal stress in comparison to group of ewes which were maintained under shed (Naqvi, et al., 2004). However, the thermal protected ewes exhibited estrus earlier (25.5+1.1 h) and the estrus period was longer (37.7+1.6 h). The reproductive performance of Tharparkar cattle in terms of dry period and calving interval was not significantly influenced by season of calving but the results of the study showed that comparative lower dry period (101.9+23.3 days) and calving interval (414.5+27.9 days) was observed in winter season calvers than summer and rainy season calvers (Patel, et al., 2000). On the other hand it was also observed that buffaloes calved in rainy season had higher reproductive efficiency in terms of lower service period (198.4+15.1 days) and calving interval (501.4+15.3 days) as reported by Patel and Tripathi (1998). The optimum service period was found 2 months in Tharparkar cattle where the milk production and reproduction efficiency was higher under arid conditions (Patel, et al., 2001). Heat stress during pregnancy slows down the growth of the foetus and can increase fetal loss, although effective mechanisms attenuate changes in fetal body temperature when mothers are thermally stressed. A reduction in pregnancy rate is observed when the average daily minimum temperature and average daily THI were equal to or exceeded 16.7 °C and 72.9, respectively (Amundson et al., 2006). During summers, when temperature rises it negatively impact on reproductive functions and milk production of buffaloes in India (Upadhyay et al., 2007). The incidence of silent heat or poor expression is common at hot temperatures during summer in buffaloes. Reproductive processes are affected by thermal stress. Conception rates of dairy cows may drop 20-27% in summer, and heat stressed cows often have a reduced expression of oestrus due to reduced oestradiol secretion from the dominant follicle developed in a low luteinizing hormone environment.

Reproductive inefficiency due to heat stress involves changes in ovarian function and embryonic development by reducing the competence of oocyte to be fertilised and the resulting embryo (Naqvi et al., 2012).

4. Growth performance: The body weight gain in growing age is an important aspect for any domestic animal reared for economic benefit. The climatic stress particularly due to heat during growth period of animal reduced the body weight gain. Higher body weight gain was observed in the 6 month old male kids of Marwari breed, when reared under closed type Improved Animal Shelter during summer months. Kids gained 9.52 kg body weight in Improved Animals Shelter than 7.52 kg in Traditional Animal Shelter during 6 months period of experiment from May to October (Patel et al., 2007). The month of birth of lambs affects the body weights, lambs born in January to February were heaviest at 6 months body weight (30.6+0.93 kg) with decreasing trend in lambs born in subsequent months i.e. March to December time period (Poonia, 2004). Harsh environment conditions of arid zone coupled with low forage availability in grazing area affected the body weights of different goat breeds of semi-arid region. The lowest body weight of adult goats (22.8 kg) was observed in Parbatsari breed followed by Jhakrana and Jamunapari. However, highest body weight (31.0 kg) was maintained in adult Marwari goats, which was native of this region (Patel, et al., 1998). But the supplementation enhanced the higher body weight gain in Jhakrana (54%), followed by Jamunapari (53%), Parbatsari (47%) and lowest in Marwari (16.2%). Rohilla and Khem Chand (2004) also observed a significant growth in Marwari kids when they were supplemented with concentrate feeds at daily and alternate day in arid conditions.

The major factors that affect average daily gain is availability of nutrients, hormones, enzymes and environmental factors like increase in ambient temperature (Hafez, 1987). Even though voluntary food intake of animal increases the digestibility of the feed, this frequently reduced in cold-stress. Cold exposure may restrict the growth of the animal when insufficient nutrient availability combined with an increased maintenance cost. In calves, growth, health and future performance is influenced by heat stress (Hoelscher, 2018).

Management strategies

The animals should be raised in the optimal thermal zone for welfare point of view. The implementation of the knowledge, for the welfare of animals maintained under extensive management systems, is difficult because of objective limitations to monitor heat stress and

economic compulsions in applying measures to ameliorate heat stress (Hansen and Arechiga 1999). The following recommendations are general rules that can be applied under extensive conditions: (i) provision of shade shelter in areas where typical ambient temperature during summer exceeds the normal (ii) provision of water at reasonable distance between watering spot and grazing area (Hahn *et al.* 2001, Collier *et al.* 2003). Shade against direct solar radiation can be provided by either trees like khejri, neem, or house/ thatched roof made of straw and other locally available materials (Patel, 2010). Animals kept outside during summer are comfortable under tree shade which protects them from direct sun light during peak hours of the day (Buffington *et al.* 1983). A properly designed shading structure provides the most adequate protection to the livestock not only in hot summer but also in winter (Armstrong 1994). The longer side of the animal shelter should have an east-west orientation (Mishra, et al., 2006). This reduces the amount of direct sunlight shining on side walls or entering the house (Ugurlu and Uzal 2010). A proper closed type shelter helped in improving the body weight, milk yield and composition of Marwari goats in arid zone (Patel et al., 2001, 2007).

Present status of Shelter management practices in the arid region

A survey study revealed that in arid western Rajasthan, only 10% farmer provide thatched house for small ruminants, while rest of the farmers kept their sheep and goat in enclosures without any roof structure. The materials used for making the enclosures are mainly thorny bushes of this region. Though, the facilities of minimum shelter were found in majority of the farmers, but they prefer to tie their animals outside the animal house during normal climatic conditions of every season. However, during extreme environmental conditions e.g. rainy hours, extreme hot hours in mid-day in summer, and cool hours in nights during peak winter, animals are housed inside the shelter. It was observed that 80% animal houses where in rectangular shape and 20% found in round shape. While the surrounding of open animal shelter was in round shape and mainly made by thorny bushes but some time stone slabs were also used for the purpose. The average dimensions recorded of animal shelter were 12’ x 10’ x 7 ’for rectangular shape, 5-8’ radius for shelter with round shape. There is no fix set of rules for orientation of animal house but farmers make a wall in north of the animal house to prevent the entry of cold air from north during winter. No pucca floor was observed in any animal shelters, in all cases, only mud floor was seen. A slope was provided in floor towards the open space in most of the shelters, to avoid dampness. All the animal houses were well ventilated, as the walls of the house were much lower than the

height of the roof. Observations of the microclimate of the thatched animal houses showed that the ambient temperature of the house was 2-4^{o}C lower than the temperature outside the animal houses.

Local plant materials: Farmers use of various types of local materials for the construction of thatch roof, wall and other parts of the houses. Most of these materials consisted of basically branches, twigs of shrubs/trees available in abundance in arid region (Table-1). The frequency of repairing the thatched roof was once in one or two years, as per the conditions of the roof before the onset of winter season (October - November).

Table (1): List of local plant materials used for making thatch house for livestock

S.No.	Plant Material	Utility area
1.	Aak (*Calotropis procera*)	Used in making the side walls and roof.
2.	Bui (*Aerva pseudotomentosa*)	Used in thatch roof manufacture.
3.	Bordi (*Zizyphus nummularia*)	Used for making thatch roof and side walls.
4.	Babul twigs (*Prosopis juliflora*)	Used for preparation of thatch roof.
5.	Khimp (*Leptadenia pyrotechnica*)	Used for preparation of thatch roof.
6.	Shinio (*Crotalaria burhia*)	Used for preparation of thatch roof.

Feeding manger: were made in almost all animal houses for large ruminants and iron pans were used for goats, but water trough was found only in 20% animal houses, since the animals are taken for watering to common tanks or other water bodies of the village. The feed mangers were mostly made by stone slab, whereas, iron pan, wooden boxes and used tyres were also used as feed manger. The average dimensions of the manger was observed to be 10’ x 1.5’ x 1’ for L x W x D, respectively.

Drainage system: The drainage system to dispose the urine and faecal material was not common in animal houses since the pacca floor was not found; only soil floor was common in almost every animal house, since, soil floor directly absorbed the animal waste due to low relative humidity in the arid environment.

Ancillary structure: Feed storage structure was common in this region, which could be due to the higher value of feed and fodder in livestock husbandry. Farmers gave due care in storing the feed and fodder for longer time for dealing with the lean period within year as well as in drought years which are a common feature of this area. About 80% farmers constructed pacca and semi pacca type structure for feed storage while 20% farmers stored their feed material in kutcha or traditional type of structures.

Systematic housing system was not found for small ruminants, where proper alley or passage was present and no separate house was provided to pregnant, sick animals and breeding male but newborn kids or lambs were provided separate closed type house to protect them from predation and cold climate. In general three types of shelters for livestock were observed in the rural areas of the arid zone, viz; open housing system (Barbed enclosure without any roof), Kutcha (Thatched roof house) and Pucca housing system which was a closed type pucca house (Patel, et al., 2005).

Design of Improved Animal Shelter (IAS) for goats

This was observed from the studies conducted on various type of housing systems that a close type housing system with open space was better for both hot and cold weather conditions. An improved animal shelter was designed and developed based on the study of different factors like orientation, wind direction, sun movement, air temperature, local materials for construction etc. (Fig-1). Improved animal shelter consists of angle iron frame, asbestos sheet and stone slabs. (Mishra, et al., 2006). The orientation of this shelter was kept east-west direction; the long axis of shelter is 60 ft which is open from south direction and north direction. Hence, this orientation with generous provision for ventilation / air movement to help dry up threshold will be most suitable. Furthermore, the south facing shelter has the advantage of receiving larger solar radiation during winters than during summer. Small over hang on south faced can cut off direct solar radiation during summer and allow it during winter. It also gives protection from rains. The open space of north axis was covered by plastic curtain to minimise the entry of cold winds inside the shelter during winter.

Fig. 1: Design and development of Improved Animal Shelter for livestock

The double slope roof of the shelter was made by corrugated asbestos cement sheets (1x3mtrs.) on angle iron frame. The roof height is 10 feet from centre and 7 feet from sides. 4 inch thick thatch panels were fixed just below the asbestos sheets to provide insulation. The side walls were erected using stone slabs with 4ft height in north faced and 3ft in south faced. The floor of this shelter is elevated 1ft from the ground and filled with calcified soil to give compactness, which also absorbed the urine and faecal material of the goats. The feeding manger of 50 ft length was constructed along with the wall of north side of shelter by using stone slabs of this side. The height of manger was kept 1ft 9 inch from the ground level with 9 inch depth and 12 inch width for holding ample feed material.

Microclimate of Improved Animal Shelter: The Improved Animal Shelter provide more comfortable environment to the goats than Traditional Animal Shelter (TAS) as the maximum average temperature in IAS was found lower (35.7 ºC, range 31-40.3 ºC) during

summer months (March to September) in comparison to TAS (37.2 ºC, range 32.7-42.4 ºC). However during winter from October to March the higher values of minimum temperature (14.7 ºC, range 12.7-18.1ºC) was achieved in IAS than TAS (13.1 ºC, range 11.1-16.4ºC). The maximum average temperature in IAS was also found slightly higher (30.8 ºC) compared to 29.8 ºC in TAS.

In IAS, the higher value of minimum temperature was mainly due to the absence of direct entry of air temperature inside close type animal house, secondly the minimum temperature which was attained usually in absence of thermal radiation during the time beyond midnight, remained higher in closed type animal shelter, because of inadequacies in loss of absorbed heat and low ventilation also add to this effect. The lower values of maximum temperature in IAS during summer months could be due to the failure of direct sunlight to reach inside closed type animal shelter and thatched roof insulation, which prevented the rise of ambient temperature much beyond that in open, whereas the refection radiation in addition to direct radiation caused higher maximum temperature in TAS. The higher level of relative humidity in IAS has been observed, which could be due to low ventilation means and less air flow inside shelter.

Production performance of goats under Improved Animal Shelter

(1) Milk Production Performance: The study showed that despite the better adaptability of Marwari breed to the climate of this region, goats of traditional animal shelter (TAS) produced lower milk yield (129.3 lit.) during lactation than the goats of IAS group, which produced 157.6 lit of milk. The peak yield of this group was also found higher 1.46 lit as compared to 1.38 lit in Group-I. (Table-2). The reason of higher milk production performance in IAS was probably due to complete protection of goats from cold weather in winter season. Whereas, the goats housed in traditional shelter were unprotected due to open type shelter with only simple thatched roof. During night in winter, the effective temperature of the outer environment may be very much lower than the absolute air temperature because of increased radiant losses to the night sky. This result in increase in the rate of loss of body heat and therefore, the feed energy requirement is utilized for maintaining the optimum body temperature rather than for the production of milk. On the other hand the provision of proper shelter i.e. closed type with open space reduces the animal's metabolizable energy requirement. Thus, the energy available with the animal is utilized for production purpose in proper shelter conditions.

Table: (2) Lactation performance of Marwari goats under different housing systems.

Parameters	Traditional Animal Shelter	Improved Animal Shelter
90 –Days Lactation Yield (lit)	64.0±6.2	69.3±5.0
Total Lactation Yield (lit)	129.3±10.1	157.6±20.8
Lactation Length (days)	180.5±17.5	193.0±18.8
Peak Yield (lit)	1.38±0.14	1.46±0.16
Fat (%)	3.42±0.13	3.60±0.10
SNF (%)	8.18±0.10	8.29±0.07
TS (%)	11.69±0.19	11.89±0.18

The kidding of Marwari goats takes place during the period from mid-September to December months. The first two winter months October and November are comfortable for the goats from the climate point of view. However in later two to three months i.e. from December to February, animals undergo cold stress especially during night hours due to lowering of the atmospheric temperature and blowing of chilled air (Fig.-2) As per the lactation curve, the lactation performance of goats is on peak in these months. Therefore, the peak lactation of the goats during winter can be protected with provision of Improved Animal shelter in the arid region. Keeping this finding, the housing practice ought to be adopted to achieve the optimum milk yield in goats of this arid region.

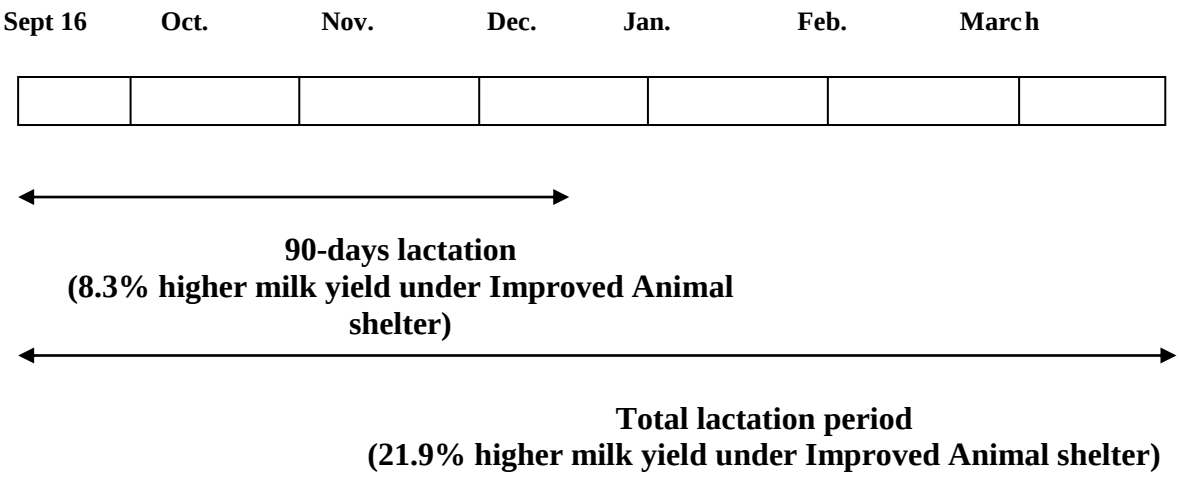

Fig. 2 Lactation period of Marwari goats in a calendar year

(2) Growth performance: Six month old kids of Marwari and Parbatsari breeds (10 from each breed) were maintained under traditional animal shelter (TAS). Whereas, kids of another group were kept under Improved Animal Shelter (IAS). The lower minimum temperature was observed in TAS, whereas, the lower maximum temperature was observed in IAS during the summer period i.e. May to October months. The micro-climate of TAS was close to macro-environment because it was open from all sides and only roof is covered by thatch, which could provide only shade to the animals.

The kids were kept for six months period of experimentation from May to October, which was hot dry and hot-wet weather. Both the groups were stall fed with 400 gm./day/kid Lentil dry fodder and 200 gm PCF (CP 18%) up to end of June, after which the quantity of fodder given was increased to @ 600 gm/day/kid. These kids were also let out for grazing in closed fenced area of the farm from July onwards. The animals of Group-I was let out after 10 AM for three hours and Group-II was let out in early morning from 7 AM to 10 AM. Water was supplied *ad libitum* to these animals.

Table (3): Water intake (lit) of Male kids in two different housing system during hot months.

Months	Improved Animal Shelter(kid/day)	Traditional Animal Shelter (kid/day)	Difference	Percent Difference
May	1.76	2.18	0.42	23.9
June	1.80	2.45	0.65	36.1
July	1.32	1.60	0.28	21.2
August	1.37	1.41	0.04	2.92
Average	1.56	1.91	0.35	21.03

Table (4): Body weight of male kids under different housing systems during hot season.

Type of shelter/Age	Traditional Animal Shelter		Pucca Animal Shelter	
	Marwari	Parbatsari	Marwari	Parbatsari
6 Months	12.24±1.84	16.60±1.87	12.52±2.06	15.60±2.21
9 Months	14.16±2.14	19.30±1.21	16.24±2.37	20.10±2.18
12 Months	19.76±2.00	24.60±2.46	22.04±2.64	26.45±2.34
Body Weight Gain	7.52±0.60	8.00±0.68	9.52±0.70	10.85±0.43

Higher water intake was observed in kids of Group-I (1.91 lit./day/kid) than the Group-II (1.56 lit/day/kid).The difference between water intake in two groups was more

visible during hot dry months in comparison to hot humid months (Table-3). Higher body weight gain was achieved in kids of Group II. The average body weight gained was 10.2 kg. in kids kept under Improved Animal Shelter, whereas 7.8 kg. body weight was increased in kids of Group I (Traditional Animal Shelter) during the experimental period.

When these breeds were compared, higher body weight gain was found in Parbatsari than Marwari kids, but the difference in between two breeds was more visible in IAS group (Fig.-3). Parbatsari kids gained 10.85 kg. body weight and Marwari gain 9.52 kg. in Group II, whereas, body weight gain was more or less similar in both breeds in Group I, which was 7.52 and 8.0 kg. for Marwari and Parbatsari kids, respectively (Table-4)

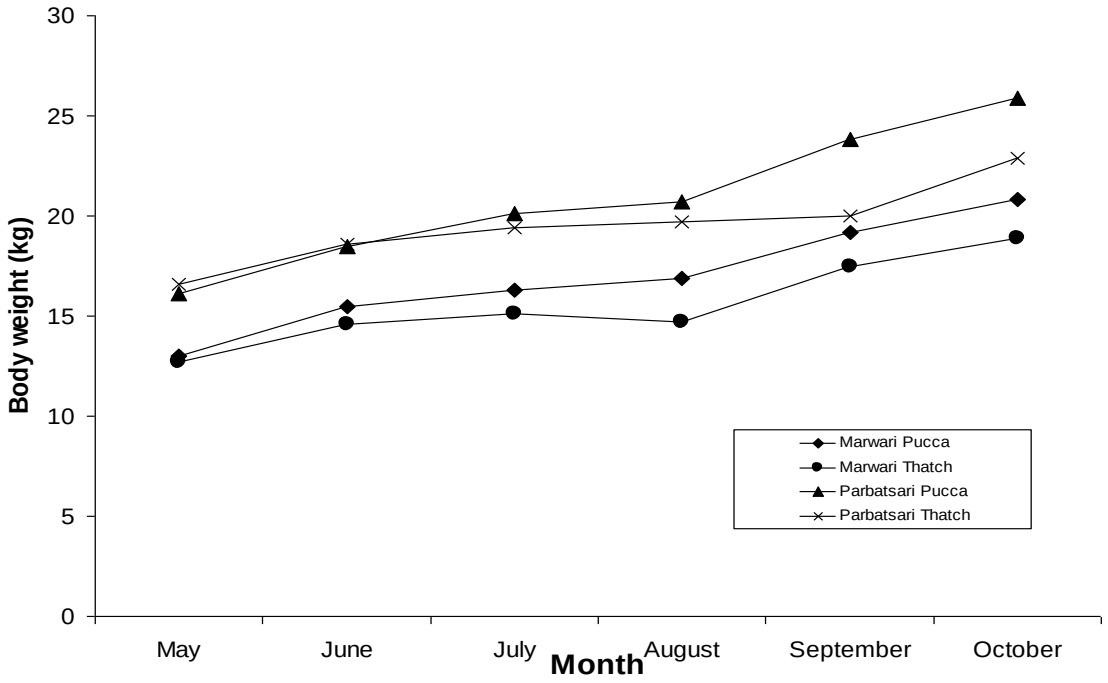

Fig.3 - Body weight gain of male kid under different housing system

(3) Behavioural changes: The behavioural changes in goats due to climatic variations under different housing system were also studied. During early morning hours of very cold days, when minimum temperature was recorded to 8 degree ºC with cold waves from north direction, goats in open housing system showed shelter-seeking behaviour. Animals tried to conserve body heat by reducing the body surface area with erected coat hair and huddling. While, the goats of pacca housing system (i.e. closed type) were found inside the closed area of the shelter. The low atmospheric temperature together with chilled winds affect the

productivity at greater extent because wind increases the loss of body heat from the surface of an animal.

Conclusions

The role of livestock in livelihood of rural people and food security is very well acknowledged. In climate change scenario intensity of extremes of hot and cold weather will increased further, which affect the productivity of small ruminants despite of their hardiness character against harsh climatic conditions. The effort in selecting animals should be primarily planned toward robustness and above all adaptability to heat stress. Animal scientists work with scientists of other disciplines to get solutions to overcome the problems of degradation of pasture lands, non-availability of good quality of forage, thermal stress etc. Efforts are needed to enhance forage availability through crop residues, grasses, weeds, monsoon herbages, forest etc. to the animals. Research must continue in developing new techniques of cooling systems such as thermo-isolation and concentrating on techniques requiring low energy expenditure. Tree shed has been found to be common available shelter to the livestock, with its limitations. Closed type shelter with open space for free movement for livestock, has been found to be most suitable animal shelter in extremes of climatic conditions.

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Chapter-7

Transferable Technologies of Rapeseed-Mustard

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Introduction

The slow growth rate in oilseed production combined with the high expenditure elasticity for edible oils has led to an increase in demand which was met through imports causing a significant drain on foreign exchange. Enhancing the domestic edible oil availability is one of the prime concerns of the policy planners to check the rising edible oil imports. Rapeseed-mustard is one of the important sources of edible oil in the country which has made a significant contribution to domestic edible oil availability over the last few decades. In India, rapeseed-mustard is one of the important crop among nine cultivated oilseed crops. The crop is grown in diverse agro-climatic conditions ranging from north-east to north-west and northern India to the south with wide acceptability as an edible oil.

The crop is grown as sole or in mixed cropping under both rainfed as well as irrigated conditions. The production and productivity of rapeseed-mustard in India showed a steady positive trend in the last three decades. The productivity level of rapeseed-mustard increased from 560 kg per ha during 1980-81 to 1524 kg per ha during 2020-21. The production of rapeseed-mustard also increased during the period from 2.3 million tonnes in 1980-81 to 10.21 million tonnes in 2020-21. Rapeseed-mustard crop has good production potential, where the cultivation is supported with technology and knowledge inputs.

Over the last decade, the number of rapeseed-mustard technologies have been developed, yet for certain proven technologies, there is a profound adoption gap particularly among smallholder farmers. Increased technology adoption, broadly defined to include adoption of improved agricultural practices, crop varieties, inputs and associated products has the potential to contribute to economic growth through increasing production and productivity of rapeseed-mustard.

Major technologies of rapeseed mustard recommended by ICAR-DRMR, Bharatpur are discussed in detail as given below:

1. Selection of Varieties

The selection of the appropriate variety suited to the growing condition and specific characteristics of the region is the most important factor in determining the yield and production of the crop. A large number of varieties suited for cultivation in various parts of country have been identified and notified under the All India Coordinated Research Project on Rapeseed and Mustard (AICRP-RM). The adoption of improved and suitable variety alone can make significant difference in the crop productivity. On the basis of recommendation of AICRP-RM/state/SAUs and results of FLDs, the following varieties are most suitable (Table1)

Table1: Recommended varieties of rapeseed-mustard

Variety	Maturity (Days)	Oil (%)	Yield (Kg/ha)
Indian Mustard			
Timely sown Irrigated condition			
DRMRIJ-31 (Giriraj)	137-153	42	2246-2757
RH-0749	146-148	39.5	2600-2800
NRCDR-02	131-156	40	1900-2600
RRN-573	137	41.85	2072
NRCHB-506 (Hybrid)	130-140	41	1550-2542
Rainfed condition			
DRMR 1165-40	141-142	41-41.5	2200-2600
RH-725	141	42.2	2370-2810
RH-761	137-143	40-41	2500-2700
RH-0406	142-145	39.0	2200-2300
RGN-229	146	40.7	2360
RGN-298	134-157	37-41.5	2062-2245
Late sown condition			
DRMR 2017-15 (Radhika)	122-139	40-41	1686-1847
DRMRIC 1638 (Brijraj)	122-139	39-40	1681-1801
CS-56	113-147	38	1170-1425
NRCHB-101	105-135	35- 42	1382-1491
Pusa mustard -26	115-137	30-41	1481-1895
RGN-145	121-141	35- 39	1448-1640
RGN-236	127	39.1	1636
Saline and sodic condition			
CS-58	128-142	38.5-39.5	1734-2168

CS-60	125-132	40-41	2000-2200
Quality Mustard			
PM-29	143	37.2	2169
PM-30	137	38	1824
Pusa Mustard-31 (PDZ-1)	142	40.7	2020-2500
Pusa Mustard-32 (LES 54)	141	37-39	2600-2820
Pusa Mustard-33 (PDZ 11)	141	38	2644
RLC-3	145	41.5	2175-2435
Taramira			
RTM 1355	133-145	38-39	1300-1400
Toria			
TS-38	90-95	40-41	1200
TS-46	94	40-41	900
TS-67	90	40-42	700
Yellow Sarson			
NRCYS05-02	94-181	40-46	1239-1715
YSH401	110-113	43-45	1273-1651
Pitambri	110-115	40-48	1417-1765

2. Seed treatment

Prophylactic seed treatment is one of the low cost technologies which can contribute to higher productivity of rapeseed-mustard crop. The seed treatment provides protection against a range of diseases. The recommended dosage of chemicals for seed treatment is given in Table 2.

Table 2: Recommended seed treatment for rapeseed-mustard

Fungicide	Dose (g/kg seed)	Disease
Apron SD 35	6.0	White rust and Downy Mildew
Carbendazim	2.0	Sclerotinia stem rot
Captan	3.0	Root Rot and Wilt
Trichoderma	8-10	Sclerotinia stem rot
Imidacloprid	5	Painted bug

Seed should also to be treated with Azotobactor+ PSB each 250 gm in formulation per ha seed.

3. Land preparation

Preparation of the land is important for maintaining a proper tilth and other soil characteristics required for the crop. Adoption of proper land preparation technology also helps to reduce the pest and diseases infecting the crop apart from providing good control of weeds in the field. The following aspects should be kept in mind during land preparation.

- Deep ploughing during summer should be done, which helps to destroy pests.

- Under irrigated condition, first ploughing should be done with soil turning plough followed by 3 to 4 harrowing or ploughing and planking after every ploughing. Pulverize the soil, using cultivator before sowing.
- Under rain-fed condition, disc harrowing should be carried out after every effective shower in monsoon to conserve soil moisture. Planking should always follow the harrowing or ploughing to avoid clod formation and moisture loss. Pulverize the soil, using cultivator before sowing.

4. Date of sowing

Timely sowing is an important aspect to obtain good seed and oil yield and the timely sown crop often escapes diseases and pest attack. Delayed sowing of the crop could result in reduced yield and increased incidence of pest and diseases. Since rapeseed-mustard crops are grown in diverse agro-climatic conditions, the optimum sowing time varies widely. It should also be ensured that crop is sown when the maximum daytime temperature is not more than 32^0C, which is essential for proper germination of the seeds. The rain-fed crop of Indian mustard should be sown during the period between 25th September and 15th October. The recommended period of sowing for normal sown irrigated crop is the month of October and the late sown crop can be sown as late as the first week of November. The toria crop can be sown up to 7th September and *Taramira* should be sown during the period between 25th September and 15th October. Timely sowing of the crop is an important non-monetary technology intervention for enhancing crop productivity.

5. Seed rate and spacing

In general, the optimum seed rate is four to 3-4 kg/ha. The distance between rows should be 45 cm and plant to plant distance within the row should be maintained between 10 -15 cm, when Indian mustard is grown under rain-fed conditions. In timely sown Indian mustard crop grown under irrigated conditions, the row to row spacing should be 30 cm and plant to plant spacing within the row should be 10-15 cm. The proper spacing can be ensured by the use of seed drills. The method of line sowing using seed drills gives a higher yield per unit area when compared to broadcasting of seeds.

6. Thinning and interculturing

To keep an optimum plant population per unit area and uniform plant growth, thinning operation by removing the extra plants should be done at 15 to 25 days after sowing. Thinning operation provides good aeration to the roots, conservation of moisture and removal

of weeds. Apart from thinning intercultural operation should be done with double wheel hand hoe before the first irrigation.

7. Nutrient management and dosage of fertilizers

Rapeseed-mustard is an energy rich oilseed crop which requires adequate quantity of nutrients. Keeping in view, the diversity in the nature of soil, cropping sequence and agro-climatic conditions, the application of fertilizers should be done based on regular soil testing, which can help in determining the exact fertilizer dosage required. Fertilizer recommendations must be modified based on soil test value for attaining better nutrient use efficiency and for minimizing the cost of fertilizers. The general recommendation of fertilizers a is given below in Table 3

Table 3: Recommended Dosage of Fertilizers for rapeseed-mustard

Crop	Irrigated Condition			Rain-fed Condition		
	N	P	K	N	P	K
Mustard	60-100	30-40	20-30	30-40	20	0
Taramira	-	-	-	20-40	15	0

These recommendations are general in nature and the actual fertilizer requirement may vary depending upon the soil test values and cropping systems. Along with the right quantity of fertilizers the timing of fertilizer application is also important for the crop. The following aspects should be kept in mind while deciding the dose and timing of fertilizer application

- Half of the recommended dose of N should be applied as basal at the time of sowing preferably through drilling at least 5.0 cm below the seeds for proper absorption. The remaining half should be applied by top dressing before the first irrigation and necessarily before flowering. Best nitrogen use efficiency can be obtained by combining soil application with the foliar application of 20 kg N /ha (concentration of urea < 2 %) 30-35 days after sowing.
- Full dose of phosphorous (P_2O_5) is recommended as basal application at the time of sowing of irrigated crop. If the soil test values indicate deficiency of potash (K), apply the full dose of potash at the time of sowing under irrigated condition.
- Sulphur nutrient is important for oilseed crops and it helps in increasing the oil yield and is recommended @ 40 kg/ ha for deficient soils under irrigated condition. Sulphur requirement can be met by applying single super phosphate or gypsum.

- The deep rooting habit of Brassicas is partially helpful in meeting its micronutrient requirement in normal soils. However, boron and zinc nutrient deficiency is reported from many regions. Soil testing should be done to judge the status of availability of these nutrients in the soil. In soils deficient in Boron and Zinc application @ 1 kg boron/ha and 25 kg zinc sulphate/ha is recommended at the time of sowing.

8. Irrigation: management and scheduling

The rapeseed-mustard crop requires about 190-400 mm of water. In general, two irrigations are recommended for Indian mustard. These irrigations are to be given at 30-40 days after sowing and 70-80 days after sowing.

9. Intercultural operations

Intercultural operations should be done 20-25 days after sowing of the crop. It helps in removal of weeds and conservation of soil moisture, which is important, especially in rainfed areas. The crop should be thinned 15-21 days after sowing to maintain a distance of 10-15 cm between plants in a row. Presence of weeds in the field reduces the nutrient availability to the crop and leads to competition for other resources. This will result in reduction in yield of the crop. Therefore the field should be kept free from weeds. The weeding should be done either along with thinning or immediately after thinning. Mechanical weeding using double wheel hand hoe is recommended since manual weeding with traditional *Khurpi* is time consuming and expensive. Mechanical weeding also improves the aeration of the soil.

10. Harvesting, threshing and storage management

The proper harvest, threshing and storage of the crop is important. The crop should be harvested when 75 per cent of pods turn to golden yellow in colour. At this stage, majority of seeds are firm when pressed between fingers. After harvesting, the harvested plants are made into bundles and stacked in the sun in for 7-8 days before threshing. Threshing should preferably be done by using threshers. Threshing is followed by winnowing, where the seeds are separated from the straw. The seeds should be sun dried for approximately one week to reduce the moisture content. For safe storage, moisture content of seeds should be eight per cent

11. Insect-pest and Disease management

11.1 Insect-pest management

Among the major insect pest in rapeseed-mustard, mustard aphid (Lipaphis erysimi), saw fly (*Athalia proxima*), painted bug (*Bagrada cruciferarum),* pea leaf miner

(*Chromatomyia horticola*), bihar hairy caterpillar (*Spilosoma obliqua*) and Diamond back moth (*Plutella xylostella*) are the important pests.

11.1.1: Management of Mustard aphid (*Lipaphis erysimi*):

Grow improved and early maturing varieties of Indian mustard (Brassica juncea) as they are fairly tolerant to mustard aphid and have more yield potential than rapeseed (Brassica campestris). Early sowing of the crop (Before 15th October) can help the crop to avoid the infestation by mustard aphid. Other management strategies include

- Use the recommended fertilizer dose, monitor the crop field, especially during the month of December and January, when the chances of infestation and resultant yield losses remain high. Pluck and destroy infested twigs 2-3 times at 10 days interval during this period to prevent the multiplication of aphids.
- Apply chemical control when the aphid population reaches the economic thresh-hold level (ETL). Generally, ETL is reached when 25-26 aphids/ plant is observed in at least 10 per cent of the plant population.
- Foliar spray of 2% neem oil or 5% Neem Seed Kernel Extract (NSKE) dissolved in 700-800 litre of water/ha is effective and avoid toxicity to pollinators.
- Use predators such as coccinellids, syrphid and lacewing, etc to minimise the incidence.
- Chemical control is done by spraying Oxydemeton methyl 25 EC @ 1.0 litre dissolved in 700-800 litres of water/ha when ETL is reached. Repeat the spray at 15 days interval, if the aphid population builds up again. Spray the pesticides in the afternoon (after 4 PM) to avoid toxicity to insect pollinators

11.1.2: Management of Painted bug (*Bagrada cruciferarum*)

- Deep ploughing of the field in summer, clean cultivation by weeding, hoeing and destroying of debris in and around the field, apply first irrigation 3-4 weeks after sowing of the crop, harvest the crop at appropriate time (75% pod have golden yellow colour) and thresh as early as possible to avoid the further losses will help in management of the insect.
- Seed treatment with imidacloprid 70WS @ 5g/kg seed.
- Conserve bio-control agents such as *Alophora* spp. (tachinid fly) parasitizing eggs of painted bugs.

11.1.3: Management of Mustard sawfly (*Athalia proxima*)

- Deep ploughing of the field in summer to destroy the pupae, clean cultivation by weeding, hoeing and destroying of debris in and around the field, early irrigation helps in killing the larvae through drowning.
- Conserve *Perilissus cingulator* (parasitoids of the larvae), and the bacterium *Serratia marcescens* which infect the larvae of sawfly.
- Spray the crop with malathion 50 EC @ 500 ml in 500 litre of water in one hectare. Repeat the spray if population builds up again.

11.1.4 Management of Bihar hairy caterpillar (*Spilosoma obliqua*)

- At the initial stages destroy the pest through hand collection, which is effective and eco-friendly and collect the infested leaves and dip them in kerosene or any insecticide treated solution.
- Conserve the natural bio control population of spiders, long horned grasshoppers, praying mantid, robber fly, ants, green lace wing, damsel flies/dragon fly, flower bugs, shield bugs, lady bird beetles, ground beetle, predatory cricket, earwig, braconids, trichogrammatids.
- Dust the border of fields with Malathion 5% dust to check the spread of larvae to new fields. Dust the crop with Malathion 5% dust @ 25-30 kg/ ha against young caterpillars.
- Spray the crop with malathion 50 EC @ 1.0 litre in 500 litre of water in one hectare. Removal of alternate host plants from the surroundings of the field is beneficial

11.1.5: Management of Pea leaf miner (*Chromatomyia horticola*)

- Pluck the infested leaves and bury them to kill the maggots and pupae resting inside.
- Parasitoids: *Gronotoma micromorpha (larva and pupa), Diglyphus isaea(larva) Halticoptera circulus and Opius phaseoli (pupal) Chrysocharis pentheus, Neochrysocharis formosa* (westwood)
- Predators : Lacewings, ladybug beetle, spiders, fire ants
- Foliar spray of systemic insecticide such as Oxydemeton methyl 25 EC @ 1.0 litre in 600-800 litre of water/ ha controls the pest effectively.

11.1.6: Management of Diamond back moth (*Plutella xylostella*)

- Collect and destroy pest infested leaves.

- Conserve *Cotesia plutelfae*, as it is an important parasitoid for diamond back moth.
- *Diadegma insulare* is the most important parasitoid of the diamondback moth.
- Application of 4% NSKE
- Spray the crop with malathion 50 EC @ 1.0 litre / ha in 600-800 litre of water.

11.1.7: Management Termite or white ant (*Odontotermus obesus*)

- Destruction of plant debris in and around the fields, deep summer ploughing, use only well decomposed farmyard manure, frequent irrigation helps in reduction of termite infestation, Arthropod predators of termites e.g. scorpions, frog, snakes, cricket, spiders, dragonflies, wasps and beetles. Some birds are also found to feed on alates swarmers, which consume about 10 to 30 per cent of swarmers.
- Entomopathogenic fungi like *Beauveria bassiana* 1kg multiplied in 50 kg FYM/compost can effectively control the termites.
- Application of chlorpyriphos 20 EC @ 4 litre/ ha during last ploughing and properly mixing in soil minimize the termite infestation.

11.2 : Disease Management

Diseases to a large extent are responsible for low and unstable production of rapeseed-mustard and cause the yield losses up to 90 per cent. The important diseases affecting the production and productivity of rapeseed-mustard are alternaria blight, white rust, downy mildew, powdery mildew, sclerotinia stem rot and bacterial rot.

11.2.1 Management of Alternaria blight or leaf spot *(Alternaria brassicae)*

- Timely sowing (by the first fortnight of October) of healthy and certified seeds
- Collect and burn the diseased plants debris and remove weeds to minimize the spread.
- Avoid irrigation at pod formation stage.
- Spraying of Iprodione @ 2 g per litres of water or mancozeb (dithane M-45) @ 2.5 kg/ha at 15 days interval with a maximum of three sprays, normally at 45, 60 and 75 days after sowing or Tebuconazole 50%+ Trifloxystrobin 25% 1 g /lit of water at 45 and 75 DAS (use 700-800 lit. water/ha).

11.2.2 Management of White rust (*Albugo candida*) and **Downy mildew** (*Peronospora parasitica*)

- Timely sowing (Before October 15) of healthy and certified seeds from stag head free plants
- Treat the seed with Metalaxyl (Apron 35 SD) @ 6 g/ kg seed.
- Collect and burn the diseased plants debris including stag heads and remove weeds to minimize the spread.
- Spray the crop (maximum three sprayings) with Ridomil MZ 72 WP @ 2 kg/ha dissolved in 800 litres of water soon after the disease appearance at 15 days interval.

11.2.3: Powdery mildew (*Erysiphe cruciferarum*)

- Timely sowing (by the first fortnight of October) and avoid late sowing and collect the crop debris of previous season and destroy them.
- Spray of 1 kg Dinocap or 2 kg wettable sulphur/ha dissolved in 800 litres of water at the incidence of the disease. If required, repeat the spray at 15 days interval.

11.2.4: Sclerotinia rot *(Sclerotinia sclerotiorum)*

- Collection and burning of the diseased plants along with sclerotia.
- Deep ploughing during summer.
- Follow crop rotation with non-host crops like wheat, barley and maize
- Sowing of healthy seeds free from the sclerotial bodies.
- irrigation management (no irrigation during 25 Dec-15 Jan)
- Seed treatment with Trichoderma 10g/kg seed
- Foliar Spray of carbendazim 2g or Tebuconazole 1 ml /lit of water at 60-70 DAS (use 700-800 lit. water/ha)

11.2.5: Management of Bacterial rot (*Xanthomonas campestris)*

- Follow 3-4 years crop rotation.
- Spray carboxin or Copper oxychloride @ 2.5 kg/ ha dissolved in 800 litre of water. If required, repeat the spray at 15 days interval.
- Collection and burning of the diseased plants and their residue.

12. Exploitable yield reservoir in rapeseed-mustard in Rajasthan

The adoption of improved technologies can enhance both yield and farm income. It is evident that the productivity potentials and profitability of improved rapeseed-mustard production technologies, there exists vast potential in the country to improve the rapeseed-mustard productivity under real farm situations.

There is an urgent need for effective transfer of improved rapeseed-mustard production technologies to the rapeseed-mustard growers in order to convince them to adopt such technologies so that yield gaps can be bridged and rapeseed-mustard production in the country and in turn country can be stepped up.

Chapter-8

Entrepreneurial Opportunities for rural youths in R&M Sector

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Introduction

Since independence, oil seed crops have been the focus of our policymakers with an objective to contain imports and make India self Sufficient. The efforts in this direction are still in vogue. The total domestic demand for edible oils in the country is approximately 250 lakh metric tons per year. Interestingly, around 60% of the edible oils consumed in the country are met through imports. Palm oils (crude+ refined) import constitute around 60 % of the total edible oil imported.

Industry players say that India's domestic oilseed production needs to go up about 54 MT by 2025 to reduce edible oil imports by 10 MT annually. Earlier, Technology Mission on oilseeds (1986), did not yield desired results. Recently National Mission on Edible oil -oil Palm has launched by the Union Government. Under this mission, the government has proposed to reach the total under oil palm to 10 lakh hectares. Oil seed crops are less productive and grown in dry lands, so the returns to the farmers are not encouraging. The average per-hectare yield of major oil seeds is about 50 % lower than the average yield in several crops. Therefore, the MSP for oil seeds should be encouraging farmers to compensate for the income gap.

The marketable surplus with oil seed farmers is low and hence it is not economical for them to reach far-off procurement centers. So they invariably resort to selling in the villages. Therefore, it is necessary to establish procurement centers in the vicinity of producing areas. Also enabling environment is to be created for the farmers to sell their produce directly to the millers or cooperative societies. Timely availability of credit, inputs, storage facilities, and market support will help in the expansion of the area under oil seed crops. Consistency in tariffs, duties, and import policies for oil seeds should be maintained to gain the confidence of producers, processors, and trading agencies. Indian soya meal is largely from non-GM crops and hence has high demand in the world market. By all means, the soya meal exports should be given priority. The ambitious policy to increase the productivity and area under oil seeds, and palm oil should be supported by an adequate market network, price support, price stabilization, and efficient supply chain operations for both raw and value-added produce.

In order to enable unemployed workforce in agriculture sectorand overcome constraints of poor awareness, scale of economyand low risk-taking ability, provisions have been created in law to facilitate formation of Farmers Producers Companies (FPC) to undertake agribusiness activities like other business entities. Recently, NABARD and other organizations have taken initiatives to establish the Farmer Producer Organizations with common agricultural as well as specific commodity targets. Commodity specific FPOs are being registered either under the Cooperative Societies Act or Indian Companies Act. ICAR also strengthened Institute Technology Management Units (ITMU) by establishing Agri Business Incubation (ABI) Centers to facilitate the start -up in agricultural sector.

About ABI Host institute

The Indian Council of Agricultural Research, New Delhi established Directorate of Rapeseed-Mustard Research (DRMR) on October 20, 1993 at Bharatpur, Rajasthan to develop location specific ecological sound and economical viable production and protection technologies for rapeseed-mustard, their assessment and dissemination. Besides the basic and strategic research in Rapeseed-Mustard, being the Project Coordinating Unit at DRMR, it is also co-ordinating and managing the Rapeseed-Mustard research having a strong network of 181 scientific, technical and administrative personnel at 11 main-and 12 sub- centers spread over 17 states in country.

Objectives

- O Utilizing frontier research for better exploitation of genetic resources.
- O Development and identification of appropriate production-protection technologies.
- O Capacity building and knowledge management through technology assessment, refinement and dissemination.

Functions

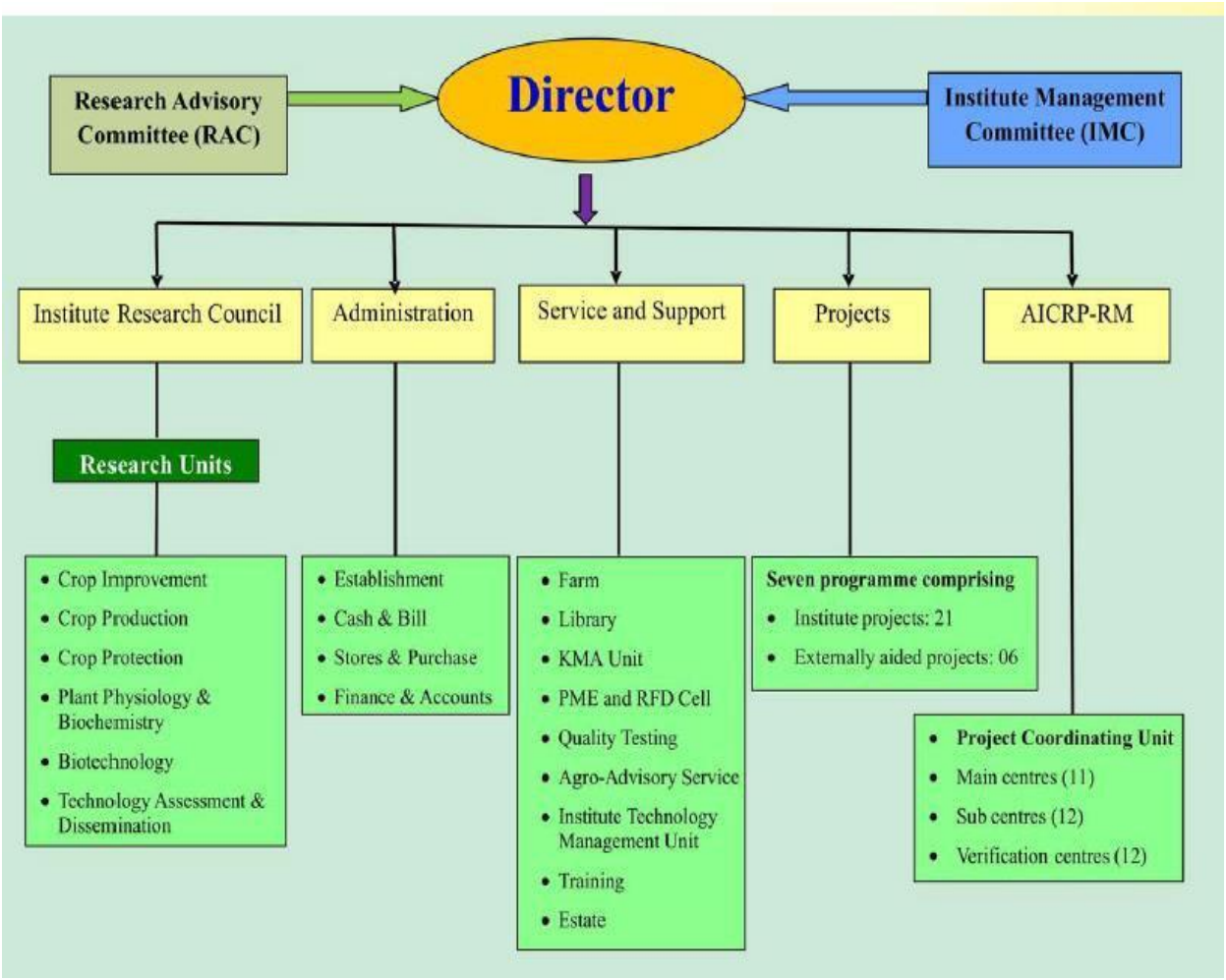
- National repository for rapeseed-mustard genetic resources and information.
- Basic, strategic and applied research to improve the productivity and quality of oil and seed meal.
- Development of ecologically sound and economically viable production and protection technologies for different situations.
- Generation of location specific interdisciplinary information based on multi-location testing and coordination.

- Establishment of linkages and promotion of cooperation with national and international agencies to achieve above objectives.
- To extend technical expertise and consultancies

Agri-business Incubation Centre

The ICAR- Directorate of Rapeseed-Mustard Research is prepared to host Agri-business Incubation (ABI) Center because of following vantage points and has been successfully running it the past two years:

1. The Institute is one of its kinds in the Indian Council of Agricultural Research (ICAR) where research and development in rapeseed-mustard and value addition goes hand in hand. Technology Business Incubator facilitates the transferring of technology for commercial and social use in most supporting manner involving its existing stakeholders.
2. Institute has best infrastructure resources for linking both agriculture and industry.
3. Locational advantage, since Bharatpur, Rajasthan is a hub of both agriculture and related industries.
4. Institute has expertise in networking and joint collaborative programmes
5. Institute is endowed with project implementation on pilot basis which requires up scaling.
6. Availability of well-trained human resource of the institute to immediately gear up for undertaking the proposed initiative.
7. Entrepreneurship and innovation is the core expertise of the proposed coordinator Dr. Vinod Kumar for implementation & execution of ABI.
8. A competent institute for entrepreneurial activity on rapeseed-mustard value addition and commercialization.
9. Delivered an inspirational experience for youth to seriously take up the career in agribusinesses.
10. Synergistic effect due to strong research- industry – farmer linkages.



Scope for innovation and entrepreneurship

i. Technologies available and commercialized if any, in the previous three years as per the Table given below.

Name of Technology	Name of Private Partners/ Linkages developed	₹in Lakh
NRCDR- 2	J. K. Agri. Genetics Pvt. Ltd.	02.00
NRCHB- 506	Signet Crop Sciences India Pvt. Ltd. Gurgaon	03.00
NRCHB- 101	Signet Crop Sciences India Pvt. Ltd. Gurgaon	02.00
NRCDR- 2	Bayer Bio- Science Pvt. Ltd.	02.00
NRCHB- 101	Bio Seed Research Pvt. Ltd. India	03.00
NRCHB- 506	Bio Seed Research Pvt. Ltd. India	04.00
Voice based (Sun Sunayen Peet Kranti Layein)	Krishi Bharti Jaipur, a Monthly Agriculture Magazine.	00.10
Voice based (Sun Sunayen Peet Kranti Layein)	Halder Times Jaipur, an Agriculture News Paper.	00.10
Voice based (Sun Sunayen Peet Kranti Layein)	Society of Extantion Education, Agra	00.10
NRCHB- 101	Hytech Seed India Pvt. Ltd.	01.50
Giriraj (DRMRIJ- 31)	Kalash Seeds Pvt. Ltd.	01.50
NRCHB- 101	Nandi Seeds Pvt. Ltd.	01.50
Herbicides BAS 71401H	BASF, India Ltd Mumbai	12.792
NRCHB- 506	Genesis Seed Company, Agra	01.50
NRCHB- 506	VNR, Seeds pvt.ltd.	01.50

Seed & Planting Material: Hybrids, Varieties, Parental Lines and Value Added Genetic Stocks available for licensing and commercialization

a. National extant and new rapeseed-mustard varieties and hybrids

Name of Cultivar	Registration No.	Name of Cultivar	Registration No.
Uttara(PT 2002-25)	REG/2013/11	CS56 CS234-2	REG/2012/642
Pant pili sarson 1 (PYS 2005)	REG/2012/645	Geeta	REG/2013/29
YSH 0401	REG/2013/24	Gujrat mustard 3	REG/2018/181
Aravali	REG/2012/646	Kanti	REG/2013/9
Ashirwad	REG/2013/08	Maya	REG/2013/6
Basanti	REG/2013/10	Navgold (YRN 6)	REG/2012/648
CS 54	REG/2014/203	NRCDR 2	REG/2012/410
NRCHB 101	Extant variety	Registered	REG/2012/411
NRC HB 506 (Hybrid)	REG/2012/412	RCC 4	REG/2013/139
RB -50	REG/2013/26	RLC 1	REG/2013/178
RGN 13	REG/2013/4	PBR 210	REG/2013/179
RGN 48	REG/2013/5	KBS 3	REG/2013/144
RGN 73	REG/2013/3	GSC 5	REG/2013/143
RGN 145	REG/2013/2	GLC 6	REG/2013/142
RH 119	REG/2013/28	Neelam (HPN- 3)	REG/2013/141
RRN 505 (RN 505)	REG/2014/660	Him Sarson- 1 (ONK- 1)	REG/2013/140
Swarn Jyoti (RH- 9801)	REG/2013/27	NRCYS- 05-02	REG/2014/658
Urvashi	REG/2013/7	GIRIRAJ (DRMRIJ 31)	REG/2014/2135
Vasundhara (RH 9304)	REG/2013/25	DRMR 601 (NRCDR 601)	REG/2014/1258

b) Directorate has also registered rapeseed-Mustard germplasm for specific traits.

Crop name	Year	Pedigree	Novel unique features
Brassica carinata			
Karan rai	2010	VARUNA/BPKR 13	Early maturity (135 days), long shoot (110 cm) and bold seed (1000 seed weight:5.5 g)
Karan rai	2011	MJA 1 (B. juncea) x KR 9 (B. carinata)	For male sterility
Brassica napus			
Rapeseed	2010	BEC 107 (B.juncea) x NRCG 11 (B.napus)	Early flowering (34 days) and dwarf plant type (75 cm)
Brassica campastris			
Yellow Sarson	2013	Collection from West Bengal	Yellow sarson genotype with white flower.
Brassica juncea			
Indian mustard	2010	MDOC 8 x PCR 7	High WUE, thermo toleranace at terminal stage, salinity tolerance at juvenile stage
Indian mustard	2010	TM 2x PCR 9202	High WUE, thermotolerance at juvenile stage
Indian mustard	2011	PCR-20 X RH-30	Only for thermo- tolerance at juvenile stage
Indian mustard	2012	B 33 x Sanjucta asech	White petal colour
Indian mustard	2013	Chapka x PCR-9301	Salinity tolerance at juvenile stage, high WUE.
Indian mustard	2013	MDOC 8 x PCR 7	Salinity tolerance at juvenile stage, Thermo tolerance at juvenile stage.
Indian mustard	2015	(RH-819 x BPKR 13) x RH-819	Drought tolerance (high WUE under rainfed conditions).
Indian mustard	2017	HB 9916 X ZEM 2	Moricandia system based CMS line. Resistant to white rust disease.
Indian mustard	2017	EC399288 x BEC-107	White rust resistant.
Indian mustard	2017	PHR 1/BEC 107	White rust resistant.

i. Patents and other IPRs granted:

IPRs Granted:

- ***Registered Varieties with PPV & FRA*** Obtained the registration of 22 Rapeseed-Mustard varieties developed by the DRMR and AICRP centres for different agro-ecosystem form Protection of Plant Varieties and Farmers' Rights Authority, India.
- Obtained the registration of14 Rapeseed-Mustard germplasm developed by the DRMR for different specific traits
- ***Copyrights***

ICAR-DRMR, Bharatpur	10855/2016/CO/SW	RM select: Web based expert system for rapeseed-mustard variety selection
ICAR-DRMR, Bharatpur	11609/2016/CO/SW	Agri pubinfo- Agricultural public information management system

ii. Other notable activities in innovation and entrepreneurship:

- Organized National Seminar on "Strategic interventions to enhance oilseeds production in India February 19-21, 2015.
- Organized winter School "Strategies to enhance oilseed brassica production under climate and resource constraint scenario sponsored by ICAR during Nov. 11- Dec. 1, 2014.
- Organized winter School Winter School on new paradigms in diseases management: conventional and molecular approaches for rapeseed-mustard production. sponsored by ICAR during During December 09-29, 2015.
- Regularly organizing training program for extension personals, farmers.

iii. Recent one week Trainings programme organized for KVKs/ extension personnel/ farmers

Title	Participants	Sponsoring agency
Scientific production technology of mustard and Agriculture management	ATM/BTM/TA /Farmers	State Institute of Agriculture Management, Rehamankheda under ATMA, PD ATMA Pandit Deen Dayal Updhayay Unnat Krishi Shiksha Yojana State Institute of Agriculture Management, Rehamankheda under ATMA
Bee keeping and Agriculture management		
Scientific production technology of mustard and Bee Keeping		
Organic farming/ natural farming and cow based economy under		
Oilseed production Technology and its usefulness		

Beside above number of 2, 3 and 4 days training programme organized regularly. A total of 276 farmers and 100 field level extension workers were provided extensive training about scientific production technology of mustard and agriculture management through these programmes. Rapeseed-Mustard technology showcasing by organizing demonstration and exhibitions and farmer's fairs

Feasibility of ABI

The ABI will benefit immensely from the inherent strengths of the host institute ICAR – Directorate of Rapeseed-Mustard Research(DRMR), Bharatpur. The host institution ICAR – DRMR is the nodal central agency to work on all aspects of oilseed research and development mostly on rapeseed-mustard under the auspices of Indian Council of Agricultural Research (ICAR). ICAR-DRMR is engaged to conduct extensive research on all aspects of rapeseed-mustard and oil quality.

i. Strength of the Institute in hosting ABI

- DRMR is ISO 9001-2008 certified institute
- DRMR has Competent multidisciplinary team with deep knowledge on all aspects of the rapeseed-mustard, developed high yielding end use specific varieties and hybrids of mustard, Strong Thematic R&D and research leads and Strong PPP linkages with industry and allied sectors of agri business division (Mustard Oil Producer Association (MOPA), Jaipur, J. K. Agri. Genetics Pvt. Ltd., Signet Crop Sciences India Pvt. Ltd. Gurgaon, Bayer Bio- Science Pvt. Ltd., Bio Seed Research Pvt. Ltd. India, Hytech Seed India, Pvt. Ltd., Kalash Seeds Pvt. Ltd., Nandi Seeds Pvt. Ltd., Genesis Seed Company, Agra, VNR, Seeds pvt.ltd. , Jabalpur Krishi Bharti Jaipur, Halder Times Jaipur and other Oil Extraction Industries at Bharatpur)
- The training programmes at DRMR are giving extra impetus to preparedness of the directorate for such initiatives. The directorate has developed strong network with Kishan clubs, NGOs and other stakeholders. These group would be ready to work and provide needed support in Incubation process.
- Directorate has been continuously engaged in research, training, and consultancy activities. The researchers have gained experience and recognition at national and international platforms in public sector, private and other non-ICAR forums.

- ICAR-DRMR has following state-of-art laboratories to cater research needs of potential entrepreneurs (biochemistry, Biotechnology lab, centralized instrumentation facility etc.)
- Well established seed processing unit with latest machineries over Rs 1.5 crores and well equipped quality control lab.
- The ICAR-DRMR, as an institution for rapeseed-mustard research has a key role in enabling the AICRP Centres to remain vigilant about constraints and develop ecological and economical viable solution. The directorate has yearly reviewed and reorganized its programmes and activities during the Annual group meeting in accordance with the changing requirement.

ii. Overall business environment of the location and ecosystem in the region

- DRMR is Located in Bharatpur district of Rajasthan where large number of oil industries (more than 150 edible oil extraction units including big and small) are established, these will be effectively co-ordinated through our ABI
- The Directorate has natural advantage of agribusiness entrepreneurship development Initiatives related to rapeseed-mustard and edible oil. The DRMR is situated in Rajasthan the state known as oilseed hub in country and alone contributes more than 45% of total Rapeseed-Mustard production in country. Bharatpur itself has big area of rapeseed-mustard production, and a big Mandi for sale of farmer produce. Therefore, region has the potential for business of rapeseed-mustard based technologies and products.
- The Directorate has all the basic infrastructure and space to house such centres by giving sufficient space to nurture the incubates in their needed fields of interests. There are 22 researchers with rich experiences in agricultural research as well as technology transfer. Therefore, the location and the ecosystem of the fully-integrated campus of the ICAR-DRMR is very much suited for ABI centre.
- The directorate is closely working along Oil industries, NGOs, SHG in the city and to state agriculture department, universities and other stakeholder which will help in development entrepreneurs across the country.

The main objectives of DRMR-ABI

- To provide congenial environment to commercialize rapeseed-mustard and other crops technologies.
- To give hand-holding support to entrepreneurs in developing and executing business plan with DRMR.

- To build and accelerate the oilssed-based small-scale industry clusters across the regions.

iii. Assessment of entrepreneurial needs

In agricultural research and development entrepreneurial development requires a shift from producer-driven to demand –driven or market-led agricultural development and has the potential to improve the livelihoods of the poor in rural areas, but it can also increase their vulnerability to climate and market stresses. What is needed in addition is an environment enabling entrepreneurship**.** The existence of such an environment largely depends on policies promoting agri-entrepreneurship. The effectiveness of such policies in turn depends on a conceptual framework about entrepreneurship, i.e., what it is and where it comes from.

iv. Sources of tapping new incubate entrepreneurs

The term entrepreneur implies qualities of leadership, initiative and innovation in manufacturing, delivery, and/or services. The **good entrepreneur has some skills like** High Risk Tolerance, Excellent Sales manship, An Independent Temperament, Great Negotiating Ability and Emotional Intelligence.

1. MoU with potential entrepreneurs under various business plans; licensing technology for processing and marketing or exclusively promotion and marketing.
2. Entrepreneurship development trainings for various stakeholders from across the country especially targeting new entrepreneurs.
3. Close tie up with Oil industries, state agriculture departments such as Rajasthan, UP, MP, Haryana, *etc*.

v. Processing unit

Establishing the oil expellers for primary processing and value addition could be a strategic approach to create the opportunities for rural employment. The present pre-intervention or value chain for Mustard may be viewed as one with three critical production-distribution or activity-marketing channels. Channel 1 may be viewed in terms of one for table variety and other for edible oil and De-Oiled Cake. The product is largely marketed by farmers through the APMC and village traders. Channel1 caters to the urban households and institutional buyers such as hotels, canteens and food joints which would take *kachhi ghani* oil in refined form and branded packaging at retail level such as Dhara, Dalda, Scooter, etc.

Eligible PHM & Primary Processing Activities for Oilseeds

Crops	Eligible PHM & Primary Processing Activities	Not eligible under AIF
Oilseeds	• Cleaning • De-stoning • De-husking (decorticating machines) • Winnowing • Oil extraction (ghani, hydraulic press etc.	• By-product utilization • Refining • Neutralization • Bleaching

The detailed information is given in ***Annexure*** 1 to ***Annexure*** 11

Contents Table for Annexures

Annexure 1 - Estimated cost of the project		Grand Total (in lakhs)
1	Land and site development	
(a)	Land (Lease in name of company)	-
	Total	-
2	Site Development	16.00
(a)	Total	16.00
3	Civil Work	
(a)	Civil Work	-
	Total	-
4	Plant and Machinery (indigenous)	
(a)	Plant and Machinery	46.00
	Total	46.00
5	Miscellaneous Fixed Assets	
(a)	Cost	-
6	Working Capital Margin	20.00
7	Preliminary Expenses	
(a)	Security Deposit	-
	Total	
8	Pre-Operative Expense	
	(for 6 months upto the date of commencement of commercial production)	
(a)	Establishment and Travelling and Other Expenses	-
(b)	Legal and Misc Expense	-
	Total	-
9	E mandi expense	-
	Total Cost of Project	82.00

Annexure 2 - Means of Finance		Grand Total (in lakhs)
1	Promoter's equity	8.20
2	Eligible Assistance	-
3	Term Loan	53.80
4	CC Limit	20.00
	Total	82.00

Annexure 3 - Complete Estimate of Civil and Plant and Machinery		Units	Amt
1	Building as per estimate	1	16.00
2.	Plant and machinery		46.00
1	Automatic Oil expeller	2	10.00
2	Motor	2	4.00
3	Oil filter		0.50
4	Boilers	2	0.80
5	Oil storage tank	3	0.60
6	Shaker with blower	1	0.30
7	Weighing scale	1	0.50
8	Packaging machine		2.00
9	Tractor (for foraying the produce to and from farm)		5.00
10	Electrical expense including generator		12.00
11	Bucket elevator	2	3.00
12	Seed cleaner		2.00
13	Conveyor belt	1	2.00
14	Oil testing equipment		2.50
15	Miscellaneous		0.80
Total Fixed Assets			62.00

Annexure 4 - Estimated cost of production									
Description	Year ending March 31st								
	I	II	III	IV	V	VI	VII	VIII	IX
No of Working months	12	12	12	12	12	12	12	12	12
Purchase of raw material input	2275.00	2559.38	2730.00	2900.63	3071.25	3241.88	3412.50	3412.50	3412.50
Electricity expense	118.00	123.40	129.07	135.02	141.27	147.84	154.73	154.73	154.73
Running and Maintenance expense @15% of procurement cost	341.25	383.91	409.50	435.09	460.69	486.28	511.88	511.88	511.88
Fixed running cost	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Cost of Production	2746.25	3078.68	3280.57	3482.74	3685.21	3887.99	4091.11	4091.11	4091.11
Add: Opening stock		26.30	54.48	84.54	116.48	82.67	46.97	9.39	
Less: Closing stock	26.30	54.48	84.54	116.48	82.67	46.97	9.39		
Sub Total	2719.95	3050.50	3250.51	3450.80	3719.03	3923.69	4128.68	4100.50	4091.11
Administrative salaries and wages	16.96	17.98	19.06	20.20	21.42	22.70	24.06	25.51	27.04
Packaging cost @ ₹2 per kg	63.00	67.50	72.00	76.50	81.00	85.50	90.00	90.00	90.00
Selling expenses @ ₹2.5 per kg	77.96	83.53	89.10	94.67	102.26	107.94	113.63	112.78	112.50
Total	157.93	169.01	180.16	191.37	204.68	216.14	227.69	228.29	229.54
Cost of Sales	2877.87	3219.51	3430.67	3642.18	3923.71	4139.84	4356.37	4328.79	4320.64
Expected sales revenue	2893.28	3254.93	3471.93	3688.93	3984.83	4206.21	4427.59	4394.71	4383.75
Gross Profit	15.40	35.42	41.26	46.75	61.12	66.37	71.22	65.92	63.11
Financial expense	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interest on Term Loan	3.20	2.79	2.30	1.80	1.30	0.81	0.31		
Interest on WC Loan	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
total	5.20	4.79	4.30	3.80	3.30	2.81	2.31	2.00	2.00
Operating profits (PBT)	10.20	30.63	36.96	42.95	57.82	63.57	68.91	63.92	61.11
Preliminary Expense									
depreciation	8.50	7.31	6.28	5.40	4.65	4.01	3.45	2.98	2.57
Net Profit before Tax	1.70	23.32	30.68	37.55	53.17	59.56	65.46	60.95	58.54
Income Tax	0.51	7.00	9.20	11.26	15.95	17.87	19.64	18.28	17.56
Profits after Tax	1.19	16.33	21.48	26.28	37.22	41.69	45.82	42.66	40.98
Distribution of profits (50%)	0.60	8.16	10.74	13.14	18.61	20.85	22.91	21.33	20.49
Profit transfer to balance sheet	0.60	8.16	10.74	13.14	18.61	20.85	22.91	21.33	20.49
1. Electricity are semi-fixed cost. ₹10,00,000 pa is fixed, balance is variable at ₹12 per unit usage									
2. Electricity usage in units is given below									
Usage in units	9.00	9.45	9.92	10.42	10.94	11.49	12.06	12.06	12.06
Variable cost	108.00	113.40	119.07	125.02	131.27	137.84	144.73	144.73	144.73
3. Closing stock is valued at ₹120 per kg									

Annexure 5- Projected balance sheet									
Description	Year ending March 31st								
	I	II	III	IV	V	VI	VII	VIII	IX
Asset									
Fixed Capital Expenditure									
Gross Block	62.00	53.50	46.20	39.91	34.51	29.86	25.85	22.40	19.42
Less- Depreciation	8.50	7.31	6.28	5.40	4.65	4.01	3.45	2.98	2.57
Net Block	53.50	46.20	39.91	34.51	29.86	25.85	22.40	19.42	16.85
Closing Stock	26.30	54.48	84.54	116.48	82.67	46.97	9.39		
Sundry debtors	289.33	271.24	289.33	307.41	332.07	350.52	368.97	366.23	365.31
Cash/ bank balance	164.33	132.98	122.02	110.71	163.28	225.54	291.19	327.64	351.61
Total assets	533.46	504.91	535.81	569.11	607.88	648.88	691.95	713.28	733.77
Liabilities									
Capital	8.20	8.80	16.96	27.70	40.84	59.45	80.29	103.20	124.53
Add- Profit	0.60	8.16	10.74	13.14	18.61	20.85	22.91	21.33	20.49
Less- Drawings									
Closing capital	8.80	16.96	27.70	40.84	59.45	80.29	103.20	124.53	145.02
Term Loan	49.66	41.38	33.11	24.83	16.55	8.28			
Working capital	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Creditors	455.00	426.56	455.00	483.44	511.88	540.31	568.75	568.75	568.75
Total liabilities	533.46	504.91	535.81	569.11	607.88	648.88	691.95	713.28	733.77
Current Ratio									
Current Assets	453.66	404.23	411.35	418.12	495.35	576.06	660.16	693.86	716.92
Current Liabilities	455.00	426.56	455.00	483.44	511.88	540.31	568.75	568.75	568.75
Ratio	0.997	0.948	0.904	0.865	0.968	1.066	1.161	1.220	1.261
Debt Equity ratio									
Debt	69.66	61.38	53.11	44.83	36.55	28.28	20.00	20.00	20.00
Equity	8.80	16.96	27.70	40.84	59.45	80.29	103.20	124.53	145.02
Ratio	7.92	3.62	1.92	1.10	0.61	0.35	0.19	0.16	0.14
Fixed asset coverage ratio									
Fixed assets	53.50	46.20	39.91	34.51	29.86	25.85	22.40	19.42	16.85
Debt	69.66	61.38	53.11	44.83	36.55	28.28	20.00	20.00	20.00
Ratio	0.77	0.75	0.75	0.77	0.82	0.91			

Annexure 6- Details of Manpower									
Debt service coverage ratio	I	II	III	IV	V	VI	VII	VIII	IX
Annual Wages	16.96	17.98	19.06	20.20	21.42	22.70	24.06	25.51	27.04
Interest on loan (TL + WC)	5.20	4.79	4.30	3.80	3.30	2.81	2.31	2.00	2.00
Instalment of loan	24.14	28.28	28.28	28.28	28.28	28.28	28.28	20.00	20.00
Total	29.34	33.07	32.57	32.08	31.58	31.08	30.59	22.00	22.00
Net operating income	15.40	35.42	41.26	46.75	61.12	66.37	71.22	65.92	63.11
Ratio	0.53	1.07	1.27	1.46	1.94	2.14	2.33	0.00	0.00

Annexure 7 - Computation of Depreciation				
Particulars	Building and civil work	Plant and Machinery	Misc Fixed Asset	Amount in lakhs
Cost	16.00	46.00	-	62.00
Pre operatives	-	-	-	-
Contingencies	-	-	-	-
Total				**62.00**
Rates of Depreciation	10%	15%	10%	Total depreciation for the year
1	1.60	6.90		8.50
2	1.44	5.87		7.31
3	1.30	4.99		6.28
4	1.17	4.24		5.40
5	1.05	3.60		4.65
6	0.94	3.06		4.01
7	0.85	2.60		3.45
8	0.77	2.21		2.98
9	0.69	1.88		2.57

Annexure 8 - Calculation of Income tax									
	Year ending March 31st								
Particulars	I	II	III	IV	V	VI	VII	VIII	IX
Net profit before tax	10.20	30.63	36.96	42.95	57.82	63.57	68.91	63.92	61.11
Add- dep on SLM									
Sub total	10.20	30.63	36.96	42.95	57.82	63.57	68.91	63.92	61.11
Less- Dep on WDV	8.50	7.31	6.28	5.40	4.65	4.01	3.45	2.98	2.57
Sub total	1.70	23.32	30.68	37.55	53.17	59.56	65.46	60.95	58.54
Less - Deductions									
Taxable profits	1.70	23.32	30.68	37.55	53.17	59.56	65.46	60.95	58.54
Income tax @30%	0.51	7.00	9.20	11.26	15.95	17.87	19.64	18.28	17.56

Annexure 9- Break even analysis (At maximum capacity utilization)			
Sales		0.00	4133.25
Variable cost		0.00	0.00
- Procurement cost of inputs		325,000,000	3250.00
- Running and maintenance cost		4,875,000	48.75
- Interest on Working capital		200,000	2.00
- electricity expense		14.56	3315.31
Contribution		0.00	817.94
Less: fixed cost		0.00	0.00
Wages and salaries		0.00	16.96
Depreciation		0.00	8.50
Electricity		0.00	10.00
Fixed running expense		0.00	12.00
Interest on TL		0.00	3.20
Fixed cost		0.00	50.66
Particulars	**Oil**	**Cake**	
Sales price per kg	160	39	
Procurement cost of rapeseed	36.11	26	
Running and maintenance cost	3.611	3.9	
Interest on Working capital	0.0400	0.040	
selling expenses	2.5	2.5	
Packaging cost	2	2	
Electricity charges	0.2912	0.29122	
Contribution per kg	115.44	4.26	
Contribution margin	72.154%	10.946%	
Sales mix	44.44%	55.56%	
Proportionate contribution	32.07%	6.08%	38.15%
BEP total in Rs.	13,279,420.68		
BEP	32.13%		

Annexure 10 - Repayment schedule				
Amount of Loan (in lakhs)			53.80	
Rate of interest			6.00%	
Moratorium period			6 months	
Year	Quarter	Balance outstanding	Principal instalment	Interest
1	1	53.80	0.00	0.81
	2	53.80	0.00	0.81
	3	53.80	2.07	0.81
	4	51.73	2.07	0.78
2	1	49.66	2.07	0.74
	2	47.59	2.07	0.71
	3	45.52	2.07	0.68
	4	43.45	2.07	0.65
3	1	41.38	2.07	0.62
	2	39.32	2.07	0.59
	3	37.25	2.07	0.56
	4	35.18	2.07	0.53
4	1	33.11	2.07	0.50
	2	31.04	2.07	0.47
	3	28.97	2.07	0.43
	4	26.90	2.07	0.40
5	1	24.83	2.07	0.37
	2	22.76	2.07	0.34
	3	20.69	2.07	0.31
	4	18.62	2.07	0.28
6	1	16.55	2.07	0.25
	2	14.48	2.07	0.22
	3	12.42	2.07	0.19
	4	10.35	2.07	0.16
7	1	8.28	2.07	0.12
	2	6.21	2.07	0.09
	3	4.14	2.07	0.06
	4	2.07	2.07	0.03

Annexure 11 - Cash flow statement										
Particulars	0	I	II	III	IV	V	VI	VII	VIII	IX
opening balance	20.00	20.00	164.33	132.98	122.02	110.71	163.28	225.54	291.19	327.64
Add: Capital	8.20									
Add: Loan disbursement	53.80									
Less: Purchase of asset	62.00									
Add: Sales realizations		2603.95	2983.69	3182.60	3381.52	3652.76	3855.69	4058.62	4028.48	4018.44
Less: Payment made to creditors of previous year			455.00	426.56	455.00	483.44	511.88	540.31	568.75	568.75
Add: Receipts from debtors of previous year			289.33	271.24	289.33	307.41	332.07	350.52	368.97	366.23
Less: Payments made for current year purchase		2449.18	2821.13	3005.73	3190.68	3378.02	3563.83	3750.04	3750.64	3751.89
Less: Interest payments		5.20	4.79	4.30	3.80	3.30	2.81	2.31	2.00	2.00
		169.57	156.42	150.24	143.39	206.12	272.54	342.02	367.25	389.66
Less: Income tax		0.51	7.00	9.20	11.26	15.95	17.87	19.64	18.28	17.56
		169.06	149.42	141.04	132.12	190.17	254.67	322.38	348.97	372.10
Less: Distributions made from profits		0.60	8.16	10.74	13.14	18.61	20.85	22.91	21.33	20.49
		168.47	141.26	130.30	118.98	171.56	233.82	299.47	327.64	351.61
Less: Principal repayment of loan		4.14	8.28	8.28	8.28	8.28	8.28	8.28		
Closing cash balance	20.00	164.33	132.98	122.02	110.71	163.28	225.54	291.19	327.64	351.61

Sales Budget									
	Year ending March 31st								
Particulars	I	II	III	IV	V	VI	VII	VIII	IX
Production capacity utilization	70%	75%	80%	85%	90%	95%	100%	100%	100%
Production qty for oil	14.00	15.00	16.00	17.00	18.00	19.00	20.00	20.00	20.00
Production qty for cake	17.50	18.75	20.00	21.25	22.50	23.75	25.00	25.00	25.00
Sale qty for oil	13.86	14.85	15.84	16.83	18.18	19.19	20.20	20.05	20.00
Sale qty for cake	17.33	18.56	19.80	21.04	22.73	23.99	25.25	25.06	25.00
Sales for Oil	2217.60	2494.80	2661.12	2827.44	3054.24	3223.92	3393.60	3368.40	3360.00
Sales for Cake	675.68	760.13	810.81	861.49	930.59	982.29	1033.99	1026.31	1023.75
Total Sales	2893.28	3254.93	3471.93	3688.93	3984.83	4206.21	4427.59	4394.71	4383.75

Output stock calculation - For oil									
	Year ending March 31st								
Particulars	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**
Opening Stock		0.14	0.29	0.45	0.62	0.44	0.25	0.05	
Add: Production	14.00	15.00	16.00	17.00	18.00	19.00	20.00	20.00	20.00
Ouput available for sale	14.00	15.14	16.29	17.45	18.62	19.44	20.25	20.05	20.00
Less: Sales	13.86	14.85	15.84	16.83	18.18	19.19	20.2	20.05	20.00
Closing Stock	0.14	0.29	0.45	0.62	0.44	0.25	0.05		
Value for closing stock	20.16	41.76	64.8	89.28	63.36	36.00	7.20		

	Year ending March 31st								
Particulars	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**
Opening Stock		0.18	0.36	0.56	0.78	0.55	0.31	0.06	
Add: Production	17.50	18.75	20.00	21.25	22.50	23.75	25.00	25.00	25.00
Ouput available for sale	17.50	18.93	20.36	21.81	23.28	24.30	25.31	25.06	25.00
Less: Sales	17.33	18.56	19.80	21.04	22.73	23.99	25.25	25.06	25.00
Closing Stock	0.18	0.36	0.56	0.78	0.55	0.31	0.06		
Value for closing stock	6.14	12.72	19.74	27.20	19.31	10.97	2.19		

Chapter-9

Current Outlook and High Profitability Options in Rapeseed Mustard Sector

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Introduction

The National Commission for Farmers was constituted in 2004 to suggest methods for faster and more inclusive growth for farmers. The Commission made comprehensive recommendations covering land reforms, soil testing, augmenting water availability, agriculture productivity, credit and insurance, food security and farmer's competitiveness. In its final report of October 2006, the Commission noted upon ten major goals which included a minimum net income to farmers, mainstreaming the human and gender dimension, attention to sustainable livelihoods, fostering youth participation in farming and post-harvest activities, and brought focus on livelihood security of farmers. The need for a single market in India to promote farmer-friendly home markets was also emphasized.

The now constituted DFI (Doubling Farmers' Income) Committee besides all these broad sectoral aspects, invites farmers' income into the core of its deliberations and incorporates it as the fulcrum of its strategy. In a reorientation of the approach, this Committee suggests self-sustainable models empowered with improved market linkage as the basis for income growth of farmers. India today is not only self-sufficient in respect of demand for food, but is also a net exporter of agri-products occupying seventh position globally. It is one of the top producers of cereals (wheat & rice), pulses, fruits, vegetables, milk, meat and marine fish. However, there remain some chinks in the production armory, when evaluated against nutritional security that is so important from the perspective of harvesting the demographic dividend of the country. The country faces deficit of pulses & oilseeds. The availability of fruits & vegetables and milk & meat & fish has increased, thanks to production gains over the decades, but affordability to a vast majority, including large number of farmers too, remains a question mark. The average income of an agricultural household during July 2012 to June 2013 was as low as ₹6426, as against its average monthly consumption expenditure of ₹6223. As many as 22.50% of the farmers live below official poverty line. At the basic level, agriculture when defined as an enterprise comprises two segments – production and post-production. The success of production as of now amounts to half success, and is therefore not sustainable. No nation can afford to compromise with its farming and farmers. And much less

India, wherein the absolute number of households engaged in agriculture in 2011 (119 million) outpaced those in 1951 (70 million). Then, there are the landless agricultural labor who numbered 144.30 million in 2011 as against 27.30 million in 1951. The welfare of this elephantine size of India's population is predicated upon a robust agricultural growth strategy, which is guided by an income enhancement approach.

India is one of the major oilseeds grower and importer of edible oils. India's vegetable oil economy is world's fourth largest after USA, China & Brazil. Rapeseed & Mustard is widely grown in majority of Continents with largest area of 8 million ha in Canada followed by China (7 million ha) and India (6 million ha). Majority of the countries grow rapeseed, whereas, India has largest area under mustard. The diverse agro-ecological conditions in the country are favorable for growing 9 annual oilseed crops, which include 7 edible oilseeds (groundnut, rapeseed & mustard, soybean, sunflower, sesame, safflower and niger) and two non-edible oilseeds (castor and linseed). Oil Palm is comparatively a new crop in India and is the highest vegetable oil yielding perennial crop. With quality planting materials, irrigation and proper management, there is potential of achieving 20-30 MT Fresh Fruit Bunches (FFBs) per ha after attaining the age of 5 years.

According to Directorate of Oilseed Development (DOD) Oilseeds cultivation is undertaken across the country in about 27 million hectares mainly on marginal lands, of which 72% is confined to rainfed farming. The oilseed accounts for 13% of the Gross Cropped Area, 3% of the Gross National Product and 10% value of all agricultural commodities. Oilseeds occupy an important position in the Indian economy as they account for 14 per cent of the gross cropped area and contributing more than 4 per cent to the Gross National Product (GNP) as per). India is the third largest rapeseed-mustard producer in the world after China and Canada with 13.5 per cent of world's total production (DES, Government of India 2019-20). The area under rapeseed-mustard in the country was 6.23 Million hectares, produced about 9.34 million tons with 1499 kg/ha productivity during the year 2018-19. With per capita consumption of vegetable oils @16 kg/year/person for a projected population of 1.64 billion, the total vegetable oils demand is likely to touch 26.22 million tons by 2050 (UNO Report). But, during the last few years, the domestic consumption of edible oils has increased substantially and has touched the level of 24.07 million tons in 2019-20 and is likely to increase further. A substantial portion of our requirement of edible oil is met through import of palm oil from Indonesia and Malaysia (NMOOP, GOI).

Globally, Rapeseed & Mustard is processed into vegetable oil for human consumption and meal for livestock feed and few examples are also of industrial use. Rapeseed & Mustard has recorded annual growth rate of area, production and yield @ 0.32%, 2.45% and 2.13% respectively during last decade (2009-10 to 2019-20). The productivity of India is the lowest among the major rapeseed mustard growing countries (Kumar *et al* 2019).

Table 1 Decadal Growth Performance of the Production of Rapeseed-Mustard

Year	All India (In 000' tons)	World (In 000' tons)	India's Share in Total Production (In %)
1960-61 to 1969-70	1339.59	4675.87	28.65
1970-71 to 1979-80	1759.61	8622.60	20.41
1980-81 to 1989-90	2981.58	18923.69	15.76
1990-91 to 1999-00	**5579.02**	**32842.80**	**16.99**
2000-01 to 2009-10	6224.83	48166.11	12.92
2010-11 to 2019-20	7849.35	70096.16	11.20

As against the World average of 2002 kg/ha, highest productivity of 4795 kg/ha of European Union, the Indian average yield was only 1161 kg/ha during 2010-11 to 2019-20. Longer crop duration and high carbon content in the soil are the major factors attributing to high productivity of rapeseed in Western part of the World (Status Report R&M, 2017, NMOOP, GOI). Total area, production and yield of rapeseed-mustard in world during 2019-20 was 35.95 million ha, 71.49 million tons (mt) and 1990 kg/ha, respectively. Rajasthan state is a leading state in oilseeds production in India. Rapeseed & mustard is an important *rabi* crop grown in the majority of the state. Rajasthan claims first position in the production of rapeseed &mustard in India with a share of 47.45 % (2020-21). (Annual Report, GoR, 2020-21).

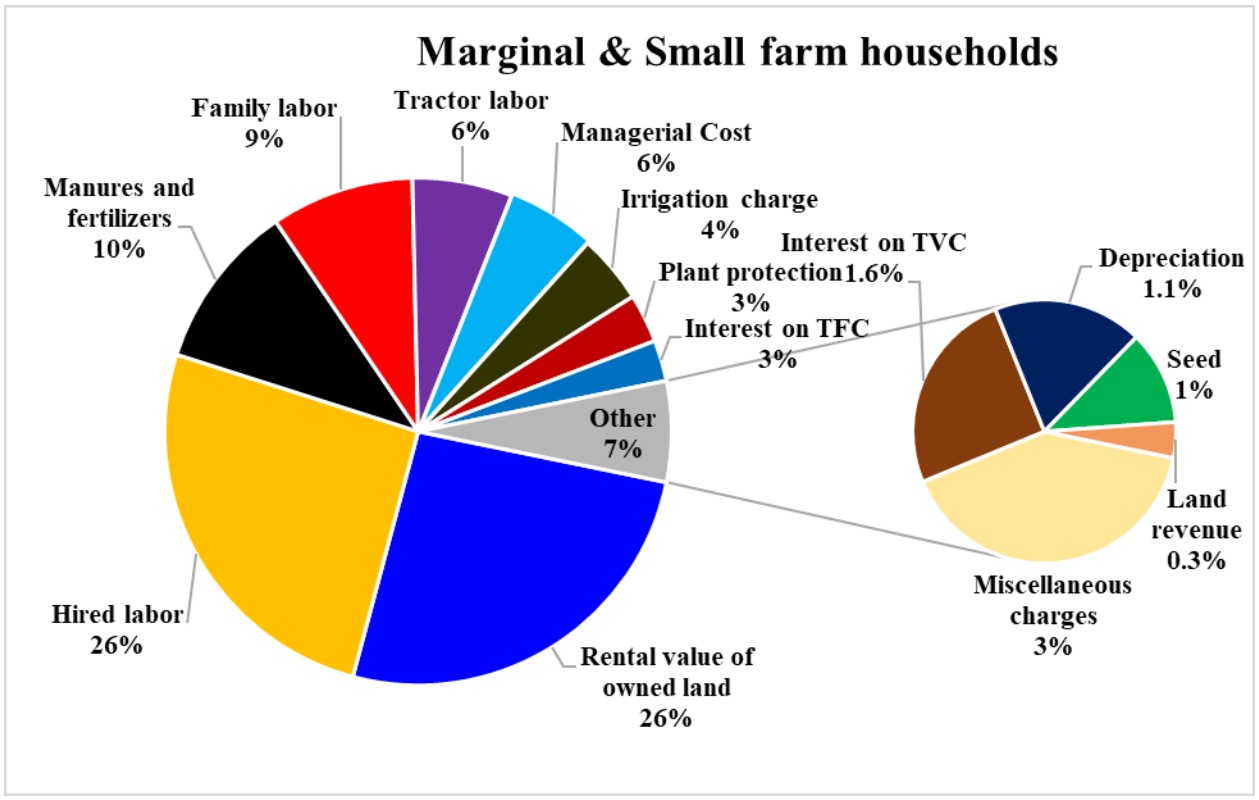
Farm level scenario of Rapeseed mustard sector: An Economic Outlook

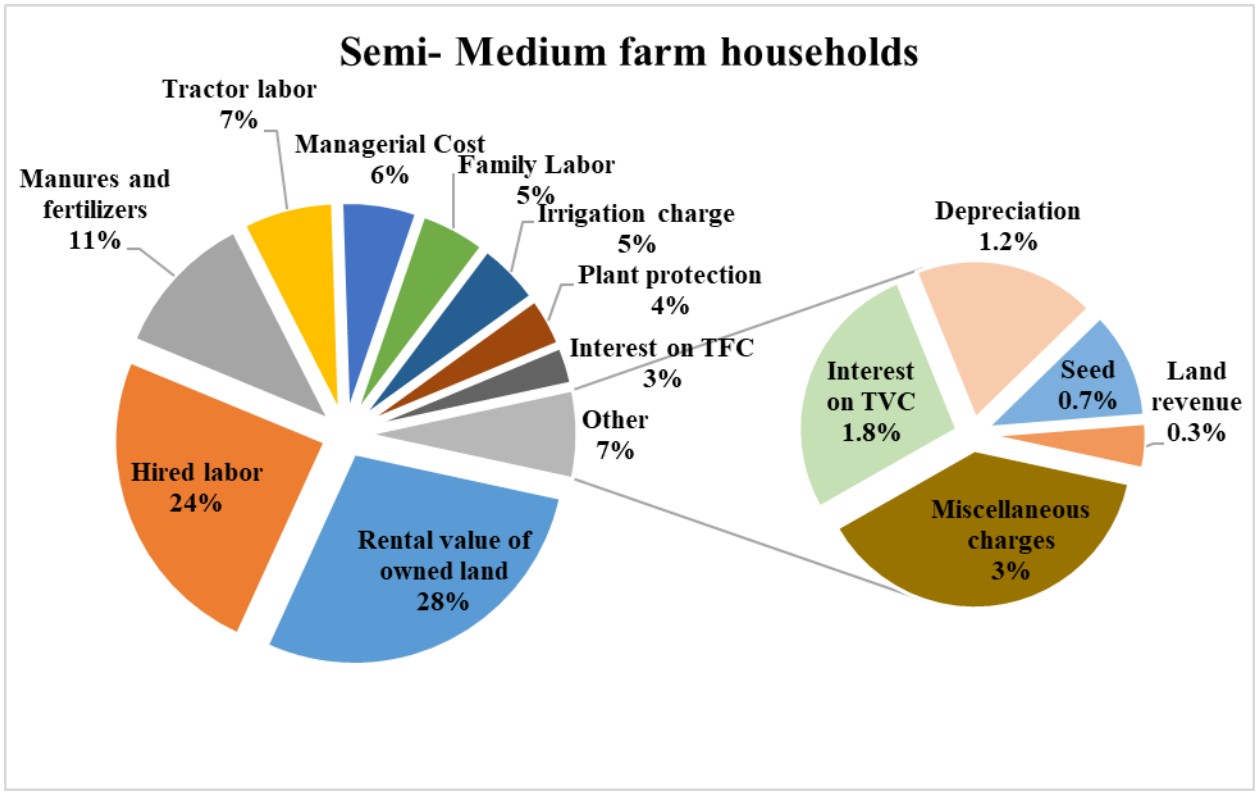
Production of oilseeds and oils has not fluorescing with increasing demand for edible oils and due to this widening demand-supply gap has necessitated imports of edible oils. With competing demands on agricultural land from various crops and enterprises, the production of oilseeds can be increased only if productivity is improved significantly and farmers get remunerative prices and assured market access. Study in Bihar revealed that average per hectare total cost of cultivation of rapeseed-mustard was estimated as ₹63873 on sample farms and the average gross income obtained was ₹83746.92/ha. The return to cost ratio was 1.39 (Rathore *et al* 2022). Bihar ranked ninth among the states, in rapeseed-mustard production, with a growth rate of 7.34% during the eighties whereas Rajasthan state with top ranked. It is the most important crops among oilseeds in terms of both area (0.08 million ha) and production (0.11 million tons) in Bihar (DES, Government of Bihar, Patna, 2018-19). Therefore, the technology should be targeted in these areas as cost effective or/ less costly than the competitive crop so that the farmers could get the net returns equivalent to that they

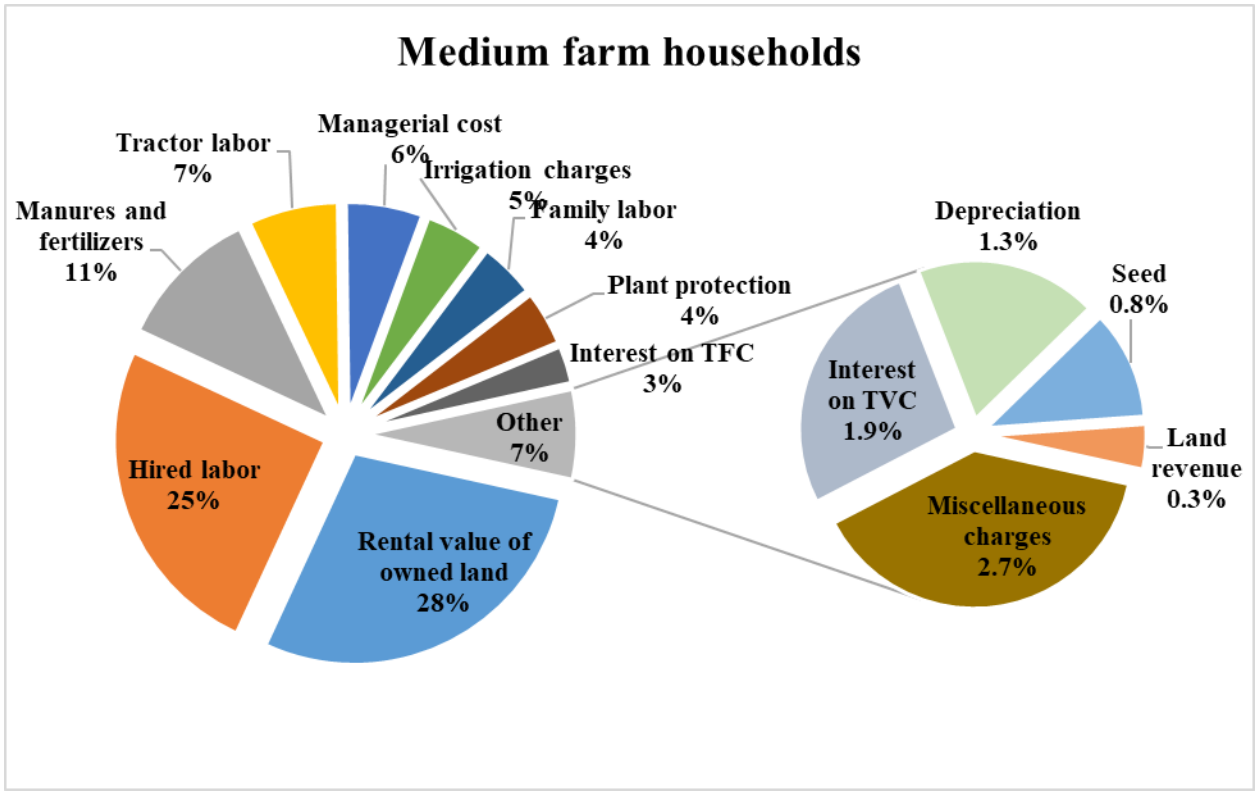
get from the competitive crops especially from wheat. Only then, the farmers will go for cultivation of rapeseed-mustard. Grant Thornton (2017) conducted a Value Chain Analysis on Mustard under Rajasthan Agricultural Competitiveness Project (RACP) and estimated the higher profitability (1.58) in comparison to Rathore *et al* 2022 (1.31).

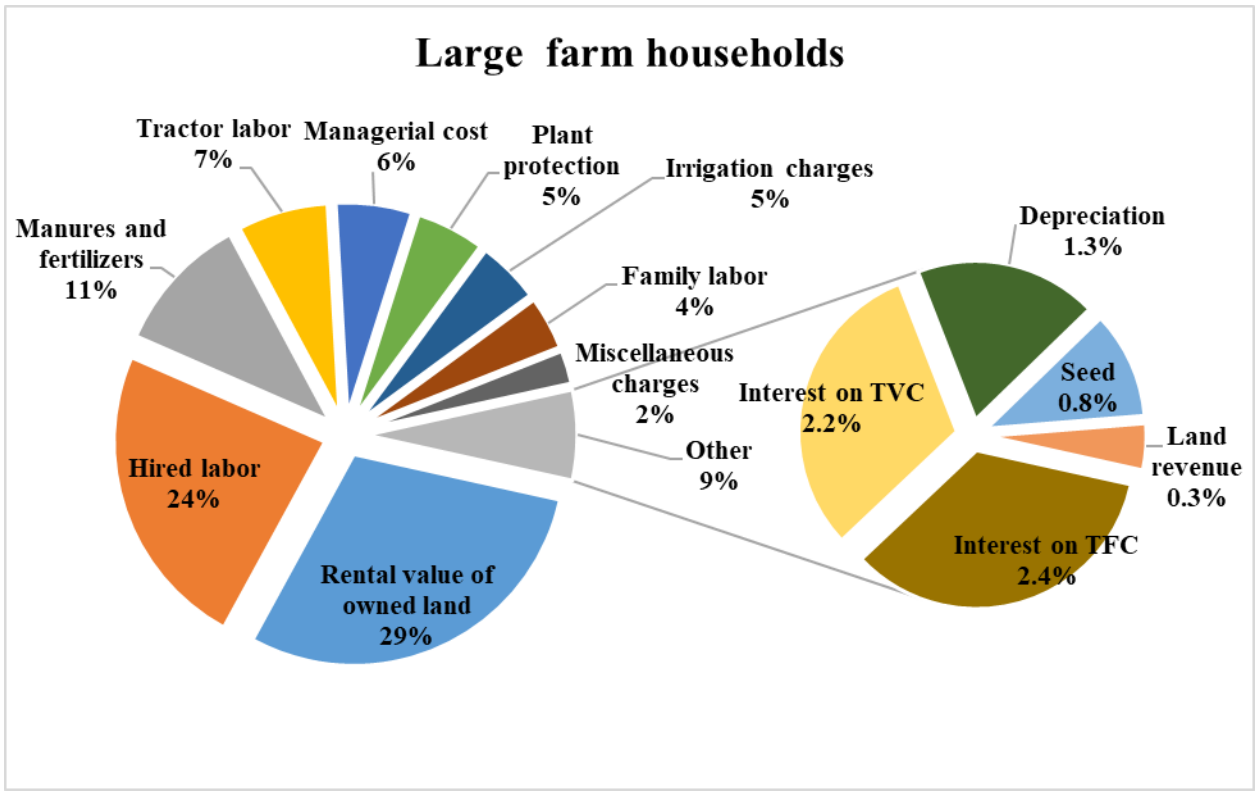
Table 2. Economic characteristics farm households for production of rapeseed mustard

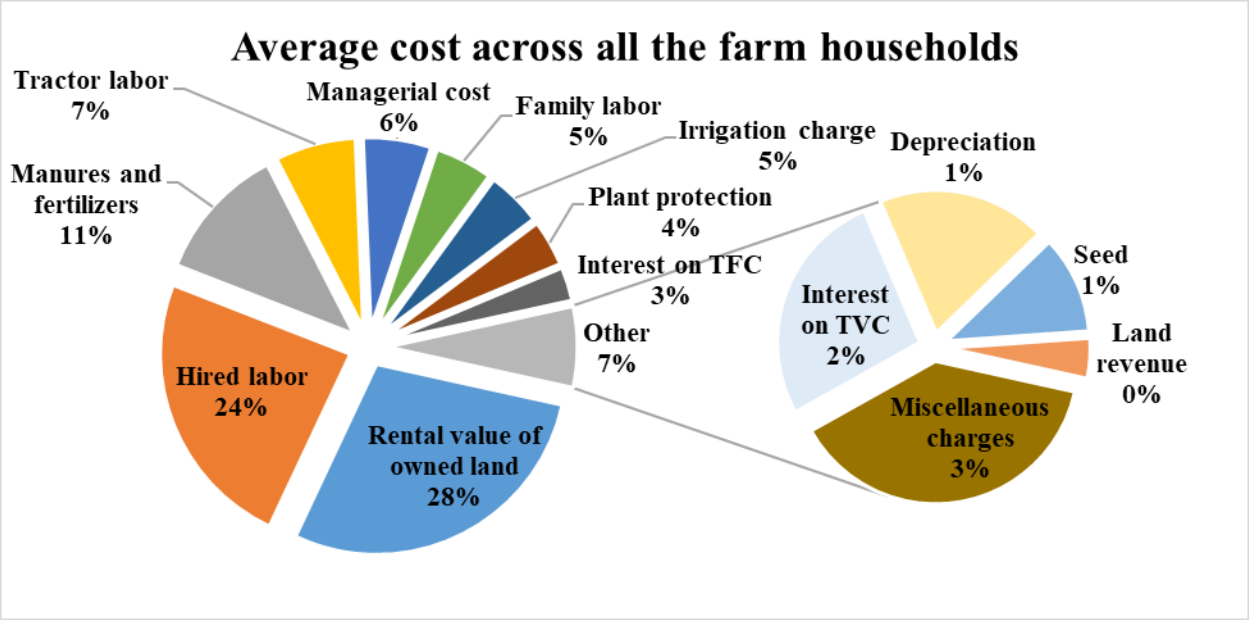
Particulars	**Values in ₹/ha**	**Particulars**	**Values in ₹/ha**
Rental value of owned land	18250	Rental value of owned land	-
Tractor Labor	4399.48	Land preparation cost (ploughing +hoeing)	6250
Hired Labor	15260.75		
Family Labor	3140.06		
	-	Weeding cost	2500
	-	Sowing cost	1250
Manures and Fertilizers	7382.22	Input Cost (fertilizer and pesticide)	3750
Plant Protection	2515.16		
Managerial Cost	3695.91	Managerial Cost	-
Irrigation Charge	3011.75	Irrigation cost	2500
		Harvesting Cost	5000
Interest on Fixed Capital	1827.95	Interest on Fixed Capital	-
Miscellaneous Charges	1688.35	Packing and Transportation Cost	2150
Interest on TVC	1171.38	Interest on TVC	-
Depreciation	842.52	Depreciation	-
Seed	487.57	Seed Cost (Av seed price 500/kg, Seed rate – 1-2kg/Acer)	2500
Land Revenue	200	Land Revenue	-
Cost C	-	Cost C	-
Grand total	**63873.1**	**Total Cost of Production**	**25900**
Yield (q/ha)	15.83	Yield (q/ha)	12.00
Unit Price (₹/q)	5290.20	Unit price (₹/q)	3400.00
Gross Income	83743.92	Gross income	40800
Net Income	23566.73	Net Profit	14900
Farm Investment Income	19870.81	Farm investment Income	-
Cost of production per (q)	3801.46	Cost of production per (q)	2158.33
BCR (On the basis of Cost C)	1.39	BCR (On the basis of Cost C)	-
BCR (On the basis of Cost D)	1.31	BCR (On the basis of Cost D)	1.58
Rathore *et al* 2022		Grant Thornton 2017. Value Chain Analysis Mustard 2017, Rajasthan Agricultural Competitiveness Project (RACP)	


Marginal & Small farm households
Family labor 9%
Tractor labor 6%
Managerial Cost 6%
Irrigation charge 4%
Manures and fertilizers 10%
Interest on TVC 1.6%
Plant protection 3%
Interest on TFC 3%
Other 7%
Hired labor 26%
Rental value of owned land 26%
Depreciation 1.1%
Seed 1%
Land revenue 0.3%
Miscellaneous charges 3%


Semi- Medium farm households
Tractor labor 7%
Managerial Cost 6%
Family Labor 5%
Irrigation charge 5%
Manures and fertilizers 11%
Plant protection 4%
Interest on TFC 3%
Other 7%
Hired labor 24%
Rental value of owned land 28%
Depreciation 1.2%
Interest on TVC 1.8%
Seed 0.7%
Land revenue 0.3%
Miscellaneous charges 3%


Medium farm households
Tractor labor 7%
Managerial cost 6%
Irrigation charges 5%
Family labor 4%
Plant protection 4%
Interest on TFC 3%
Other 7%
Manures and fertilizers 11%
Hired labor 25%
Rental value of owned land 28%
Depreciation 1.3%
Seed 0.8%
Land revenue 0.3%
Miscellaneous charges 2.7%
Interest on TVC 1.9%


Large farm households
Tractor labor 7%
Managerial cost 6%
Plant protection 5%
Irrigation charges 5%
Family labor 4%
Miscellaneous charges 2%
Other 9%
Manures and fertilizers 11%
Hired labor 24%
Rental value of owned land 29%
Depreciation 1.3%
Seed 0.8%
Land revenue 0.3%
Interest on TFC 2.4%
Interest on TVC 2.2%



Post-harvest Loss

Agriculture now has a cosmopolitan basket of produce, with large value output from horticulture, dairy, poultry and fisheries, besides customary produce like cereals, pulses, oilseeds cotton, sugarcane, *etc*. Advance estimates for 2016-17 indicate that food grains output is to touch 275 million tonnes with pulses at a record 22.95 and cereals at 252.73 (rice, wheat, maize, millets, etc.) million tonnes. Oilseeds production is estimated at 32.1 million tons in 2016-17 and in horticulture the production is reported to touch 300 million tonnes. Sugarcane, cotton, jute, tea, coffee, tobacco, meat, fish, wool, etc. will add another 330-350 million tonnes to the farm produce. A study by the CIPHET (2015) indicates, that the postharvest loss incurred, in per cent of production, in cereals is in the range of 4.65 to 5.99, in oilseeds & pulses 3.08 to 9.96, in spices 1.18 to 7.89, in livestock produce (milk, meats, fish) 0.92 to 10.52, and in fruits & vegetables at 4.58 to 15.88. However, it was observed that the study had not considered the losses that may occur in the course of long haul transport to terminal markets, having assessed only the first mile transport. A study limited regionally to Uttar Pradesh, Uttarakhand and Haryana evaluated post-harvest losses for a basket of 29 fruits and vegetables. The study observed the highest loss in case of pears (22 to 44 per cent) and lowest in case of water melon (7 to 11 per cent). The loss in the farm-to-market link segment, whether at 15 per cent or 40 per cent, is an unmistakeable opportunity to add to farmers' income.

Agro-processing is a necessary intervention where the farm produce cannot be consumed in its natural format. Examples are the processes that convert fibre crops like cotton into usable

textiles, where homespun clothing was consolidated into the textile industry. The leather and paper/pulp industry is another example, where traditional methods were converted into industry. Similar mediation of a processing unit is seen in oil extraction, the milling units that process grains into consumer ready flour, the units that harvest and make meats and fish into consumer ready food products and others.

Value chain for Mustard

The present pre-intervention or value chain for Mustard may be viewed as one with three critical production-distribution or activity-marketing channels. Channel 1 may be viewed in terms of one for table variety and other for edible oil and De-Oiled Cake. The product is largely marketed by farmers through the APMC and village traders. Channel1 caters to the urban households and institutional buyers such as hotels, canteens and food joints which would take *kachhi ghani* oil in refined form and branded packaging at retail level such as Dhara, Dalda, Scooter, etc.

Integration in the logistics chain: The primary produce is not consumed in its natural format but undergoes processes to make it ready for consumers. This includes treatment to grain, cereal, pulse, extracting oils, and other forms. The procurement is in bulk lots to meet the processing unit's capacities. Typically, in these cases, a farmer cannot sell to the end-consumer and the linkage to the primary consumer is short, usually via the nearest mandi. A modern supply chain needs to function within the holding life, or usable life of the produce. The holding life indicates the "time spread" in hand for sales. In case of processing industry, feedstock requirements are specific, in terms of type and quality of the raw material. Such commodities are cultivated especially for the processing channel (cotton, oilseeds, sugar cane, processing variety potato, etc.) – there is normally little other use of such commodities. However, food processing is also possible on some table variety cultivars, provided the culled produce is captured at first mile. For food processing to minimize food losses, it is important that small sized processing units, co-located at village level aggregation points, are developed so as to utilise the handling waste generated at the start of the output supply chain for fresh produce. Food processing will not minimise wastage, unless such food waste is captured at first handling instance.

Produce with long holding cycle: This category of farm produce is distinct in two key aspects – that the commodities are capable of long term storage in warehouses and that these have an existing market linked user/processor network. Usually, the produce is purchased by an organised market network (FCI, millers, processors, manufacturers, commodity boards and commodity traders). Although all agricultural produce is eventually perishable, in these

cases, with minimal post-production care, the inevitable is deferred by many months or even a few years. Therefore, having a long time-spread, the majority of such commodities are also readily brokered for purposes of hedging and arbitrage.

S No.	Produce with long holding cycle	Produce with short holding cycle
1.	Food grains such as rice, wheat, maize, millets and pulses	Milk
2.	**Field crops such as cotton, jute, sugarcane, and oilseeds**	Fruits, vegetables, certain roots and tuber crops
3.	Plantation crops such as tea, coffee, tobacco, coconut and rubber	Floriculture and mushrooms
4.	Other dry produce like nuts, spices, wood, silk, aromatics, *etc.*	Meats (including fish and poultry)

In case of the majority of non-perishable produce, the demand from consumers is increasingly communicated through the processing industry. This is evident in produce like cotton, tea, coffee, oilseeds, leather, sugarcane and most food grains. As market channels for such farm produce, many have developed as large industries in their own right. In most cases, the end user does not consume agricultural produce from farms, but a product of industry. These agro industries are one of the primary users (markets) of farmers' produce.

Produce with short holding cycle: This category of produce consists of those that quickly perish, possessing a short post-harvest holding life, having a short "time spread" in their selling cycle. Food processing plays an important role in the post-harvest food supply chain as the industry is a market, for all intents, for the farmers. The industry is in a favorable position as it is intrinsic for making produce like oil seeds, food grains and cereals fit for consumption

Table 3. Notable Mustard Brands and Manufacturers around the World

Country	Brands
1. Finland	Turun Sinappi
2. France	Amora, Grey Poupon, Maille
3. Germany	Born Feinkost;, Düsseldorfer Löwensenf,Händlmaier
4. Switzerland	Thomy
5. United Kingdom	Colman's
6. United States	French's Grey Poupon. Gulden's, Plochman's (also owns the Kosciusko brand), Stadium Mustard
7. India	Fortune, Dhara, Scooter, Patanjali

This volume focuses on agri-logistics, which enables connectivity between production and consumption zones over both space and time with minimal loss of quality and quantity. It considers various aspect of agri-logistics, with primary focus on preconditioning, storage and

transportation of farm produce. The farmer requires improved logistics to move the harvest; to choose the time of transaction, they need the cold-chain for perishables, or safe storage for foodgrains; and for a change in form, they need near-farm processing facilities to feed the raw material. These aspects are discussed in this volume, riveted to a demand driven approach. The focus is kept farmer-centric, so as to enable them with choice and connectivity to immediate market opportunities, to minimise food loss and recover maximum value from the produce. Other developments required over the longer term, are also indicated. However, this volume emphasises on the immediate need to ensure that farmers as primary actors, get connected to existing demand and available opportunities, to extract value from every grain, every ounce and every drop they produce.

Consumption Trends: Indian consumers are undergoing a "food to nutrition transition", evidenced by changed preferences in food items, connected to growth in per capita income. This transition passes through an initial preference for high calorie or high energy foods, which results in increased consumption of sugars, oils, fats and processed food products. Consumption expenditure on major categories revealed that share of edible oils declined from 4.4% in 1993-94 to 3.8% in 2011-12 in rural areas while sagging from 4.4% in 1993-94 to 2.7% in 2011-12 in urban areas.

NSSO round of surveys indicate that the consumption of edible oils has shown a steady rise. Edible oil consumption has shown a steady upward trend both in rural and urban households with per capita consumption increasing from 4 kgs to 7.7 kgs per annum in rural areas and from 6.6 kgs to 10 kgs in urban households during 1987-88 to 2009-10. The composition of oils in the consumption basket has changed over the past two decades with groundnut oil consumption halving and palm oil and soybean oil emerging as the major oils consumed due to larger imports influenced by lower international prices. Nevertheless, mustard oil continued to retain the highest share among vegetable oils consumed in India. In 1993-94, mustard and groundnut oil had more than 70 per cent share in oil consumed. By 2011-12 mustard oil and refined oil forms the bulk of consumption, with *vanaspati* and ground nut oil below 10 per cent. Wherever consumers demand is sustaining, the selected produce and product types will find a ready market. Normally, pulses and all oilseeds are dependent on processing units for the necessary intermediary activity in the farm to market value system. These processing unit capacities are closely linked to their marketing capabilities and they are a primary user of these crop types. Projected demand of major food commodities in India (million tons) for 2050 revealed the need of 39 million tons of edible oils. By 2050, the

population of India is projected to increase to 1.62 billion, with urban population up to 55 per cent from current 33 per cent (ICAR NIAP Vision 2050).

Marketed Surplus Ratio (MSR): There is a general increase in the ratio between the output-marketed to output-produced, over the years. MSR of Rapeseed & Mustard increased from 71.57% in 1999-00 to 90.94% in 2014-15. However, the marketed surplus may not be finding optimal value because it is monetised at the first available instance, at nearby markets. These markets may not necessarily have sufficient demand from its consumer catchment, to absorb the entire supply. Therefore, the value gets pushed down in the local market's downwards price discovery process. It is important that besides marketed surplus, the market surplus is also monitored. Farmers should have ability to direct their supply to markets that are optimal – i.e. have sufficient demand in their catchment, or have ready links to other consumption centres. When optimal value is not realised, motivation to grow production fades away.

Government interventions

Table 4. Risk minimization and capacity building programs for agri sector

Particulars	**2018**	**2019**	**2020**	**2021**	**2022**
Pradhan Mantri Fasal Bima Yojana					
Notification (No. of crops)					
Agriculture Crops					
Rabi Season	38	37	36	26	30
Kharif Season	40	40	36	38	
Horticulture Crops					
Rabi Season	57	48	46	47	49
Kharif Season	82	83	89	92	
Coverage (No of Farm households in Crores)					
Rabi Season	2.16	2.00	1.68	1.50	1.49
Kharif Season	1.46	0.96	1.0	0.98	
Coverage (No of applications in Crores)					
Rabi Season	3.07	3.83	4.09	4.95	5.78
Kharif Season	2.20	1.76	1.98	3.25	
Agriclinics and Agribusiness Centers (ACABC)					
Trained Candidates	2500	6625	7292	1238	5675
Agriventures Established	7	1884	1452	745	2234

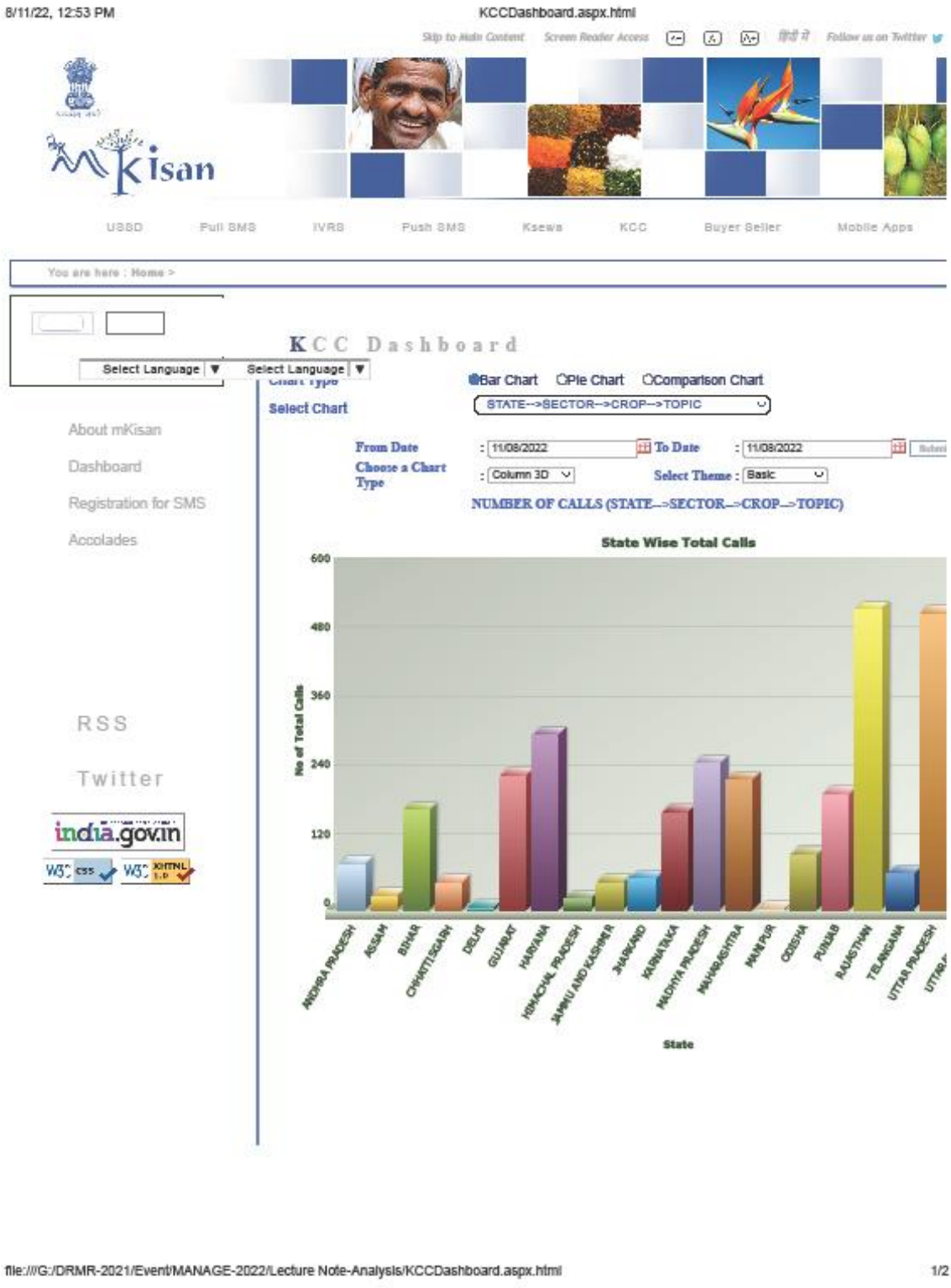
Brief Overview of the mKisan Portal: Pervasive and extensive use of the ICT is an important tool of agricultural extension. Under the National e-Governance Plan – Agriculture (NeGP-A), various modes of delivery of e-enabled services have been envisaged. These include internet, touch screen kiosks, agri-clinics, private kiosks, mass media, Common

Service Centres, Kisan Call Centres, and integrated platforms in the departmental offices coupled with physical outreach of extension personnel equipped with pico-projectors and hand held devices. However, mobile telephony (with or without internet) is the most potent and omnipresent tool of agricultural extension.

As per TRAI data of May, 2014, though there are about 38 crore mobile telephone connections in rural areas, internet penetration in the countryside is still abysmally low (in single digit percentage). Therefore, mobile messaging is the most effective tool so far having pervasive outreach to nearly 8.93 crore farm families. mKisan SMS Portal for farmers enables all Central and State government organizations in agriculture and allied sectors to give information/services/advisories to farmers by SMS in their language, preference of agricultural practices and location.

The project conceptualized, designed and developed in-house within the Department of Agriculture & Cooperation has widened the outreach of scientists, experts and Government officers posted down to the Block level to disseminate information, give advisories and to provide advisories to farmers through their mobile telephones**.** SMS Portal was inaugurated by the Hon'ble President of India on July 16, 2013 and since its inception nearly 327 crore messages or more than 1044 crore SMSs have been sent to farmers throughout the length and breadth of the country. These figures are rising ever since.

These messages are specific to farmers' specific needs & relevance at a particular point of time and generate heavy inflow of calls in the Kisan Call Centres where people call up to get supplementary information. SMS Portal for Farmers has empowered all Central and State Government Organizations in Agriculture & Allied sectors (including State Agriculture Universities, Krishi Vigyan Kendras, Agromet Forecasts Units of India Meteorological Department, ICAR Institutes, Organization in Animal Husbandry, Dairying & Fisheries, *etc*.) to give information/services/advisories to farmers by SMS in their language, preference of agricultural practices and locations. USSD (Unstructured Supplementary Service Data), IVRS (Interactive Voice Response System) and Pull SMS are value added services which have enabled farmers and other stakeholders not only to receive broadcast messages but also to get web based services on their mobile without having internet. Semi-literate and illiterate farmers have also been targeted to be reached through voice messages.



Farmer Producer Organizations (FPOs)

There are nearly 16,811 Farmer Producer Organizations (FPOs) **registered during the last 21 years** in India out of which 5000 have been promoted by NABARD. It has been seen that farmers belonging to the FPOs get additional benefits ranging from 40 %to 60 %. As

demand for high-value, diverse agricultural products rises throughout the developing world, smallholder farmers face pressure to either commercialize or exit the farm sector altogether.

FPO Hub of TCI's Center of Excellence: As the world's population increases and the demand for agricultural products rises, small farms (85% of total farm households) have an opportunity to play a big role and reap many benefits, if they can join together to form farmer producer organizations (FPOs) to increase their aggregate size. Using a data-driven, analytical approach, the FPO Hub of TCI's Center of Excellence serves as a repository of learnings, information, and knowledge for the advancement of FPOs in India. Aggregation models are potential institutional interventions that help redress the constraints of small farms, wherein groups of producers jointly manage resources or access credit, inputs, information, and product markets to reduce transaction costs. Successful aggregation models have shown increasing economies of scale, decreased transaction and coordination costs, improved access to markets, and investment in yield-stabilizing technologies like irrigation and improved crop varieties to be the main benefits of organizing farmers. In the past, cooperatives were the most common form of aggregation model in rural India. With the exceptions of dairy and sugar, cooperatives in India have been mostly ineffective due to issues involving incompetent management, political interference, financial irregularities, and corruption within the organizations. Poor management also made many cooperatives dependent on government funds for working capital. Cooperatives mandated government representation on their governing boards, allowing political interference in their functioning which further hindered growth. Being structurally different in membership, governance, and business model from cooperatives, FPOs are viewed as an advantageous alternative to cooperatives, with the key purpose of facilitating smallholder commercialization and increasing farm incomes. After the amendment of the Companies Act in 2003, farmer Producer Organizations (FPOs) emerged as a new form of aggregation model in India. Owing to a hybrid business model (between a private company and a cooperative), the new institutional form of FPOs limits membership to only primary producers who contribute equitably to the working capital and democratically control the FPO, sharing equal voting rights. Thus, being structurally different in membership, governance, and business model from cooperatives, FPOs are viewed as an advantageous alternative to cooperatives, with the key purpose of facilitating smallholder commercialization and increasing farm incomes.

Government agencies like the Small Farmer Agribusiness Consortium (SFAC) and National Bank for Agriculture and Rural Development (NABARD) were appointed as the nodal agencies for the mobilization and promotion of FPOs. Civil society organizations and

national and international funding organizations have also emerged to promote and help develop FPOs into sustainable farmer enterprises. FPOs are provided financial assistance in the form of grants from the government for a period of three years with additional provision for matching equity grants and collateral-free loans. Along with the share capital of FPOs, these funds can be utilized to meet infrastructure and working capital needs, and to pay administrative costs and salaries in the growing phase. In addition, most central and state schemes for supporting agriculture now include special provisions for promoting and nurturing FPOs.

Emergence and density of FPOs

Most of the FPOs formed in the past two decades were registered after 2014, which aligns with the more favorable policy environment created by a massive push for FPO promotion through various central and state government schemes. The largest spike occurred in the last three years, during which time 65 percent of FPOs were registered. The age of FPOs varies from 1 to 18 years. Forty-five percent of the FPOs are between 2 and 4 years old, followed by 30 percent of FPOs aged between 4 and 8 years. Only 4 percent of the FPOs (710) are older than 8. This pattern is true for most FPO-dense states. Madhya Pradesh, Gujarat, Rajasthan, and Tamil Nadu have a larger percentage of FPOs more than 8 years old compared to other states. Madhya Pradesh was among the first states to start promoting FPOs under the District Poverty Initiative Program (DPIP) by bringing together existing Common Interest Groups (CIGs) of farmers.

The total number of farmer-members served by these 3,190 FPOs across states is 1.5 million. The median number of shareholders ranges from 10 in Haryana, Odisha, and Rajasthan, to above 400 in Karnataka, West Bengal, and Tamil Nadu. Forty-seven percent of the FPOs are categorized as small-sized, with less than 100 farmer-members, while 28 percent are considered to be large, with more than 500 members. This pattern is consistent across most states. States like West Bengal, Tamil Nadu, Maharashtra, Karnataka, and Uttar Pradesh have overwhelmingly high numbers of large FPOs.

Table 5 Number of FPOs registered by year

Year	Number of FPOs registered
2010	29
2011	36
2012	65

2013	183
2014	313
2015	978
2016	1888
2017	1015
2018	1247
2019	2587
2020	4959
2021	3427

Table 6 Distribution of FPOs by state

State	Number of FPOs
Andhra Pradesh	584
Bihar	724
Gujarat	390
Haryana	803
Karnataka	746
Madhya Pradesh	891
Maharashtra	5611
Odisha	721
Rajasthan	571
Tamil Nadu	936
Telangana	620
Uttar Pradesh	1981
West Bengal	681

Table 7 Age distribution of FPOs by state

State	FPO age			
	Less than 2 years	2-4 years	4-8 years	More than 8 years
Andhra Pradesh	16%	49%	33%	2%
Bihar	18%	49%	30%	3%
Gujarat	22%	37%	32%	10%
Haryana	11%	69%	19%	2%
Karnataka	20%	37%	40%	3%
Madhya Pradesh	26%	33%	31%	10%
Maharashtra	22%	49%	26%	3%
Odisha	23%	41%	34%	3%
Rajasthan	15%	29%	48%	8%
Tamil Nadu	17%	33%	44%	6%
Telangana	10%	46%	41%	2%
Uttar Pradesh	24%	47%	24%	5%
West Bengal	16%	53%	27%	4%
Total	20%	46%	30%	4%

Table 8 Distribution of FPOs by paid-up capital (in INR millions)

Paid-up capital	Percentage of FPOs
Less than 1 lakh	16.72
1-5 lakhs	55.04
5-10 lakhs	18.23
10-20 lakhs	6.83
20-30 lakhs	1.64
More than 30 lakhs	1.54

Table 9 Distribution of FPOs by membership size

State	FPO membership size		
	Small	**Medium**	**Large**
Andhra Pradesh	57%	23%	20%
Bihar	62%	15%	23%
Gujarat	53%	21%	26%
Haryana	70%	16%	14%
Karnataka	37%	16%	47%
Madhya Pradesh	49%	23%	28%
Maharashtra	43%	38%	19%
Odisha	79%	8%	14%
Rajasthan	67%	16%	17%
Tamil Nadu	35%	22%	43%
Telangana	39%	30%	31%
Uttar Pradesh	37%	17%	46%
West Bengal	23%	29%	48%
Total	47%	25%	28%

Table 10 Distribution of paid-up capital by state

State	Paid-up capital			
	Less than 1 lakh	**1-3 lakhs**	**3-10 lakhs**	**More than 10 lakhs**
Andhra Pradesh	37%	35%	21%	7%
Bihar	27%	42%	25%	6%
Gujarat	33%	41%	19%	8%
Haryana	2%	74%	12%	12%
Karnataka	33%	23%	16%	27%
Madhya Pradesh	16%	49%	25%	10%
Maharashtra	10%	62%	22%	7%
Odisha	29%	53%	16%	3%
Rajasthan	11%	58%	24%	6%

Tamil Nadu	31%	21%	22%	26%
Telangana	50%	26%	19%	4%
Uttar Pradesh	5%	55%	30%	10%
West Bengal	14%	49%	25%	12%
Total	17%	51%	22%	10%

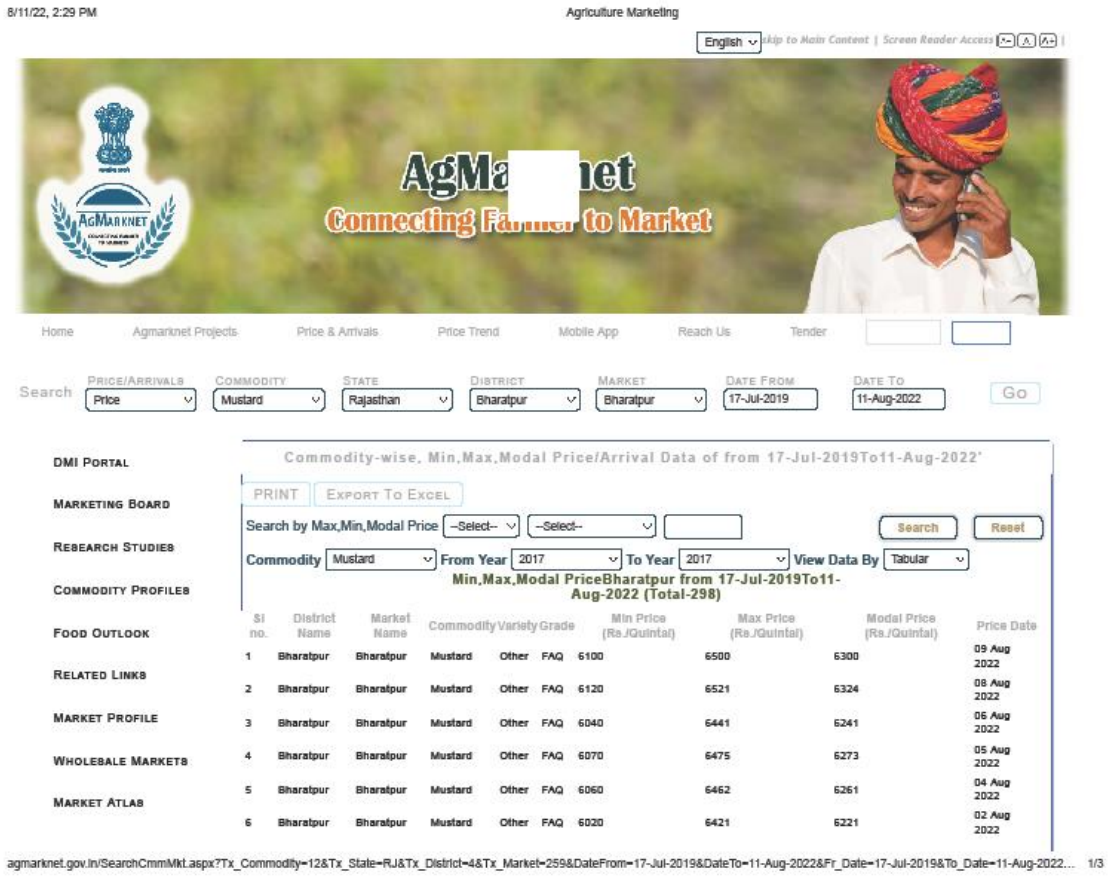


Table 11 Distribution of paid-up capital by state

State	21
Traders	2,29,449
Commission Agents (CAs)	1,05,531
Service Provider	0
FPOs	2,189
Farmer	1,73,57,096
Total	**1,76,94,265**

Agri-Invest

Agri Invest is the investment portal under the Ministry of Agriculture & Farmers Welfare, India. The portal is a one stop solution to all the investors who are looking to invest in India in the Department of Agriculture, Cooperation & Farmers Welfare. The portal highlights the steps on ease of doing business in India, the market entry strategies and the regulatory frameworks that are involved in setting up the operations. This portal enacts as the dedicated Investor Facilitation Cell of Ministry of Agriculture & Farmers Welfare, has been supporting the ministry across different aspects

Focus Subsectors for Investment Promotion

- • Agriculture Machinery
- • Seeds
- • Agrochemicals
- • Fertilizers
- • Smart Technology and Precision Agriculture
- • Logistics, Warehousing and Cold Chain

The Scheme will be operational from 2020-21 to 2032-33. Loan disbursement under the scheme will complete in six years. This financing facility will have numerous objective for all the stakeholders in the agriculture eco-system.

A. Farmers (including FPOs, PACS, Marketing Cooperative Societies, Multipurpose cooperative societies)

- Improved marketing infrastructure to allow farmers to sell directly to a larger base of consumers and hence, increase value realization for the farmers. This will improve the overall income of farmers.
- With investments in logistics infrastructure, farmers will be able to sell in the market with reduced post-harvest losses and a smaller number of intermediaries. This further will make farmers independent and improve access to market.
- With modern packaging and cold storage system access, farmers will be able to further decide when to sell in the market and improve realization.
- Community farming assets for improved productivity and optimization of inputs will result in substantial savings to farmers.

B. Government

- Government will be able to direct priority sector lending in the currently unviable projects by supporting through interest subvention, incentive and credit guarantee. This will initiate the cycle of innovation and private sector investment in agriculture.

- Due to improvements in post-harvest infrastructure, government will further be able to reduce national food wastage percentage thereby enable agriculture sector to become competitive with current global levels.
- Central/State Government Agencies or local bodies will be able to structure viable PPP projects for attracting investment in agriculture infrastructure.

C. Agri entrepreneurs and startups

- With a dedicated source of funding, entrepreneurs will push for innovation in agriculture sector by leveraging new age technologies including IoT, AI.
- It will also connect the players in ecosystem and hence, improve avenues for collaboration between entrepreneurs and farmers.

D. Banking ecosystem

- With Credit Guarantee, incentive and interest subvention lending institutions will be able to lend with a lower risk. This scheme will help to enlarge their customer base and diversification of portfolio.
- Refinance facility will enable larger role for cooperative banks and RRBs.

E. Consumers

- With reduced inefficiencies in post-harvest ecosystem, key benefit for consumers will be a larger share of produce reaching the market and hence, better quality and prices. Overall, the investment via the financing facility in agriculture infrastructure will benefit all the eco-system players.

Main Features

- Convergence with all schemes of central or state government.
- Online single window facility in collaboration with participating lending institutions.
- Project Management Unit to provide handholding support for projects including project preparation.
- Size of the financing facility – ₹ 1 lakh Crore.
- Credit Guarantee for loans up to ₹ 2 Crore.
- Interest subvention of 3% p.a., limited to ₹ 2 crore per project in one location, though loan amount can be higher.
- Cap on lending rate, so that benefit of interest subsidy reaches the beneficiary and services to farmers remain affordable.
- Multiple lending institutions including Commercial Banks, Cooperative Banks, RRBs, Small Finance Banks, NCDC, NBFCs etc.

- One eligible entity puts up projects in different locations then all such projects will be eligible under the scheme for loan upto ₹ 2 crore.
- For a private sector entity, such as farmer, agri entrepreneur, start-up there will be a limit of maximum of 25 such projects.
- Limitation of 25 projects will not be applicable to state agencies, national and state federations of cooperatives, federations of FPOs and federation of SHGs.
- Location mean physical boundary of a village or town having a distinct LGD (Local Government Directory) code.
- Each of such project should be in a location having a separate LGD (Local Government Directory) Code.
- APMCs will be eligible for multiple projects (of different infrastructure types) within their designated market area.
- Interest subvention will be available for a maximum period of 7 years.
- Moratorium for repayment under this financing facility may vary subject to minimum of 6 months and maximum of 2 years.
- Disbursement will complete in six years from 2020-21.
- Need based refinance support will be made available by NABARD to all eligible lending entities including cooperative banks and RRBs as per its policy.

Eligible Lending Institutions: After signing of Memorandum of Understanding (MoU) with National Bank for Agriculture & Rural Development (NABARD)/DAC&FW, all following eligible lending institutions may participate to provide this financing facility.

1. All scheduled Commercial Banks.
2. Scheduled Cooperative Banks.
3. Regional Rural Banks (RRBs).
4. Small Finance Banks.
5. Non-Banking Financial Companies (NBFCs).
6. National Cooperative Development Corporation (NCDC).
7. DCCBs with PACS affiliation.

Fund Allocation

Table 12 Distribution of paid-up capital by state

S No.	State/UT	Tentative Fund Allocation (₹Cr)
1	Uttar Pradesh	12831
2	Rajasthan	9015
3	Maharashtra	8460
4	Madhya Pradesh	7440
5	Gujarat	7282
6	West Bengal	7260
7	Andhra Pradesh	6540
8	Tamil Nadu	5990
9	Punjab	4713
10	Karnataka	4525
11	Bihar	3980
12	Haryana	3900
13	Telangana	3075
14	Kerala	2520
15	Odisha	2500
16	Assam	2050
17	Chhattisgarh	1990
18	Jharkhand	1445
19	Himachal Pradesh	925
20	Jammu & Kashmir &Ladakh	900
21	Uttarakhand	785
22	Tripura	360
23	Arunachal Pradesh	290
24	Nagaland	230
25	Manipur	200
26	Mizoram	196
27	Meghalaya	190
28	Goa	110
29	Delhi	102
30	Sikkim	56
31	Puducherry	48
32	A & N Islands	40
33	Daman & Diu	22
34	Lakshadweep	11
35	Dadra & Nagar Haveli	10
36	Chandigarh	9
	Total	1,00,000

Who Can Apply

- Agricultural Produce Market Committee

- Agri-Entrepreneur
- Central sponsored Public-Private Partnership Project
- Farmer & Farmer Producers Organization
- Federation of Farmer Produce Organisations
- Joint Liability Groups
- Local Body sponsored Public-Private Partnership Project
- Marketing Cooperative Society & Multipurpose Cooperative Society
- National Federations of Cooperatives
- Primary Agricultural Credit Society
- Self Help Group & Federations of Self Help Groups
- Start-Up
- State Agencies & State Federations of Cooperatives
- State sponsored Public-Private Partnership Project

Table 12 Crop-wise eligible PHM & primary processing activities

Crops	Eligible PHM & Primary Processing Activities	Not eligible under AIF
Cereals (Wheat, Paddy, etc.)	Cleaning, De-stoning, Sorting & grading Hulling, Milling, Pounding, Grinding, Tempering, Parboiling, Soaking, Drying, Sieving, Irradiation	Fermentation, Baking, Puffing, Flaking, Frying, Extrusion, Blending, Roasting
Fruits and vegetables	Washing, Cleaning, Drying, Sorting, Grading, Blanching for primary processing, Cooling, Waxing, Conditioning	Dehydration, Concentrated products, Canning, Juice extraction, Sterilization
Oilseeds	Cleaning, De-stoning, De-husking (decorticating machines), Winnowing, Oil extraction (ghani, hydraulic press etc.	By-product utilization, Refining, Neutralization, Bleaching
Pulses	Cleaning, De-stoning, Drying, Sorting & grading, De-husking, Splitting, De-hulling, Milling, Irradiation	Canning, Besan, Papads, Pulse based foods, Puffed chickpea, Pulse polishing
Cotton	Cleaning, Drying, Ginning, Pressing & Bailing, Lintering	Fibre finishing, Scouring, Purifying, Spinning, Weaving
Sugarcane	Cane unloading, Cleaning, breaking &milling, Straining, Evaporators, Centrifugation, Storage tanks, Dryers	
Spices	Cleaning, Drying, Sorting, Boiling, Polishing, Grinding, Packaging, Storage, Irradiation	Roasting, Sterilizing, Thermal treatment
Cocoa	Cleaning, Gathering of pods, Sorting, Breaking of pods, Fermentation of cocoa, Drying, Storage	Roasting, Winnowing, Alkalization
Coffee	Cleaning, Drying of cherries, Washing, Hulling, Pulping	Roasting, Grinding, Extraction
Jute	Cutting, Retting, Stripping, Washing, Drying, Bailing, Packing, Storage	
Cashew	Cleaning, Streaming in boiler, Shell cutting, Drying, Peeling, Grading, Packaging	
Moringa	Washing, Drying, Milling, Storage, Packaging	
Tea	Cleaning, Withering, Rolling, Fermentation, Drying, Sorting	
Rubber	Mastication, Mixing, Shaping, Curing, Irradiation	
Herbal and Medicinal Crops	Cleaning, Sorting, Drying	Syrup, Pills, Cream, Roasting, Frying, Distillation, Concentration

Source: http://agriinfra.dac.gov.in/Home/EligibleProjects

Conclusions

Against the total domestic demand of 25.88 million tons of vegetable oils, India is able to meet hardly 10.53 million tons (40%) through its domestic production. Rest amount 15.35 million tons (60%) is meet through imports. An expenditure of $ 75 billion (Rs 74996 Crore) was made on the import of vegetable oil during 2017-18. National Mission on Oilseeds and Oil Palm (NMOOP) is functional through its three pronged strategy including Mini Mission I (7 edible oilseeds including groundnut, rapeseed & mustard, soybean, sunflower, sesame, safflower, niger and two non-edible oilseeds including castor and linseed, Mini Mission II (Palm oil) and Mini Mission III (Tree Borne Oilseeds (TBOs) including *sal, mahua, simarouba, kokum, olive, karanja, jatropha, neem, jojoba, cheura*, wild apricot, walnut, *tung, etc*.). There is an urgent need to intensify efforts for area expansion from the current area 6.3 million hectare to 10.00 million hectares under rapeseed-mustard to enhance production in the country by 2050. Availability, accessibility and affordability of quality seeds of the suitable varieties among the farmers are very critical issues for food and nutritional security in India. Government policies regarding the development of irrigation facilities need to be revamped for addressing the major hurdle of rainfed farming system. Capacity building and skill development programs about the technical aspects including agronomic practices, nutrient and pest management among the farm households is essential for vertical as well as horizontal expansion of the sector.

The volumetric and qualitative requirement from agro-processor (miller, product manufacturer, *etc*.) is usually channeled down to farmers through commodity traders and layers of other supply chain intermediaries. However, the demand generated is closely linked to that from end consumers as the user (processing) industry is typically organized in its forward marketing. Whether small scale or of large industrial scale, they frequently compete for consumer attention by innovating their final product. The surplus inventory of such storable commodities needs to find markets wherever possible.

There is need to reconsider policies so as to open the agri-business stakeholders to be more readily responsive to market dynamics, and in turn link production with a larger market demand, including for exports. Private sector participation in farm-gate purchase of commodities can be scaled up, provided certain inventory restrictions and controls are eased. Expanding the MSP based procurement system to private sector participation is also an option to consider. The procured stock can be exempt from controls to allow the procuring agencies to trade freely. This will enable a spread in the impact of MSP as desired.

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Chapter-10

Goat Farming for Sustainable Livelihood and Enhancing Farmers' Income

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1.0 Introduction

India is blessed with rich animal resources; it is a source of sustainable livelihood and works as safety valve during the subsistence oriented crop farming. It contributes about 4% to national GDP and 25% to agricultural GDP (At 2011-12 Prices) in 2013-14. Livestock particularly sheep and goat rearing in India is closely interwoven with crop farming. Majority of goats (>75%) are reared by the households cultivating less than 2.0 ha of land (marginal and small). It is the main source of income to farmers particularly of arid and semi-arid regions in the country where crop failure is the recurring phenomenon. According to the report Situational Assessment of Agricultural Households by the NSSO, a compounded annual income growth rate of 13.7% was observed between 2003 and 2013. Restructuring agriculture processes & policy interventions required to increase the income in real terms (ICFA, 2016).

As per key results of 20th livestock census 2019, goat population in the country increased from 135.17 to 148.88 million between 2012 and 2019. This increase was 10.14% over the previous livestock census (2012). Goat is second largest livestock species (28%) after cattle. Country stood first in goat milk production, second in goat meat production and second in goat skin production in the world. The growth rate in goat population was about 1.08 % during 2012 to 2019 in spite of higher slaughter rate and annual mortality. Goat sector witnessed significant increase in output of its products like meat, milk and skin. Sector contributes 5.63 million tonnes of milk (3%), 1.08 million tonnes of goat meat (13.4%), and 0.18 million tonnes of skin to the central pool. Goats and its products contribute ₹38,590 crores annually to the national economy. This accounts for about 9% to total value of output (at current prices) from livestock sector in 2010-11. The demand for small ruminant is basically a derived demand necessitated by the demand for meat, milk, wool, hides, skins etc. High income elastic for livestock products, increasing domestic consumption due to increment in per capita income growth, variation in taste preference and urbanization are some of the driving factors of increasing demand for livestock products. Globally the demand

for livestock products, particularly for chevon and mutton is on rise, due to the increase in per capita income in developing countries.

Small ruminant sector despite its considerable contribution to livestock economy and potential to enhance millions of marginal and small farmers' household's income, it remained underinvested and could not receive support from financial and other institutions. Moreover, majority of goats reared in semi-arid regions of the country which constitutes 49% of total dry land area and 37 % of total geographical area of the country. Over 75% of the cropped area is in the semi-arid tropics in the country. Most of these districts are concentrated in Andhra Pradesh, Maharashtra, Tamil Nadu, Karnataka and Rajasthan, affecting 265 million people in the rural areas. In the present lecture, an attempt was made to explore opportunities in goat farming for livelihood security of millions of resource poor farmer and enhancing family income and become self-reliant. Its untapped potential and probable economic gains due to technological and marketing intervention were highlighted. The inferences drawn from present analysis on country's goat production — would help in planning to formulate goat development programmes in different parts of the country.

1.1 Goat Farming: Present status and opportunities

Ownership pattern of goats among different land holding categories indicated that more than 70% goats have been reared by the marginal and small holdings. It showed the importance of goat among resource poor people for their sustainable livelihood and nutritional requirement. Demand for goat meat/mutton has increased as increased 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 3% to central milk pool (187.7 million tonnes). Majority of goats in the country are reared under extensive production system and highly depended on common resources. Permanent pastures and grazing lands which is one of the most important commons are gradually shrinking.

1.2 Ownership Pattern of Goat

More than 75% of goats are possessed by the marginal and small landholdings. The share of goat ownership has improved with marginal category by 2% between 2001-02 and 2006-07. Small and marginal together constitute about 83% of total land holdings.

Moreover, flock size per goat rearing households has shown increasing trends among all the categories of land holdings (Table2). Unit level data from 59th and 70th rounds

of NSSO (Land and livestock holdings) indicate that overall flock size has marginally increased between 2002-03 and 2012-13.

Table 1: Distribution of goats according to land holding size (million)

Land Categories	1996-97	2001-02	2006-07
Marginal (<1.0)	51.5 (53.8)	60.4(52.6)	54.8(56.7)
Small (1.0 - 1.99)	18.8(19.7)	24.6(21.4)	18.8(19.4)
Semi-Medium (2.0 - 3.99)	13.4(14.0)	17.0(14.8)	12.9(13.3)
Medium (4.0 - 9.99)	8.1(8.5)	9.6(8.4)	7.5(7.8)
Large (10 and above)	3.9(4.0)	3.3(2.9)	2.7(2.8)
All groups	95.7(100.0)	114.9(100.0)	96.7(100.0)

Source: Input survey, Agricultural Census, Govt. of India

The maximum increase was observed in large category of land class flowed by landless and medium class. This may be due to increasing demand for goat products, increasing nutrition literacy among consumers, goat provide ready to cash option and easy market access. The goat rearing households has been increased by 17% during the same period.

Table 2: Average flock size in goat rearing households (no.)

Land class	Flock size (no. per goat rearing hh)		All hh	
	2002-03	2012-13	2002-03	2012-13
Landless	2.88	3.40	0.24	0.36
Marginal	3.13	3.15	0.56	0.59
Small	3.48	3.48	0.62	0.62
Medium	3.86	4.20	0.62	0.77
Large	5.52	8.66	0.97	1.65
All	3.28	3.47	0.46	0.54

Source: 59th and 70th rounds of NSSO (Land and livestock holdings)

1.3 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 149 million between 1982 and 2019(Table 3). The highest increase in goat population was recorded 16% during 1982 to 1987. About 13% increase has been recorded between 2007 and 2003. Similar trends have been noticed during 2012 and 2019, about 10% increment in goat population was observed between the same periods. 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). However, The Goat population has declined by 3.82% between 2007 and 2012. This may be due to high rate of slaughter, effect of consumer shift resulting pressure on small ruminants, shrinking grazing lands and migrations. Compound annual growth has been worked out for different sets of census periods (Table 3).

Table 3 Trends in goat population

Census year	Goat Population (million)	Periods	% increase/decrease	CAGR (%)
1982	95	-	-	-
1987	110	1987-82	15.79	2.96
1992	115	1992-87	4.55	0.90
1997	123	1997-92	6.45	1.26
2003	124	2003-97	1.34	0.27
2007	140	2007-03	13.01	2.48
2012	135	2012-07	-3.82	-0.78
2019	149	2019-12	10.1	1.08

Adoption of improved management practices will increase population growth by cutting down mortality among kids and adults and productivity. Major impediment in increasing the small ruminants' population is the dwindling area and productivity of pastures. Shrinking pastures and grazing lands is more concern to goat keepers because majority of them are resource poor and largely dependent on such resources for grazing and gleaning grasses. Commercialization of goat farming in the country is going in favour of meat goats not in breeding goats, which need to be balanced by educating such goat farmers.

1.4 Production performance of goats: Milk and Meat

Goat meat (chevon) is a main staple red meat in human diets without any social restrictions. Goats are an important nutrient (protein) source, particularly for people situated mainly in the tropics. Goat contributes 14 per cent to country's total meat production however, poultry is having lion share (50.06%) to the total meat production from all the meat producing species.

Goat meat production increased from 0.398 to 1.08 million tons with an annual growth of 7% between 2003-04 and 2018-19 (Table-4). However, meat yield increased from 9.64 to 11.30 kg/animal during 2003 to 2018. Similarly, goat milk production increased from 3.7 million tonnes in 2003-04 to 5.63 million tonnes in 2018-19. However, milk yield has increased only by hardly 136 grams/animal over the above period. The impressive growth in meat production in the country resulted mainly due to increase in number of animals slaughtered. Productivity of goat for meat and milk is low and attributed mainly to poor adoption of technologies.

Table-4: Trends in Goat Milk and Meat Production in India

Year	Goat Milk Production (million tonnes)	Goat Meat Production (million tonnes)	Milk yield (kg/animal)	Meat yield (kg/animal)
2003-04	3.71	0.398	0.314	9.64
2007-08	4.48	0.488	0.39	11.00
2012-13	5.05	0.941	0.43	10.74
2018-19	5.63	1.08	0.45	11.30

Source: Basic Animal Husbandry Statistics (various issues)

1.5 Enhancing farmers' income through improved goat management practices

1.5.1 Average monthly income of agricultural household

As per NSSO Rounds (59th and 70th), the average monthly income of farmer household between 2003 and 2013 was increased by 12% annually (Table-5). However, net receipt from animal husbandry was increased by 24% for the same periods, much higher than other income sources i.e. cultivation, wages and non-farm business.

Table-5: Change in Average Monthly Income of Farmer's Household (Rs.)

Sources of income	2003(59th round)	% to total	2013 (70th round)	% to total	CAGR (%)
Cultivation	969	45.82	3078	47.90	12.25
Wage earning	819	38.72	2069	32.20	9.71
Non-farm	236	11.16	514	8.00	8.10
Animal husbandry	91	4.30	765	11.90	23.72
All	2115	100.00	6426	100.00	11.75

Source: 59th and 70th rounds of NSSO

Perusal of Table-5 indicating that, the contribution of animal husbandry has been substantially increased from 4.30% to 11.90% over a decade. Thus, animal husbandry has great potential to improve farmers' income. However, net receipt from farm business (cultivation and farming of animals) accounted for more than 50% of the average monthly income per agricultural household in the country during both the rounds. Furthermore, households belonging to the lowest size class, farming of animals fetched more income than cultivation during this reference period.

1.6 Contribution of goat rearing in present household income

More than 75% goats are reared by marginal and small households under extensive management system. Studies revealed that in general, goat rearing contributes about 15% to the total household income of goat farmers and generates gainful employment to rural farm families. However, out of 135.04 million goats, 26.97% are pure bred, 11.77% are graded breeds and remaining 61.26% are non- descript. Field studies indicated that income per goat per year was about Rs.3200.00, by and large low in productivity and fetch less price. With some little input on nutrition, health and management, the income per adult goat per year was improved to ₹4800.00(1.5 times). Goat farmers rearing goats under semi-intensive /intensive management system and with smart marketing may earn profit at the tune of ₹6500.00 per adult goat per year (double of extensive management system). By doubling income per goat per year, the contribution of goat rearing to the household's income may increase from 15 to 30%. It needs effective support services (prophylactic) from state animal husbandry department, micro credit facilities from financial institutions for increased adoption of technologies and setting up of commercial goat farms, market and cooperative departments.

1.7 Suggestive Model for Small Scale Goat Rearing in Field Condition

Goat which is known as poor man's cow has now becoming a symbol of prosperity in rural India. Goat rearing plays an important role in livelihood security of millions of landless, marginal and small farmers. Starting of dairy farm with cows and buffaloes has become an expensive business as it requires high capital cost in the beginning. Therefore, goat farming is now preferred small scale business among resource poor farmers. A farmer initiate goat rearing with 50 goats of Barbari breed require a capital of about Rs.6.5 lakh. Goat rearing at small scale may utilize family labour (women labour) efficiently and the problem of malnutrition in women and children may also solved. An economic analysis of goat unit with 50 does and 2 male bucks of Barbari breed is given below:

Economic analysis of goat unit of 50 does:

A. Expenditure (Rs.):

a. Capital cost:

(i)	Goat shed	1,25,000.00
(ii)	Equipment	20,000.00
(iii)	50 Barbari goats @ Rs.6000/- per goat (pregnant)	3,00,000.00
(iv)	2 Breeding buck @ Rs.8000/- per buck	16,000.00
	Total capital cost	**4,61,000.00**

b. Recurring cost:

(i)	Feed cost (concentrate feed)	1,08,540.00
	Adult does, bucks and kids (@ 250-300 gram per adult goat & kid per day for 200-220 days)	
(ii)	Health management cost (@Rs.80/animal/year)	10,560.00
(iii)	Labour (imputed value of grazing) @ Rs.4000/month	48,000.00
	Total recurring cost	**1,67,100.00**
	Gross cost	**6,28,100.00**

B. Income (Rs.):

(i)	Sale of kids (76 kids of 20-22 kg body weight at 9-10 month @ Rs.250/kg/live weight)	4,18,000.00
(ii)	Value of 52 adult goats at the end of year	3,31800.00
(iii)	Depreciated value of shed (@10% per year)	1,10,500.00
(iv)	Sale of milk (after feeding kids)	21,600.00
(v)	Value of goat manure and others	10,000.00
	Total income	8,91,900.00
	Net income	2,63,800.00
	Net income per month	21,983.00
	Net return per doe	5,276.00

It is clear from economic analysis that if a poor farmer start goat rearing with a unit of 50 goats and adopt scientific practices, he may earn net income about Rs.2,64,000.00 annually. Per goat per year net income would be about Rs.5300.

1.8 Probable economic gain from technological and marketing interventions

The growth (productivity and profit) in goat rearing can be improved by technological interventions for cutting down mortality among kids and adult animals and enhancing productivity. The diseases in goats result in mortality ranging from 5 to 25% in adults and 10 to 40% in kids. With large population base and untapped potential of goats, there is a scope to harvest more benefits in short period of time. Study on disaggregated analysis of net gain by individual intervention has been indicated that breeding intervention has been focused to yield economic gains of ₹23713 million, which include ₹9977 million as cost of intervention. The healthcare intervention, which includes vaccination against important diseases, may generate an additional income of ₹24064 million. An additional net gain of ₹14002 million has been estimated through nutritional intervention after deducting 29651 million as the cost of nutrition intervention. The net economic gain through marketing of kids at commercial age has been estimated to be ₹11842 million. This has been worked out

after deducting cost of ₹13534 million for keeping animals for additional 4 months to attain the commercial age (Table 6). The order of magnitude can be gauged that opportunity cost of technological interventions on health care, nutrition and marketing together are equivalent to about 1.24% of total value of output (at current prices) from livestock sector in 2010-11 and 14.74% of the value of output from goat sector for the year 2012.

Table 6: Net economic gains from proposed technical interventions in goat production (in million Rs.)

Interventions	Gross gain	Cost of intervention	Net gain	Gross gain to cost ratio
Breeding				
Additional kids born and survived due to improved prolificacy	10834	5318	13735 (24.15)	2.38
Improvement in body weight	6703	4659		
increment in milk yield	6175			
Healthcare				
Reduction in mortality due to health intervention	24064	6758	17306 (30.42)	3.56
Nutrition				
Body weight gain due to nutrition intervention	19795	11757	14002 (24.62)	1.47
Improvement in milk yield	23859	17894		
Marketing				
Sale of kids at their commercial age	25376	13534	11842 (20.82)	1.87
All	116809	59922	56887 (100.00)	1.95

Source: ***Dixit et al., 2015***

1.9 Goat based business models: Success stories of CIRG Trainees

Goat based Business Models: Success stories of CIRG Trainees

Name: Mohd. Rashid (60th Batch NTP 2013)

Al-Bakar Goat Farm, Vrindawan, Mathura

- Started goat farm in 2014 with 12 goats of Barbari breed with a total investment of Rs.8 lakh.
- Now maintains 110 goats of Barbari breed 54 adult females and 10 breeding bucks.
- Selling adult male and kids (castrated) during festive season and females for breeding purpose.
- Target to increase flock size up to exclusively 500 Barbari goats
- Earn Rs. 4-5 lakh annually, net of cost.
- Now, starting training programme for rural unemployed youths



Goat based Business Models: Success stories of CIRG Trainees

Name: Mr. B.D.Kushwaha (64th Batch NTP 2014)

Himani Goat Breeding and Horticulture Farm, Saraswati Vihar, Dehrad (UK)

- Started integrated farm (Horti + Goat farming) in Dehradun
- Started goat farm in 2014 with single pair of Jamunapari goat and two poly houses of 1000 sq. meter (500 sq.m each).
- Now maintains 12 adult females, 2 bucks and 6 kids.
- Introduced 4 females of Beetal with a buck.
- Selling goat milk 5-6 lit per day @ Rs.150 per lit to a group Bakri Chaap. And selling milk Rs. 200 per lit to hospital. Average milk yield is 3 lit/day. Sold two male goats @ Rs. 16000 each.

- Growing high yielding verities of tomato (French beans as intercrop), broccoli (Coriander & spinach as intercrop) during winter and bitter gourd during summer earning Rs. 1.5 lakh from tomato, Rs. 50 t from bitter gourd and Rs. 30 t from broccoli.
- Earn Rs. 2 lakh from horticulture crops, net of cost.
- Planning to increase flock with 50 Beetal goats in next month.

Goat based Business Models: Success stories of CIRG Trainees

Name: Mr. Kalyan Koley (52nd NTP 2012) Age-36 years

AEGIPAN Animal Biocare Pvt. Ltd.(Sanjevani Khemar) Harit, Hooghly, W.Bengal

(www.sanjevanigoats.com)

- Started A.I. center with Black Bengal diluted liquid semen now.
- Maintaining 63 Black Bengal bucks with recurring expenses of Rs. 4.5 lakh (feed,vet care, labour etc.). Producing 2000 semen doses/buck/year @ cost of Rs. 7 per dose. Selling @ Rs. 15 per dose.
- Imparting training to unemployed youths and women empowerment with the help of local veterinary officers hands on A.I in goats. He earns Rs. 50,000 from training and trained more than 3000 youths (500 women) who earn Rs.3000 to 5000 per month.
- Total annual earning was Rs. 8 lakh, net of cost (Rs. 4.52 lakh).
- Income per month was Rs. 60 to 65,000.
- He is working with collaboration of NDRI, Kalyani and CIRG, Makhdoom
- With scientific inputs the conception rates increased to 51.95% (Karunakarn, M. *et. al.* 2016)
- Received grant Rs. 22 lakhs for frozen semen lab development from IIM Calcutta Innovation Park also ranked in top 40 in the SMART FIFTY Contest organised by DST & IIMCIP, New Delhi.

2.0 Challenges in Small Ruminant Farming

In spite of having potential of good economic returns from small ruminant rearing, sheep and goat farmers have very poor income levels. There may be a number of reasons for it and summarized briefly as follows.

i. Knowledge gap on scientific interventions and technologies have not yet been effectively disseminated and adopted by the sheep and goat keepers.

ii. Prevalence of non-descript or poor genetic-make-up of animals in want of selection and breeding practices.

iii. Scarcity of superior bucks-Breed dilution is common feature due to indiscriminate breeding. Sale of males with higher growth rate at 3-6 months of age and small flock holders are not willing to keep breeding buck, thus low potential males are being used for breeding the goats.

iv. Scarcity of feed and fodder: Under feeding and inadequate housing further deteriorate the immunity level of animals and made them vulnerable for diseases.During last few decades' sheep and goat flock and herd sizes were reducing due to shrinkage of common grazing resources and deficiency of biomass in rangelands.

v. Higher mortality on account of very low adoption of prophylactic and curative health measures: Prophylactic health measures were highly uncertain and followed by few (<10%) farmers.

vi. Inadequate housing-Sheep and goats were housed predominately in human dwelling, in open and under enclosures made up bush and shrubs (50-55%).

vii. Depletion of grazing resources due to over grazing on account of very high stocking rate and poor management of grazing resources. Expenditure on feed and fodder account for more than 60% of recurring cost, which matter for landless goat and sheep keepers and small land holders. During draught or flood the availability of biomass from CPR reduces from3.5 q/ha to 0.5 q/ha per year. Thus productivity, survivability and income go down upto70%.

viii. Low availability of veterinary and other support services mainly institutional credit to goat keepers- Veterinary services are very poor and not reaching to majority (>82%) of farmers.

ix. Low price realization due to unorganized marketing and lack of milk cooperatives. Majority of small ruminants was sold through middlemen and share of middle man in total income varied from 15-35%. Distress sale of sheep and goat due to very urgent natures of domestic needs and thus farmers realized lesser share of income.

Recommendations:

- From agribusiness perspective, goat sector is dominance of small holders and landless labourers with disbursed production and diseconomies of scale. Consolidation of production is essential to overcome problems of costs associated with diseconomies of small scale, poor access to services, inconsistence marketable surplus and quality.
- Building efficient, inclusive and financially sound value chains for goats and their products is a big challenge, but is not insurmountable if key players follow innovative and targeted approaches.
- Collective action through goat based SHGs, goat cooperatives and goat producer's companies is essential to overcome scale limitation of smallholders' participation in value chains, and to reduce transaction costs and risks
- Support from the government or its subsidiaries for enabling business environment to different stakeholders / players in the form of financing value chain for means of production and services providing agencies at initial stage.

- Development of business models for various level of production e.g. contract goat farming, milch goat farming, goat banks and broiler goat production with buy back schemes etc.
- Value addition of goat products and by products and development of cold chain goat products.
- Technology dissemination through need based customised capacity building programmes for goat farmers and other stakeholders
- Support for regulatory market of goat and credit support

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Chapter-11

Entrepreneurial Opportunities for Rural Youth in Arid and Semi-arid Horticulture

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ABSTRACT

The horticulture sector is playing significant role in agriculture and rural India growth as a whole through providing better opportunities of crop diversification, higher productivity per unit area, extended cultivation in resource poor areas, employment generation and export promotion. So far, India has achieved many milestones in horticulture production becoming second largest producer of fruits and vegetables including holding first rank in many fruits and vegetable production. Horticulture sector can be a driving force for augmenting farmer's income and job creation in rural areas. Several entrepreneurial opportunities are available in arid and semi-arid fruits and vegetables crops production, quality planting material/seed production, smart marketing and value addition. Fruits and vegetable seedling nursery, vegetable dehydration, fruits and vegetable powders, pulp processing, minimal processing etc are the areas where rural educated youth have opportunities for setting-up of small business. Handholding of stakeholders in the area of skill development, technology up gradation, liberal financial lending, and support in marketing and branding is essentially needed for promoting rural entrepreneurship.

Introduction

Indian horticulture sector contributes about 33% to the agriculture Gross Value Added (GVA) GDP and making very significant contribution to the Indian economy. Apart from ensuring nutritional and economic security of the nation, it also provides alternate rural employment opportunities, diversification in farm activities, and augmented profits to farmers. India is currently producing about 320.48 million tones of horticulture produce which has exceeded the food grain production, that too from much less area *i.e.* 25.66 million ha occupied by horticulture crops against 127.6 million ha under cereal and other food grains. Productivity of horticulture crops is much higher compared to productivity of food grains (12.49 tones/ha against 2.23 tones/ha.). India has emerged as world leader in the production of a variety of fruits like mango, banana, guava, papaya, sapota, pomegranate, lime & aonla and is the second largest producer of fruits and vegetables after China.

2. Arid and Semi-arid Horticulture

The areas receiving low annual rainfall (<-66.7% are classified as arid regions. The arid regions are further divided into hot and cold arid region. The hot arid regions cover 31.7 million ha concentrated in the state of Rajasthan (61%), Gujarat (20%), Andhra Pradesh (7%), Punjab (5%), Haryana (4%), and Karnataka (3%). The soils of arid regions are predominantly light textured. Low and erratic rainfall and high atmospheric evaporative demand coupled with a poor water holding capacity of soil limits the crop growing period up to 90 days, and therefore short duration vegetable crops mainly cucurbits and legumes, drought tolerant perennial vegetables and fruit crops are largely cultivated in the region (Samadia *et al*., 2015).

The area receiving annual rainfall between 500-1000mm and moisture index between -33.3 to -66.7 is classified as a semi-arid region, covering about one third of total geographical area of the country and is largely concentrated in western and southern peninsular parts. The semi-arid region is further divided into dry and moist semi-arid regions. The area with 500-750 mm annual rainfall and a crop growing period of 90-120 days falls under dry semi-arid region and is spread over 41.6 million ha. The area receiving750-1000 mm annual rainfall, with a crop growing period of 90-150 days is classified as moist semi-arid region and covers about 72.2 million ha. (Rathore *et al*., 2019).

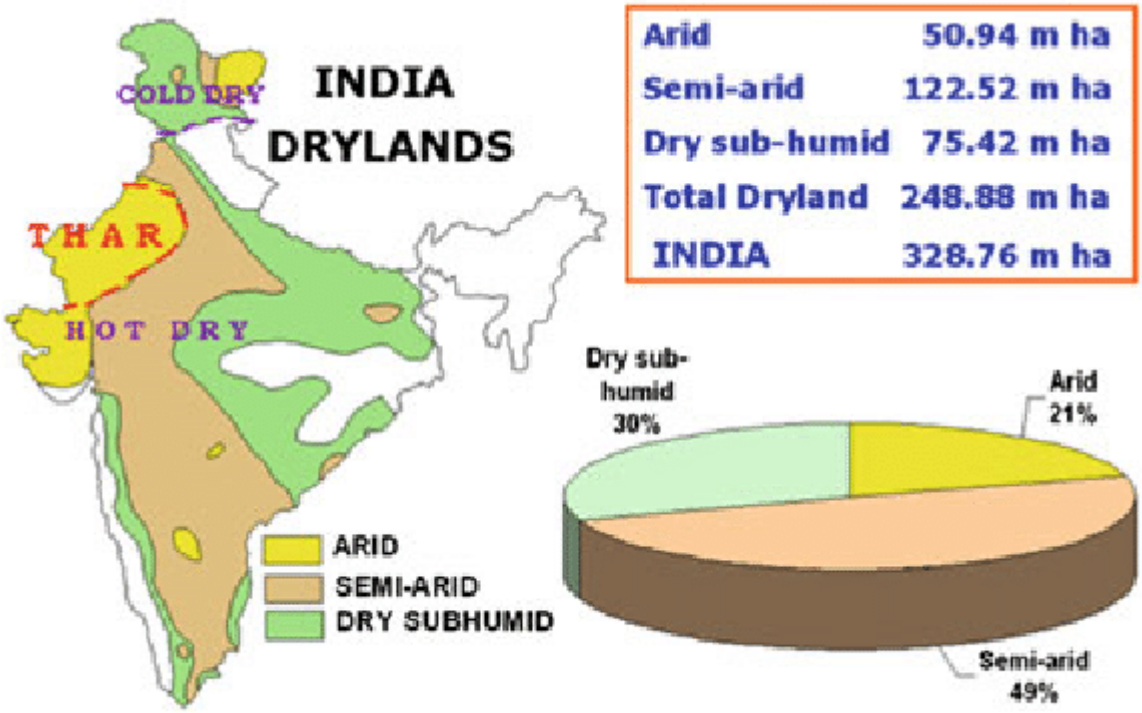

Fig. 1 Arid, semi-arid and dry sub-humid regions of India (Tewari *et al*., 2014).

Arid fruits and vegetable crops: Despite climatic-edaphic challenges large numbers of fruits and vegetables are being cultivated in arid regions. The fruit and vegetable crops like ber, date palm, aonla, lasora, phalsa, ker, Khejri, kinnow, bael watermelon/mateera, kachri, snap melon/phoot/ kakadi, long melon/kakri, round melon/tinda, guarphali, bottle gourd and ridge gourd are crucial crops grown in these areas.

Semi-arid fruits and vegetables crops: The crops being grown semi arid- regions are mango, guava, aonla, bael, litchi, pomegranate, jamun, mahua, chronji, sapota, tamarind, jamun and many vegetable crops.

3. Need of rural entrepreneurship

COVID-19 pandemic has left many people jobless and reverse migration has taken place where workforce migrated from urban to rural areas. This situation thrown up enormous opportunities for entrepreneurship development in rural areas to provide sustainable income source for rural folk. Rural entrepreneurship development will encourage setting-up of horticulture based cottage industries in villages which further augment agri-infrastructure, capital formation, horticulture produce value chain development, employment generation, reduce post-harvest losses, enhanced farmer income, prevent urban migration and also help in popularized local horticulture produce at global level. NITI Ayog policy paper on doubling farmer's income also suggested promotion of rural entrepreneurship and shifting of cultivators/farmers/rural women in non-farm occupations as one of the strategy for doubling farmer's income (Ramesh Chand, 2017). Therefore, it is the need of current time to inculcate entrepreneurial skills in youth for tapping young workforce to develop horti-based enterprises in rural areas.

4. Entrepreneurial opportunities in arid and semi-arid horticulture

Arid and semi-arid areas contributing more than 50% of total arable land and many horticultural crops are successfully grown in these areas. Many entrepreneurial opportunities are available in horticulture sector and the new generation of educated farmers and unemployed rural youth have several chances to become entrepreneur and adopt horticulture as a business enterprise. Entrepreneurial opportunities in arid and semi-arid horticulture are presented in Fig.2.

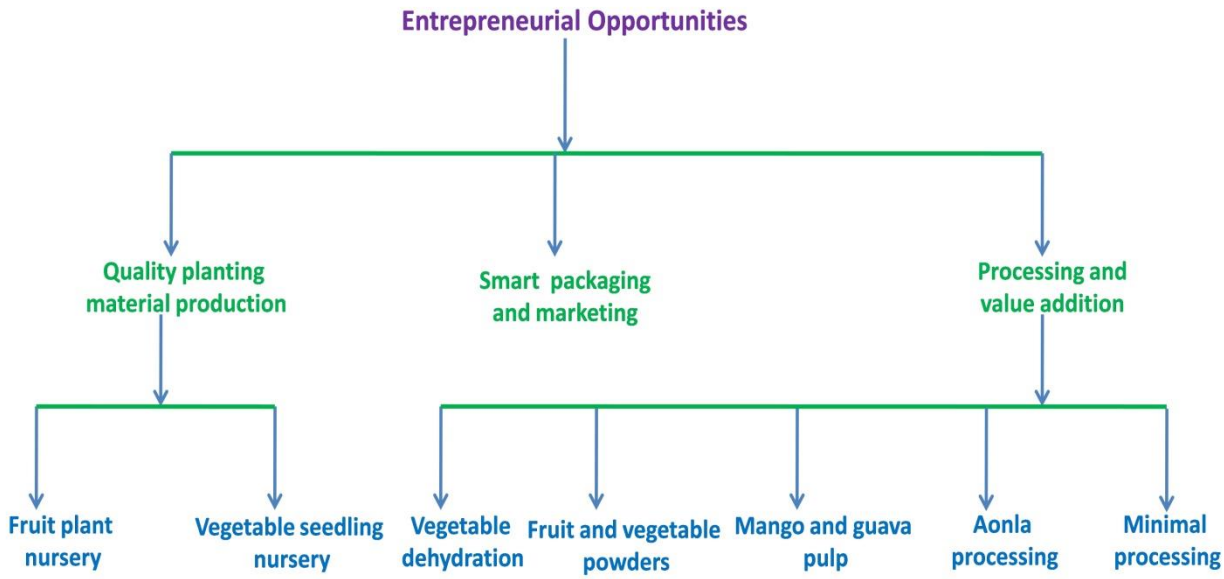

Fig. 2. Entrepreneurial opportunities in arid and semi-arid horticulture

4.1. Quality planting material production

Nursery is an important enterprise which has potential to create enormous employment opportunities in rural as well as peri-urban areas. Recently, trend has been changed and several farmers are shifting from field crop cultivation to fruit orcharding in our country. Therefore, requirement for disease free and quality planting material has been enhanced and still there is big gap between demand and supply. This scenario provides an excellent opportunity for farmers, rural women, youth and entrepreneurs to initiate new business and start-ups in the area of fruit crop nursery. Fruit crop nursery includes many components such as rootstock raising, scion bank, budding/grafting operation, and hardening-off of tissue culture plants, production of growing media, input required and nursery plants marketing.

Considering the fact that good quality planting material fetches a premium price, investment in a commercial nursery unit is considered to be a viable and profitable proposition. Apart from perennial horticulture crops, there is an increasing demand for nursery plants for ornamental flowers and foliage plants. Exclusive production of vegetable seedling and supplying the same to farmers is also emerging as a profitable horticulture enterprise in major vegetable growing belts across the States. Based on resources available and market demand an entrepreneur can choose from fruits, vegetables or flowers nursery or simultaneously start with two or more ventures.

Fruit plant nursery: The fruit crop nursery required a moderate area from production of sufficient number of plants but it is not necessary nurseries should have a large area.

Table 1. Popular varieties of fruit crops, propagation method, rootstock and their scion source for establishment of mother block

Crop	Variety	Source	Propagation method	Rootstock
Guava	Arka Kiran, Arka Mridula, Arka Rashmi, Allahabad Safeda, Lalit, Shweta, L-49	IIHR, Bengaluru, CISH, Lucknow, CHES Godhara	Grafting	Chinese guava
Mango	Amrapali, Mallika, Dashehari, Langra, Chausa, Arunika	CIAH, Lucknow	Grafting	Desi mango
Sweet Orange	Mosambi, Nagpur orange	ICAR-CIAH, Bikaner	Budding	Rough lemon, Ranpur lime
	Pusa Sharad, Pusa Round	IARI, New Delhi	Budding	
	Jaffa, Blood Red	ICAR-CIAH, Bikaner, ICAR-CCRI, Nagpur	Budding	
Mandarin	Kinnow, Nagpur, Nagpur Seedless, Clementine, Daisy		Budding	
Acid lime	NRCC-7, 8, Vikram, Parmalini, Sai Sharbati, Balaji	ICAR-CCRI, Nagpur	Budding	Rough lemon
	Pusa Abhinav, Pusa Udit	IARI, New Delhi	Budding	Rough lemon
Bael	Goma Yashi, Thar Divya	CHES, Godhara	Budding	Desi bael
	CISH-B-1, CISH-B-2, NB-5, NB-9	CISH, Lucknow	Budding	Desi bael
Jamun	Goma Priyanka and Jamvant	CHES, Godhara, ICAR-CIAH, Lucknow	Budding	Desi Jamun
Ber	Gola, Seb, Banarasi Kadka, Thar Sevika, Thar Bhubraj, Thai Apple	ICAR-CIAH, Bikaner	Budding	*Z. rotundifolia*
Aonla	NA-7, Laxmi-52, Chakaiya, Krishna, Kanchan	ICAR-CIAH, Bikaner	Budding	Desi aonla
Pomegranate	Bhagwa, Solapur Lal, Ganesh, Phule Arakta, Jalore Seedless	ICAR-CIAH, Bikaner, ICAR-NRCP, Solapur	Hard wood cutting	-
Wood apple	Thar Gaurav	CHES, Godhara	Budding	Desi seeds
Khejri	Thar Shobha	ICAR-CIAH, Bikaner	Budding	Desi Khejri
Lasoda	Thar Bold, Maru Samridhi, Karan Lasoda	ICAR-CIAH, Bikaner	Budding	Desi Gunda
Phalsa	Thar Pragati	ICAR-CIAH, Bikaner	Cuttings/seeds	-
Karonda	Thar Kamal	ICAR-CIAH, Bikaner	Cuttings	-
Tamarind	Goma Prateek	CHES, Godhara	Budding	Seeds
Mulberry	Thar Lohit, Thar Harit	ICAR-CIAH, Bikaner	Cutting	-
Chirounji	Thar Priya	ICAR-CIAH, Bikaner	Soft wood grafting	Seeds

The size of nursery and site selection depends on many factors, including production method and crops grown. Plants can be propagated in outdoor beds, propagation frames, and various types of greenhouse structures. In addition to these growing areas, space for soil preparation, potting, and transportation will be needed. An adequate, clean, pest-free water source must be available. Propagation in beds requires a well drained, well-aerated soil .The site should have good air circulation and a slightly sloping topography for excess water runoff. Frost pockets and windy locations should be avoided. The disease hot spots and nematodes affected soil should not be selected for the nursery purpose.

The important factor for nursery is the source of seed for rootstock and mother plant for scion wood. The seed of horticultural crops are available with the agencies developing the varieties. But the sources of scion wood are limited as the transportation and storage of scion wood is difficult. The best option is the nursery man should develop his own mother plant blocks or he/she may select the elite plants from the existing orchard. Popular varieties of fruit crops, propagation method, rootstock and their scion source for establishment of mother block are given in table 1.

Requirement for establishment of nursery: For setting up a nursery unit to produce about 30,000 grafts/planting material, an area of about 2 acres (0.80 ha) with assured irrigation facilities is required. Other requirements are mother block, potting mixture preparation yard, poly house, shed net house, propagation tools like spade, hand hoe, budding grafting knife, patch budding knife, pruning saw, rake, sieve, rose can, hosepipe etc. and inputs like potting media, sand, compost, coco peat are essential for nursery.

Think before you start a nursery business: An entrepreneur should analyze some aspects pertaining to nursery to make a successful venture in quality planting material production are infrastructure requirements, source of capital for investment, availability of skilled labour, market demand, marketing channel and availability of inputs.

5. Smart packaging and marketing

Poor handling during harvesting and post harvest chain and marketing led to quality and post harvest loss. Proper handling during harvesting, post harvest handling and packaging will results into enhancement of post harvest quality and shelf life. An entrepreneurial opportunity lies in the cool chain management of these crops from farm gate to consumer plate. Profit making entrepreneurial models may be developed through which middle men involved in marketing chain can be removed and fresh produce procured from farmer's field should be directly brought to consumer's plate.

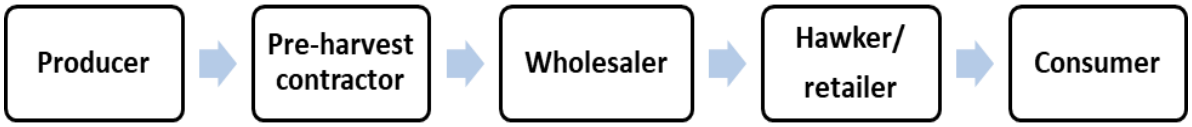

Fig. 1: Traditional channel of marketing of arid fresh fruits and vegetables

Fig. 2: An innovative channel of marketing of fresh fruits and vegetables

6. Processing and value addition

India holds second position in terms of fruit and vegetable production after China. To minimize losses of fresh fruits and vegetables, and to add value to them, government of India is promoting food start ups through financial support, tax concessions, rural agriculture infrastructure development and capacity building of stakeholders. At present several opportunities are available for setting up of small scale businesses in the domain of fruits and vegetables processing and value addition.

6.1. Vegetable dehydration

The dehydrated vegetable market of India is expected to grow at a CAGR of 16% by the year 2025. The supportive agro-climatic conditions, potential domestic market, cost competitiveness, and government support are some of the key factors which will drive the growth of this industry (ASSOCHAM, 2018). Preservation and value addition through dehydration has many advantages over other methods such as low cost, easiest method of preservation, no need of chemical preservative etc. Dehydrated products are fairly ideal for backpacking, hiking due to light weight and more concentrated form and also low investment needed in storage, transport and distribution. Solar drying is proved to be the most ideal method for dehydration of arid and semi-arid fruits and vegetables owing to abundance solar radiation in this region. Different kind of solar dehydrators like portable, tunnel type, convective, photoveltic, inclined type etc have been developed by many research institutions and entrepreneurs. Setting up of small scale vegetable dehydration units in rural areas will reduce post-harvest losses, create employment opportunities particularly for rural women, enhance off- season availability of vegetables, reduce glut in the market and farmers also get better price for fresh produce.

Table 2. Equipments required and economics of small scale vegetable dehydration unit

S. No.	Equipments	Capacity	Cost (Lakh)	Economics
1	Vegetable/fruit washer	100kg/hr	2	Capacity: 100 MT /annum, Working hrs per day: 8-10, Working day per year: 300, Average sale price of dried product: ₹250/kg Average recovery rate: 20% Margin: Rs 30/kg Expected profit generated per annum: 30x20000= ₹600000/-
2	Vegetable peeler	100 kg/hr	1	
3	Slicer	50 kg/hr	1	
4	Blancher	100 kg/hr	2	
5	Solar dryer	100 kg/8hr	3	
6	Sealing machine	10 pouches/min	3	
			12	
	Civil work and other expenses		3	
	Total		15	

6.2. Fruits and vegetable powders

With changing lifestyle patterns, consumers are inclined towards convenience foods meeting specific nutritional requirements. The aforementioned trends have led to a growth in the demand for nutraceuticals and in turn, will fuel the market for fruit and vegetable powder. The global dried fruit and vegetable powder market size is expected to reach US$ 23.96 billion by 2025 as a result of a positive outlook towards the nutraceutical industry (TPCI report, 2020). Consumers are continuously striving for the fulfillment of their nutritional intake through functional food and drinks. Rising awareness regarding the importance of micronutrients including vitamins, minerals and amino acids has resulted in increased product demand. Value addition of fruits and vegetables through powder making have several advantages over other method of processing because it is comparatively easy to produce, cost effective, low volume and high value final product, long shelf life, low cost involve in transport and storage.

In arid and semi-arid areas raw mango powder (*amchur*) and kachri powder are the two horticulture based commodities where rural youth has big opportunity for setting-up of small scale processing units and can supply final product to big players of *masala* industry. Both amchur and kachri powder are used in making curries, chaat masala, flavouring agents in smoothies, sauces, chutney, *sambhar* etc. Amchur and kachri powder are also utilized for tendering meat and pork therefore large amount of both the commodities exported to gulf countries. The process for making raw mango and kachri powder is quite simple and after training rural youth and women can do it in villages as well. The process is depicted in flowchart given below.

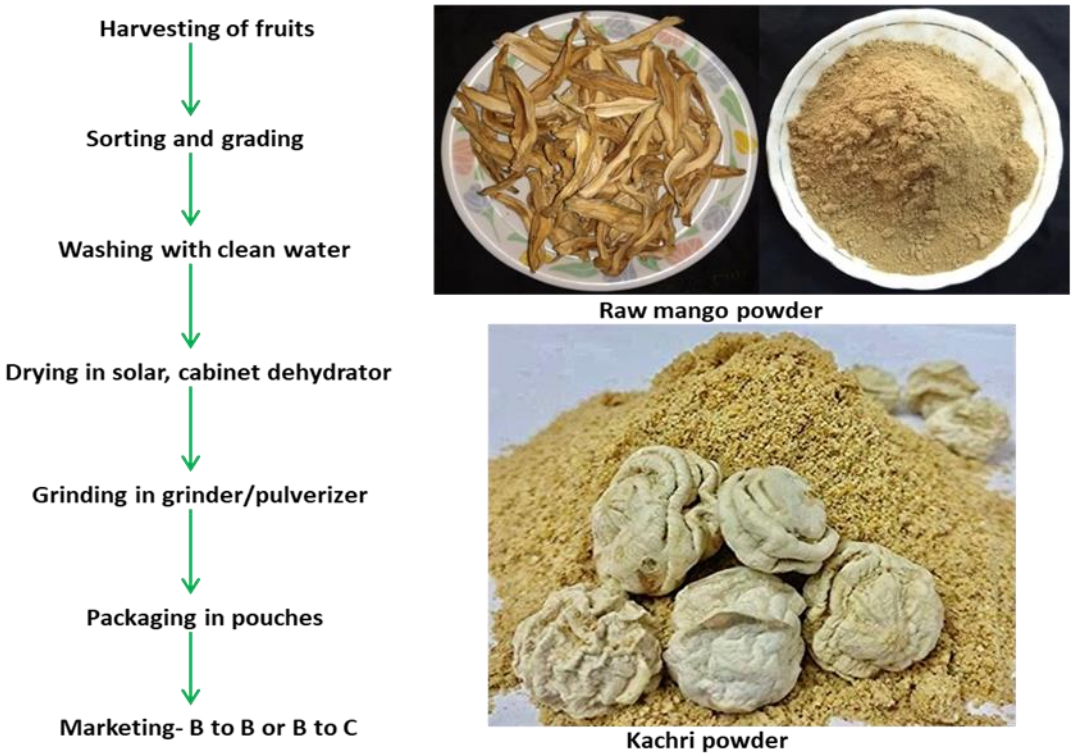

Fig. 3. Process for making raw mango powder and kachri powder

6.3. Mango and guava pulp processing

Mango Pulp/Concentrate is very much suited for conversion to juices, nectars, drinks, jams, fruit cheese and various other kinds of beverages. It can also be used in puddings, bakery fillings, fruit meals for children and flavours for food industry, and also to make the most delicious ice creams, yoghurt and confectionery. However, in recent years the popularity of mango has spread to the western markets with consumers showing interest in the taste. The US juice industry and fresh market has shown consistent interest in both fresh mango and its processed products. The US juice industry has been making more and more use of mango pulp in its orange juice blends.

Mango pulp exports from India: India is also a major exporter of Mango Pulp in the world. The country has exported 123,476.69 MT of Mango Pulp to the world for the worth ₹924.52 crores/ 124.11 USD Millions during the year 2021-22 (APEDA report, 2021-22). India accounts for contributing approximately 67 percent of the total world export when it comes to processed mango product. That is almost half of the world production of mangoes. The bulk of this share goes to Middle East followed by Southeast Asia and Europe. Saudi Arab, Yemen Republc, Netherland, Kuwait and U K were the major export destinations for mango pulp during 2021-22.

Currently, two main clusters of mango pulp processing are situated in the country, which has around 65 processing units with a good backward linkage of Alphonso and Totapuri variety of mangoes. These clusters are located in Chittoor in the state of Andhra Pradesh and Krishnagiri in the state of Tamil Nadu. A few number of the mango pulp processing units are situated in the state of Maharashtra and Gujarat. Mainly Alphonso, Totapuri, Banganpalli and Kesar varieties are processed into pulp in India. However, a number of good quality varieties like Dashehari, Langra, Chausa, Amrapali etc are growing in northern states of India which are having excellent pulp colour, flavor and taste. These mangos may be processed into pulp through setting up of pulp processing units in northern states of India.

Industry standards for mango pulp: The minimum pulp TSS should be 16 ºBrix for Dashehari, Alphonso and Kesar while for Totapuri TSS should be 14 ºBrix. Pulp pH should range from 3.5-4.2 and pulp consistency ranged from 7 to 14. Pulp acidity ranged from 0.3-0.9 %. For pulp concentrate minimum TSS is 28 ºBrix, pH 3.5-4.2, consistency less than 10 and acidity 0.4-1.6%.

Table 2: Quality standards for mango pulp of different varieties.

Mango variety	Product	TSS (ºBrix)	pH	Consistency	Acidity (%)
Dashehari	Pulp	16	3.7-4.3	7-14	0.3-0.9
Alphonso	Pulp	16	3.7-4.3	7-14	0.3-0.9
Kesar	Pulp	16	3.5-4.2	7-14	0.3-0.7
Totapuri	Pulp	14	3.5-4.5	7-14	0.3-0.8
Totapuri	Concentrate	28	3.5-4.2	<10	0.4-1.6

Mango pulp extraction and preservation process: Pulp is extracted from ripe fruits with the help of pulper, finisher and pasteurized by electronic pasteurizer at 95 ºC temperature. Flowchart of mango pulp extraction method is given figure 4.

Pulp packaging: Mango pulp is packaged in various types of packaging material. Canned pulp is packed in tin cans of various filling capacity ranged from 0.5 kg to 20 kg. In case of aseptic packaging, mango pulp can also be packed in polypropylene pouches internally lined with acid resistant material through pulp filling machine. Aluminium aseptic bags are also available for packaging of mango puree for export to European market. Mango pulp or puree aseptically filled in aluminum bags then these bags are keeping inside steel drums or cartons. Frozen mango pulp is packed in both aluminum pouches and food grade plastic buckets with hermetic lid.

Pulp marketing: There is tremendous demand for mango pulp in domestic as well as international market. According to the publisher, the Global Mango Puree Market is accounted for $995 million in 2017 and expected to grow at a CAGR of 8.7% to reach $2110 million by 2026. One of the key factors such as mango puree widely used in making drinks, juices, jams and nectars, increasing consumption of mangoes across the globe are driving the market growth. In India, Parle agro, Cocacola, Nestle, Mother Dairy, Amul, Tasty Treat etc are the major mango puree buyers. In international market, Middle East, gulf countries and Europe are recognized as the major consumers of Indian mango pulp.

Fig. 4. Process of mango pulp extraction and preservation

6.4. Aonla processing and value addition:

Aonla fruits are highly beneficial with great neutraceutical and pharmaceutical value (Pathak *et al*, 2003). Fruits are highly perishable and not suitable for fresh consumption due to high acidity and astringency. Processing of aonla fruits is imperative for making it palatable. Therefore, aonla based processed products are always remain in high demand from consumers side. High demand for aonla based value added products is opens the ways for startup development in this area. To meet the increasing demand of aonla value added

product in market small scale processing unit can be established in rural areas keeping into consideration the availability of raw material, existing resources and marketing facility.

Requirements for establishment of processing unit: One should consider availability of raw material for processing, financial requirements, uninterrupted water and electricity supply, skilled manpower and marketing of processed products for establishment and successful running of processing unit. FSSAI license issued by food safety department of concern state government is necessary for building consumers confidence in product and it will also facilitates marketing.

Table. 3. Equipments and investment needed for establishing small scale processing unit

S. No.	Equipment	Cost (Lakh)
1	Fruit Washer	0.5-1.0
2	Grader	2.0-2.5
3	Pricking machine	2.5-3.0
4	Shredder	1.2-1.5
5	Hydraulic press	2.0-2.5
6	Steam Jacketed cattle	1.0-1.2
7	Tray or solar dryer	0.8-1.0
8	Mixing and storage tank	0.5-1.0
9	Bottle filling and crown coking machine	1.0-1.3
10	Pouch filling and sealing machine	2.5-3.0
	Total	13.5-18.0

Aonla products: Aonla preserve, Aonla candy, Aonla segment in syrup, Aonla powder, Aonloa jam, Aonla shreds, Aonla supari, Aonla pickle, Aonla juice

6.5. Minimal processing of fruits and vegetables

Consumer demands for convenient but fresh and healthy foods are driving the food industries to apply new and mild preservation techniques, which satisfy the increasing market demands for fewer preservatives, higher nutritive value, and fresh sensory attributes. Traditional preservation technologies and techniques are highly affected the appearance, sensorial characters, and the nutritional value. Minimally processed (MP) fruits and vegetables are fresh fruits and vegetables processed to increase their value without greatly changing their fresh like properties. Fresh-cut produce industry has been on a double-digit growth rate in reaction to an increased demand by consumers, particularly in developed countries.

Scope of minimal processing: The present day nuclear families needs ready to cook and ready to eat foods because of paucity of time. The Mandi structure is collapsing slowly and retail giants are tying up with the primary processing companies to supply clean fresh and cut vegetables to their stores.The minimally processed vegetables may benefit marginal farmers as they get an assured price for the produce for a definite period even if the market fluctuates. This will reduce the wastage and create job possibilities in the rural areas thus stopping the move towards the cities for better job prospects.

Purpose of minimal processing: The original purpose of minimal processing is to minimize the heat treatment (thermal processing) used by traditional thermal techniques to reduce the quality loss that has been caused by long and high temperature treatments. Minimal processing of raw fruit and vegetables has two purposes:

1. It is important to keep the produce fresh and supply it in a convenient form without losing its nutritional quality.

2. The microbiological, sensory and nutritional shelf life of minimally processed vegetables or fruit should be at least 4-7 day, but preferably even longer, up to 21 days depending on the market, the loss of ascorbic acid and carotenes is the main limiting factor of nutritional quality.

Equipments needed for minimal processing of vegetables: Plastic tables, plastic crates, washing unit, peeling, dicing, slicing machine, pretreatment chamber, hot-air dryer for dewatering, pouch sealing machine, modified atmospheric storage packing machine and cold storage.

Key requirement for minimal processing of fruits and vegetables

1. Good quality of raw materials (correct cultivar variety, correct cultivation practices, correct time of harvesting and storage conditions)

2. Strict hygiene and good processing practices use of hazard and critical control point principles.
3. Correct temperature and humidity during distribution and retailing.
4. Low temperature during processing.
5. Use of mild additives in washing water for disinfection or the prevention of browning.
6. Careful cleaning and/or washing before and after peeling
7. Good quality water (sensory, microbes free, heavy metal free, and pH) for washing.
8. Gentle spin drying following washing.
9. Correct packaging materials and packaging methods.
10. Gentle peeling, cutting, slicing and/or shredding

Conclusion

There are enormous entrepreneurial opportunities in arid and semi-arid horticultural seeds/planting material production, crop production, marketing, value addition and production of input needed in successful growing of these crops. Establishment of small scale rural enterprises based on different aspect of horticultural crops will certainly plays a significant role in job creation, farmers economic empowerment, reduce post-harvest losses, building value chain and overall improvement in rural economy. Capacity building of stakeholders, credit facility, hand holding of rural youth in agri-incubation centers, single window system for startup registration and creation of basic rural infrastructure like road, water and low cost electricity is required for promotion of entrepreneurship in rural areas.

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Chapter-12

Forage Densification, Handling, Transport and Storage for Entrepreneurship Development

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Introduction

Drought, floods, earth quake, and cyclone are becoming common phenomena in India. During such natural calamities many efforts are done for survival of human beings and ignoring most of the times animals due to poor management of forage resources and an unorganized sector of feed and fodder resource management. Tremendous amount of different varieties of crop residues and grasses are available in India for different uses like paper making, bio-energy generation, fiber extraction, briquetting etc. and could also be well utilized for animal feeding. These feed and fodder resources are either in the form of small size like wheat straw, thick stem plants like sorghum stock or in the form of whole dried crops like paddy straw or dried grasses. All of these fodder resources are highly voluminous and having lower density varying from 40-70 kg/m^3 due to which transportation, storage and handling are very cumbersome and expensive and therefore cannot be utilized up to a maximum extent. Further, the available fodders resources may also be categorized as low-grade roughage, which could be well enriched through ammoniation (liquid ammonia or urea treatment), mixing molasses or changing their physical shape and blending them with leguminous herbaceous additives for enhancing their nutritive value and digestibility as per requirement of different groups of animals.

Need of the day!!!

Conserving the fodder resources scientifically, is therefore a need for animal feed sector to mitigate the losses occurred in various steps, reduce the cost of handling, storage and transportation, serve timely the needy group in case of natural disasters, to enrich the value of roughages and strengthen the economic power of the farmers. This is possible only by creating fodder bank in different zones of the country after assessing the balance sheet of fodder production. This will not only provide the timely supply of the feed to the most affected area in the country but it will also serve as community based bank from where a needy farmer can deposit his share, withdraw as per his requirement, sale his share or even he can take loan from the bank with a promise to return with interest in term of fodder only and not in cash. The bank would have to maintain its own products in the form of densified

blocks, pellets, silage and hay and if agreed by the members leguminous green fodder would also be produced and procured either for sale or conserving as raw material for adding the value to the roughages. It has been observed that various post harvest operations viz. material handling, drying, storage and transport and marketing system influences the total fodder production and its fruitful utilization both in terms of quantity and quality. Being agricultural commodity they are also affected by the surrounding environment resulting into loss of quantity and nutritional quality. An urgent need to conserve the available forage resources is therefore felt for developing a fodder bank in the different regions of the country. This paper presents briefly about status of some important unit operations involved in developing fodder bank.

Practices in Material Handling, Transport and Storage

Various unit operations including size reduction and drying are involved in the development of a fodder bank but material handling and transport and storage are the most important. Drying, size reduction and baling/densification/pelleting etc. are practiced for specific product formulation or when crop residues are wet or green fodder needs to be dried for adding in various products.

Material Handling and Transport. It includes a number of operations that can be executed either by hand (manual) or by mechanical means or devices to convey materials and to reduce human drudgery. After harvesting the agricultural commodity are moved, transported or conveyed from place to place *e.g.* grasses after harvesting are conveyed for drying, size reduction, storage, feeding etc. Similarly, wheat straw is collected after harvesting and threshing wheat crop and is either conveyed for storage, marketing or for feeding. Thus the material handling and transporting should aim to lighten the work of human labour. The important material handling equipments for most of the agricultural commodities are belt conveyer, bucket elevator, screw conveyer and pneumatic conveyer. Selection of these equipments depends upon the characteristics of the products to be handled and design details of these equipments are available mostly for grains/ granular materials (Sahay and Singh, 1994). For horizontal moving of bagged or bulk material the belt conveyer may have flat, V-shaped or some other enclosed shape. Bucket elevators with belts are employed in food industries for vertical conveyance of grains, derivatives and flours. However, the screw conveyor is widely used in grain handling as well as in animal feed industries for conveying products generally for distances and could be well applied for mixing of different products. Thus, treatment of straw with urea (solid and liquid), steam, molasses etc. is possible using screw conveyor and could be used for mechanizing the process of conveying as well as for

treatment of the straw. The traditional conveying equipments or a method for on farm conveyance with their conveying capacity was however not reported in the literature, which may play greater role in costing of the process.

Carts drawn by various animals viz. bullocks, horses, camels etc. are also available and equally important for rural transportation specially for form operations. Bisen (1977) designed, fabricated and tested an improved bullock cart and later Deshpande and Ojha (1984) presented the theory and design of animal drawn vehicles. The design details of animal drawn carts are presented by Sahay and Singh (1994) with the detailed design of bullock cart's wheel, falleo, spoke, hub, yoke, cart frame and cart body. They said that the design criteria should suit the size of bullocks, load to be carried and the kind of the road. They however, did not define the effect of these factors in designing and also did not mention the optimum load to be carried out by the different size of bullocks.

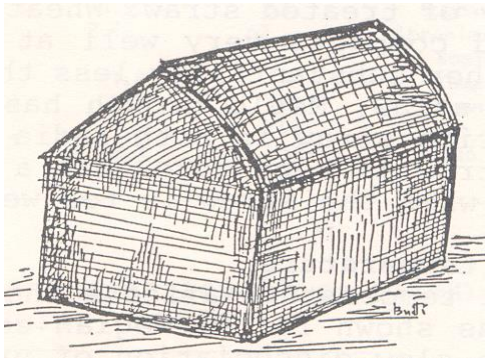
Crop residues being voluminous in nature and have lower bulk density than grains need more space, labour, time in handling and farm operation causes more cost in the transportation. Traditionally the wheat straw in loose form is transported by trucks, tractor trolleys and by bullock carts depending upon the distance traveled. Transporting loose straw violated the traffic rules due to bulging and causes losses. Transport losses of loose straw were not reported in the literature. However, transporting bales of different products (grasses, wheat straw and paddy straw) causes 1.5 to 4.0% losses in weight and 15.5 to 43.9% reduction in volume. The study reveled that about five times of the paddy straw when densified can be transported in comparison to loose paddy straw in a single trip of truck (Pathak et al. 2008). The average weight losses during transportation of bale crop residues for 200km distance is 4.51%. In a simulation test at PAU Ludhiana a loss of 6% in the weight of paddy straw bales and 7-15% for wheat straw bales was observed which could be accounted for the conveyance loss (Annon, 2003). Therefore, it could be said that type of crop transported, carrying capacity of transport modes, physical dimensions of transport modes, filling methods, time and labour required in filling and emptying, distance to be transported and physical dimensions of filled wagons/trucks/trolleys are the important factors, which affects the economics and efficiency of material handling and transport.

Storage

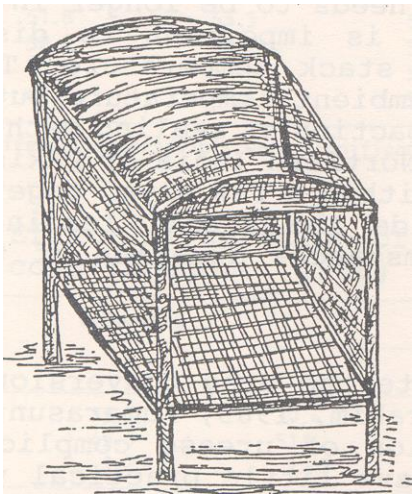
Storage is a repeated phase during transit of agricultural produce and the product needs to be stored from one harvest to next thus, demanding additional carry over as safe guard, against speculation in price and market demand or against shortage and famine. The

storage structures and or methods for crop residues, grasses and fodders are different to those of grains due to variation in physical characteristics. Several structures have been traditionally used for storing these crop residues, grasses and fodders and may be classified into different groups. They may be permanent and temporary structures depending upon the constructional material used, underground or above the ground depending upon ultimate use of the product, on farm or at other places depending upon their marketing and use. However, most farmers prefer to construct their own storage structures depending on availability of infrastructure and economic considerations. The method of storing crop residues, grasses and fodders also differs depending upon their size and could either be stacked in case of long straw like from rice in the north and finger millet and sorghum in the south or stored in the structures like room, 'bonga' or 'dhar' etc. as in case of wheat straw. Farmers use various others storage structures like earthen pits, wooden or cemented clamps, cemented silos, and sacks. Earthen pits could be lined and plastered with mud and cow dung and covered with jute bags. Storing straw in pits has difficulties for contamination of straw with soil and seepage of water from the side of pit especially during the rainy season and is difficult to fill or to unload and may not be suitable for digging in rocky lands. The traditional method of storage of rice straw - making stacks on the ground in open area by putting layers of straw and making the shape like the dom of mosque was reported by Mamun *et.al*. (2002) in Bangladesh. While surveying the existing practice of storing rice straw they also quantified the losses of straw. The straw losses were reported in three stages - during harvesting (about 8 and 10% for Boro and T. aus straw, respectively), processing (25 and 23% of Boro and T. aus straw respectively) and storage condition (about 18-20% of straw). Loss of straw in storage was mainly due to earthen evaporated gas, rat, termites, *anjona* (a reptile pest), poultry birds and excessive rainfall and advocated to improve storage system. Suggestion for improving storage condition to some extent is to build the stacks under trees to give some protection or on raised wooden platforms. Polythene, corrugated iron or coconut tree leaves can also be used to improve storage condition.

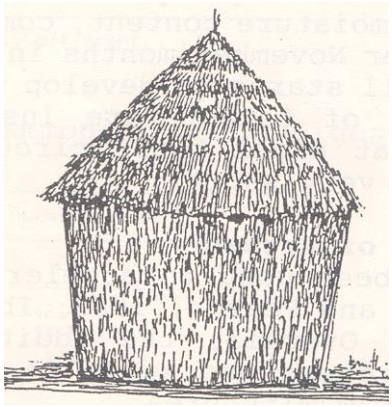
In temperate zones of India bundles of dry grass from the grassland is carried by both men and women on their back and is stored in pyramid shaped structure called *toil*. Farmers in the hilly region have evolved safe, cheap and protective methods to store hay and fodder for use in dearth period. Hay or fodder is stored in open fields from September to October for meeting needs in winter. These are piled up in a circular shape of pyramid or *telang*. A cloth made of yak hair, called *thobi* is used for covering these structures. Stones of heavy weight are used for pressing it and to keep the hay/fodder in place.



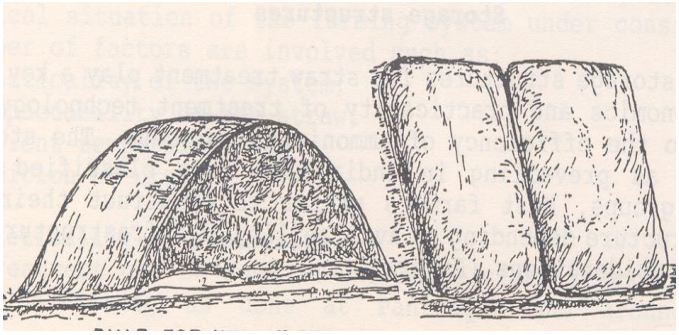
Paddy straw stack (on ground)



Paddy straw stack (above ground)



Bonga for wheat straw



Dhar for wheat straw and polythene covering

Some improved storage structures for crop residues, straw and grasses were also used. A improved store houses of gable type tin shed with raised slate about 1½ ft height from the ground was built (Mamun et. al. 2002) and compared the quality with that of traditional method in Bangladesh. The size of the storage was length- 22.5 ft., height- 9ft., and width- 13ft. It was found that improved storage method significantly increased nitrogen free extract, in vitro dry matter digestibility and in vitro organic matter digestibility of rice straw. No significant difference was reported in crude protein and organic matter. A cover and plinth storage structure for storing bales/blocks of five different products of grasses, wheat stubbles and paddy straw was made at IGFRI, Jhansi, which includes platforms of size 9X3 m with 0.76 m height from ground and polythene sheet of 1000 gauge for covering the stored bales (Pathak *et al* 2007). Each platform had storage capacity ranging from 1100 to 1600 bales weighing 13-32 t per storage platform depending upon the density of individual block up to a height of 3 m. Ensiling green fodder is done in underground fodder preservation cum storage

structure of 900x1250 mm size having capacity 300 kg (Malaviya, 2002) which could be used for making available the product for round the year and in lean period.

Economics of the process

Any process developed should be economically sound for success of any sector and it is true for fodder bank too. The economics of fodder bank could be evaluated depending upon individual products as well as the whole unit. In view of assessing the economics, the capacity of the bank could be established first, depending upon the size of the targeted herd to be served and category of the herd like milch animal, draft animal, small or large ruminants etc. The purpose of the bank could then be clearly identified according to the product type, time of storage and ingredients added. The process line could then be drawn specifying the different products and material and energy balance for each unit operation be given. Machine for each operation be identified with the matching capacity of previous and next operation. In between two operations suitable material handling equipments should also be identified depending upon the nature and quantity of the material to be handled in view to mechanize the process. A list of all such equipments and machine needs to be prepared with their cost. Housing of these equipments and storing the raw material and final product is also essential which could be identified as per requirements and nature and type of the materials. Such houses are to be well electrified with power backup and water supply. The expenditure on purchasing all raw materials, manpower requirement (labour and supervisor), energy requirement etc. are noted for cost assessment. Expected loans on all these expenditures are also recorded with different taxes and insurances to be paid. The expected output with an assumption of 75-80% plant efficiency is recorded for assessing the profit. All these expenditures are grouped into following headings and are used for calculating process cost, cost benefit ratio, profit, break-even point, payback period etc. The rates of banks, insurances, taxes should be taken as per applicable in the area. Cost of safety should also be taken care.

Example of cost analysis: A work sheet

Plant details

Plant capacity	-------- T/ day (to be decided depending upon herd size, type product, ingredients etc.)
Working days /year	300 with 80% plant efficiency (assumption)
Working hours	24 in 3 shifts (decided by management depending upon machinery available and target etc.)
Operation type	Continuous/batch (depending upon process)

1. Expenditure on Equipments

a. Baling machine 1 no. cost

b. urea molasses mixture 1 no. cost

c. conveyors 1 no. cost

d. water tank 1 no. cost

e. molasses tank 1 no. cost

f. other equipments like harvester, choppers etc1 no. cost

g. security machines/ equipment (because fire may attract during operation)

(the no. of all these will be decided as per process line and matching capacity)

Total cost	Rs.-------
10% of all above for installation	Rs.-------
Total cost including installation	Rs.-------

2. Expenditure on fixed capital

a. Building for -----m X -----m space @ ₹-------/sqm of plinth area Rs.-------

b. Electrification @ 12.5% of (a) Rs.-------

c. Internal water supply @5% of (a) Rs.-------

Total Rs.-------

3. Total fixed capital investment including building nd machines = 1+2 (Rs)

4. Expenditure on annual working capital (all material required for continuous working of the plant is added here) like below

a. cost of molasses -------l/day @₹------/kg = Rs.-------

b. cost of other materials like leaf meal, concentrate,

mineral mixture etc added separately = Rs.-------

c. cost of crop residues -------kg/day @₹------/kg = Rs.-------

d. Miscellaneous charges for handling etc. @ 10% of (a+b+c+ ---) Rs.-------

Total Rs.-------

A. Annual Fixed Cost

a. Depreciation

Machinery @10% Rs.-------

Building @ 5% Rs.-------

b. interest on loans

60% of total fixed capital @ 18% Rs.-------

75% of working capital Rs.-------

c interest on remaining money

40% of total fixed capital @ 10.5% Rs.-------

25% of working capital @ 10.5% Rs.-------

d. taxes and insurances

@ 2% of total fixed capital Rs.-------

Total Rs.-------

B. Daily Variable Cost

a. cost of raw material like straw

b. cost of binding agent (viz. molasses, bentonite, gwargum powder etc) should be given separately) Rs.-------

c. cost of water Rs.-------

d. cost of value aided ingredients other than molasses like concentrate, leaf meal, cake, mineral mixture, salt etc. Rs.-------

e. Electric charges Rs.-------

(add the total power consumption/day from all the sources in term of kwh/day)

f. repair and maintenance @ 5% of machine cost Rs.-------

g. man power

supervisor 1 no.@ Rs.------- Rs.-------

Labour ---no. @Rs.------- Rs.-------

h. miscellaneous @10% of all above Rs.-------

Total daily variable cost Rs.-------

C. Annual Variable Cost = Total daily variable cost X no. of days of operation in a year (say 300as given in plant detail) = Rs.-------

D. Annual Total Revenue

It is calculated in terms of production unit per day (or capacity of plant) X rate of the product per kg or per unit X no. of days of operation (say 300as given in plant detail)

E. Net Profit is calculated using expenditure incurred in the process and the return obtained.

Conclusion

Many methods for crop residues handling, transport and storage are available in the country at farmers threshold varying with location, type and size of crop residues, type of need (long term or short term), animal type and economic condition of the farmer e*tc*. and are

modified as per the requirement by researchers and farmers. An inventory for such methods is required to compare their benefits and bottle necks. These methods could finally be selected depending upon cost economics, use and loss in quality and quantity for development of a crop residues based fodder bank.

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Chapter-13

New Interventions for Commercial Sheep Farming and Wool Production

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Abstract

Although sheep rearing was practiced in India before the 19th century under the traditional system, it was contributing wool, meat, milk, and manure along with the livelihood to shepherds / nomadic people under migratory/stationary systems. High meat and wool-producing strains, health care, and rearing practices were developed, which has triggered the mutton production and made India a position in the top ten lamb, mutton, and wool producer countries in the world. With the inception of the agri-business incubation centre in 2019, there has been a paradigm change in the small ruminant sector. It has been rapidly progressing as a commercial farming and sustainable enterprise of value-added products.

Introduction

Sheep contribute to poverty alleviation. It is a livelihood source for thousands of small and marginal families in India. Sheep is one of the livestock species that ably utilize poor quality vegetation and convert it into good quality animal protein having high biological value. It acts as a moving ATM (Any Time Money) for the farmers as they can sell them at their wish for the household requirements. Sheep farming can be started with minimum cost. Sheep provide meat, wool, milk, skin, and manure. Therefore, sheep is also named a '5-STAR' animal.

Sheep technologies for commercial sheep farming

ICAR-CSWRI has developed several sheep strains for producing higher meat yields with improved production efficiency and functional quality. Avishaan, Avikalin, and Bharat Merino are some of the examples of sheep strains developed by ICAR-CSWRI. Over the years, ICAR-CSWRI has developed various need-based technologies for all stakeholders. Some prominent technologies are mentioned below:

Avishaan breed

Avishaan (Fig. 2) is developed from indigenous and native breeds of India to have Garole (12.5%), Malpura (37.5%) and Pantawadi (50.0%). Avishaan produces 70% multiple births with a litter size of 1.75 that yielded 50% more litter weight than Malpura at 3 months of age. They attained a slaughter weight of 24.4 kg at 6 months of age, the ideal finishing weight for

meat yield and quality in the domestic market. Avishaan ewes produced 45% more mutton than monotocusMalpura ewes.

Fig. 2 Avishaan sheep developed by ICAR-CSWRI

To enhance the mutton production in the country, the prolificacy (*FecB*) gene from prolific Garole sheep has been introgressed into monotocous sheep to produce twins/triplets with increased litter weights and lambing rate. CSWRI producedAvishaan sheep through the *FecB* introgression program. Use of Marker Assisted Selection (MAS) in sheep breeding was successfully implemented by a screening of lambs for *FecB* gene status in the selection program. This screening has reduced generation interval in the selection program as lambs could be tested for Fec*B* carrier status even on day one.

Progesterone Impregnated Vaginal Sponges (AVIKESIL-S) for Oestrus Synchronization

Progesterone Impregnated Vaginal Sponges (AVIKESIL-S) for Oestrus Synchronization have been developed at ICAR-CSWRI (Fig. 3). Oestrus synchronization facilitates concentrated breeding and Artificial Insemination. In this technology, the sponge is loaded into the vaginal speculum, and pushed using a plunger until it reaches the cervix. Sponges are kept in situ for 12 days and oestrus is detected 24 h after sponge removal. It reduces heat detection time. By using this technique, the production of three lamp crops per two years is possible. The success rate at the field level is > 60%.

Fig. 3 AVIKESIL-S kit for Oestrus Synchronization

Memnaprash for Lamb: High Survival and Productivity

Memnaprash (Fig. 4a), the tradename acquired for 'Liquid Milk Formula (LMF)' developed by ICAR-CSWRI.Memnaprash has 24-28% protein and 10-12% fat. Around 1 kg of powder makes 6 L of milk that can be bottle-fed to lambs. This additional feeding at a crucial time of small age of lambs increases the survivability and supports the faster growth of pre-weaning lambs. It is observed that the weight of the 90-day lamb significantly improved (20.4 kg) using memnaprash compared to the control lamb (16.2 kg).

Fig. 4 (a) Memnaprash – a milk replacer; (b) Avikaminmix – area specific mineral mixture for sheep

Avikaminmix: Area-specific Mineral Mixture

Avikaminmix (Fig. 4b) is an area-specific mineral mixture for the semi-arid region of Rajasthan. It is available in powder & pelleted forms. It is developed for improving the health, reproduction, and production of sheep, goats cattle, and buffaloes. The pelleted/tablet form has the advantage of delivering the micronutrients in a more complete & quantifiable manner. It is useful for correcting the mineral deficiency in the flock that is not generally fed

with concentrates. A packet of 1 kg can meet out mineral requirement of a flock comprising 100-200 sheep.

Avikhad

The institute has developed a technology to utilize wool waste (30%), sheep manure (50%), and crop waste (20%) into organic compost named "Avikhad. The advantages of wool waste include high water holding capacity, higher amount of natural potash, improvement in soil fertility, and high crop productivity.

Sheep milk products

Sheep milk contains about one-third more energy than cow and goat, making it a favorite of high-performance athletes. Various value-added sheep milk products developed such as Mozzarella cheese, paneer, gulabjamun, pedha, and kulfi. Sheep mozzarella cheese is 33% rich in proteins. Paneer obtained from sheep milk contains 26% protein and 11% fat. It has an 18% cook yield.

Sheep meat products

Sheep mutton products like sausages, patties, nuggets, loaves, enrobed products, croquettes, kabab, kofta, pickle, and mutton soup have been developed (Fig. 5). The functional, inulin fortified, low-fat mutton nuggets have been developed which can be stored for 18 days. The fiber content of mutton nuggets has been improved using a 5% seedless date paste. Meat from cull sheep is very tough. The toughness is reduced by CucumistrigonusRoxb (Kachri) powder and papain. Mutton-based snacks and biscuits were developed which could be stored for up to 45 days. It is a condensed nutrient source for army people. The meat products from sheep have a good market in the southern part of the country as well as in the north-east and Jammu & Kashmir states.

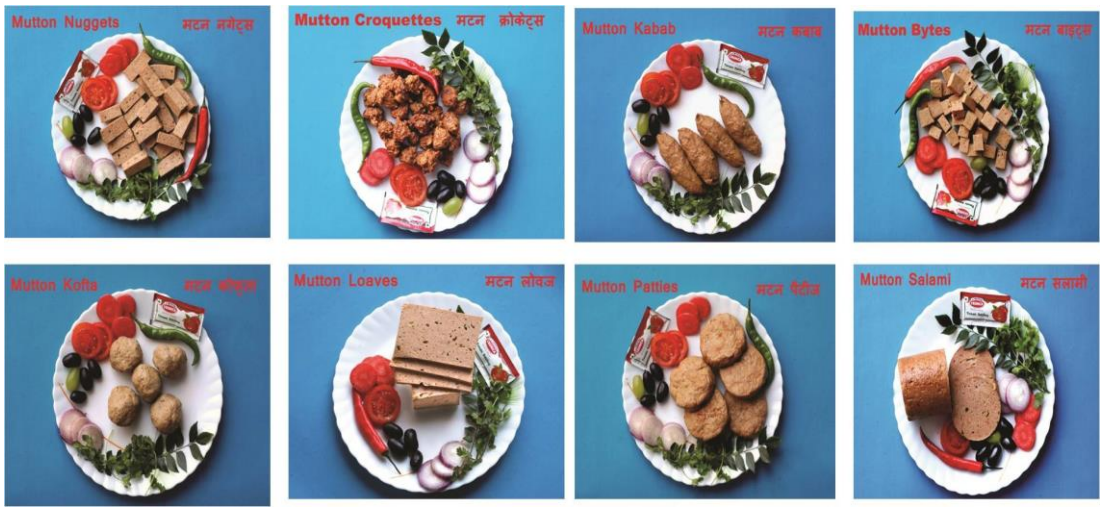

Fig. 5 Sheep mutton products developed at ICAR-CSWRI

Value-added wool products

The majority of wool produced in India is of carpet and coarse grade. It infers that native wool is not suitable for making apparel wear wool fabrics. Taking into account this fact, ICAR-CSWRI recently developed various value-added, low-cost wool products that can cater to real-world applications (Fig. 6). Examples are wool sapling bags, wool reinforced composites, braided mats, novel handicrafts, low-cost quilts (Rajai), and shawls from specialty hair fibers like Pashmina and Angora fibers. The developed Rajai is lightweight, warm, soft, and affordable compared to the Jaipuri cotton quilt. This is most suitable for cold climate regions of the country. different home furnishing articles like handmade paintings, soft toys, wall hangings, and usable households are developed by using the novel manufacturing technique. All these research interventions offer economical utilization of coarser wool and good opportunities for women/ artisans to improve their livelihoods.

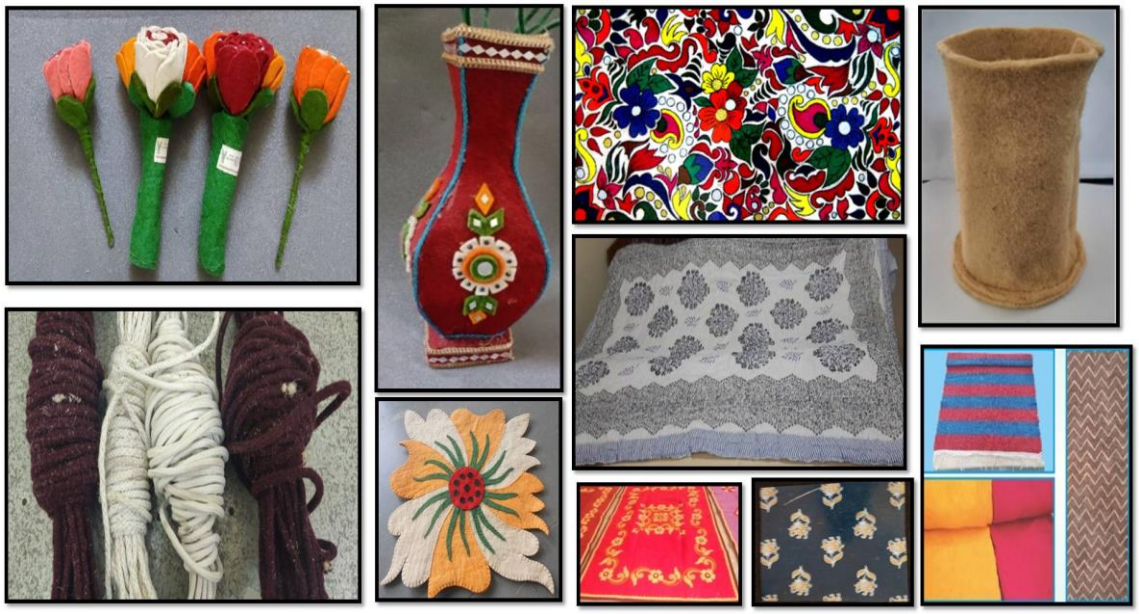

Fig. 6 Coarse wool value-added products

Agri-business incubation

The Agri-business incubation center (ABIC) has been established in the ICAR-CSWRI in 2019 with a vision to promote entrepreneurship through the transfer of innovative technologies to the end-users. ICAR-CSWRI wishes to inculcate a culture of advanced motivated entrepreneurship in the animal husbandry sector for the growth and success of emerging technology in small ruminant production, utilization, and allied sectors.

In the ABI center, the institute provides a platform to entrepreneurs/industries/students for Research and Development in process/ product development to improve the quality of their products. The institute provides infrastructure and technical expertise to entrepreneurs in different areas of small ruminant production, utilization, and allied sectors disciplines along with assistance in commercialization.

As of now, the institute has 30 ABI registrations which include private companies, NGOs, young entrepreneurs, and farmers. Moreover, MOUs have been signed with 14 registered incubatees. ABIC filed two patents in collaboration with the entrepreneurs in the last two years.

Success stories

ICAR-CSWRI has given Avishaan in field and the response is excellent. Farmers and entrepreneurs are demanding continuously the germplasm of Avishaan due to its commercial viability and profitability. For example, 10 Avishaan in Fatehpur farm increased to 30 in 7 month time.

ICAR-CSWRI and its one of the incubate M/S Orgro Fibre LLP, Vadodara developed wool sapling bags for agriculture, horticulture, and forestry applications. Wool sapling bags can replace conventional synthetic plastic bags. The wool bag is the best substitute for single-use plastic bags for horticulture/agriculture/forestry applications. Day by day, the government is imposing strict norms to avoid plastic and plastic-basedmaterials. This innovation is in line with sustainability development. Moreover, the wool sapling bags are air and water-permeable which improves germination and overall plant growth. It is observed that the bag also improves soil fertility over the period. This bag is non-toxic and beneficial for the entire ecosystem. The patent for the

product and process of making bags has been filed. This innovation has received recognition at KRITAGYA2.0 a national-level hackathon for precision and economical farming. Recently, the incubatee received a grant from Gujrat Government for scaling up the manufacturing.

Mukesh Kumar a young entrepreneur and incubate of ICAR-CSWRI initiated the scientific rearing of sheep, goats, and rabbits under the guidance of ICAR-CSWRI. He has developed total livestock of more than 100 in recent times. Mukesh also won a commercial sheep and goat rearing project from the National Livestock Mission (NLM) of the department of animal husbandry and dairy, Govt. of India.

Conclusion

ICAR-CSWRI is committed to technical interventions in the areas of sheep genetics and breeding, nutrition, reproduction, health, and post-harvest technologies for doubling farmers' income and contributing to scientific developments and making the commercial sheep farming techno-economically feasible. The ABIC center of the institute has provided a good platform for young entrepreneurs with offerings like infrastructure, counselling, technical mentoring, pilot-scale production, and advisory services. There is a great potential for entrepreneurship development in the small ruminant sector and the ABI centre of the ICAR-CSWRI looking forward to future collaborations for inclusive development and holistic growth.

Chapter-14

Technological Interventions for Value Addition in Seed Spices and Entrepreneurship Development in Semi-Arid Zone

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Significance of post-harvest processing in seed spices is utmost importance in view increased trade competition in domestic as well as international market. If we want to maintain our supreme position as world leader of spices in general and seed spices in particular we have to thrust more upon post-harvest processing of farm produce. At small level, production of neat and clean seed spices is the required for which ordinarily cleaning through winnowing is enough but for premium domestic market and export perspectives maintaining desirable standards of produce is necessary. Pre cleaning with aerial separator followed by cleaning, grading and separation through a system like gravity separator can increase the produce quality. In coming paragraph, we will highlight some post-harvest processing for value addition in seed spices.

Value addition means:

"The enhancement added to a product or service by a company before the product is offered to customers. (investorwords.com)''

or

"Value added refers to the additional value of a commodity over the cost of commodities used to produce it from the previous stage of production. (wikipedia.com)''

or

"The value added to any product or service as the result of a particular process. (webopedia.com)"

A broad definition of value addition is "to economically add value to a product and form characteristics more preferred in the market place". The value addition focuses on improving existing processes, procedures, products or services.

Spices are most important constituents of Indian food and cuisines, and are used not only for household purpose, but also in hotels, restaurants, eateries and food processing industries. In the regions where spicy food is consumed, cumin, coriander, black paper and other seed spices are important part of most recipes. Spices are used in whole, grounded form-pure and also forms part of various blended special purpose spices, which are used to add flavours to various dishes throughout India and Asia.

India despite being the largest producer of seed spices could not exploit their value addition potential as majority of export is in the form of raw produces. There is a great potential for increasing export of Indian spices in the form of value added products. To realize this potential there is need to enhance the quality as per international standard through post-harvest technology and value addition at different level of post-production system.

Value addition to seed spices

With the change in the life style and disposable income the popularity of qualitative processed value added products has increased in seed spices. The extrinsic as well as intrinsic quality of products is major concern for value addition. The extrinsic quality in case of spices relate to size, appearance, colour, flavor and odour. These characteristics of seed spices though vary depending upon agro climatic condition, the harvest and post-harvest operation play important role in improving these qualities through proper grading, sorting and packaging. Moisture, volatile and fixed oil present in the spices determine the intrinsic quality. The spice must be safe, free from health hazardous substances and contamination. The value addition deals with all these aspects to obtain the greater benefits. The value addition can be from its simplest form of cleaning and grading of material to completely different product such as essential oil and oleoresins. The value addition in case of seed spices should be done at two levels viz. at farm level and at processors level. The value addition at farm level or catchment areas enhances the rural employment and income and provide quality raw material for processors so that they can produce high quality end products.

The value addition can be from its simplest form of cleaning and grading of material to completely different product such as essential oil and oleoresins. The value addition in case of seed spices should be done at two levels viz. at farm level and at processing level. The value addition at farm level or catchment areas enhances the rural employment and income and provide quality raw material for processors so that they can produce high quality end products. The main value added products from seed spices are:

Ground spices

These are the whole spices milled to a certain degree of fineness. Various studies have been done on grinding techniques. The efficient grinding of spices prevents changes with respect to flavour and pungency. The optimum size of the grind for each spice depends on its end use

and accordingly the conventional methods normally employ a hammer mill (coarse grinding), plate mills (domestic use) or pin mills (fine grinding).

Curry powder

Curry powder is a ready-made mixes of various spices in ground form. The number of spices varies from 5 to 20 depending upon the producer and its end use. The ingredient of curry changes with the need for different foods. Curry powder is used to add taste and flavour to foods. Presently, a range of variety is available from multipurpose Sabji masala to Biryani masala and many indigenous processors and spice traders are involving in this business. Seed Spices mainly coriander, cumin and fenugreek are the major ingredient in various curry powders. The export trade in curry powder at present is dominated by India. The packaging of curry powder has gained considerable importance as it increases the self-life and fetches the consumer preference. The development of new and improved packaging materials and machines created new opportunities for packaging industries. Exporting consumer packed spices can earn more unit value for the same quantity.

Spices extracts

Spices extracted compound serve as the alternate to whole and ground spices. They are used in various food products like sauces, confectioneries, beverage, pharmaceutical and perfume industries. The Essential oils and oleoresin are principal extracted compounds for value added modules. The essential oils are the aromatic; volatile compounds present in seed spices. The essential oils extracted mainly by the method of distillation. The oil yield and quality of essential oil depend on the nature of feed material and pre-treatments.

Oleoresin represents the overall flavour profile of the spices. It consists of the essential oil and non-volatile fraction constituents present in seed spices. The oleoresin is therefore designated as the true essence of spice and mostly used as flavouring agents in food products. Oleoresins generally produced by solvent extraction. In solvent extraction, choice of solvent and removal of final solvent traces is critical concern. The choice of solvent is also depending upon the user requirement because countries do not allow all solvent for extraction.

Mouth fresheners

Coriander dal (*dhania dal*) is mainly used as an adjunct in supari or pan masala. Coriander dal is obtained from the seed of coriander. The coriander seeds are dehusked, flaked and given a mild heat treatment. Then, it is salted. The treated seeds are highly flavoured and

consumed as a digestive chew. Fennel is another seed spice having great potential as mouth freshener. This is key ingredient of many mouth fresheners available in the market.

Confectionary items

Cumin and Ajwain is commonly used in confectionary items like cookies, biscuits, sweetened pills, chocolates etc. Fennel, cumin syrups are also available which not only provide good taste with medicinal utility.

Medicinal utility products

Fenugreek seed are being consumed as medicine in case of diabetes. Capsules, pills and powders are available. Ajwain products are also available as Ayurveda medicine. Dill seeds oleoresin is used in preparation of medicine for stomach-ache of infants. Oils and oleoresins of nigella, fenugreek, anise, ajwain are being used for treating many human disorders.

Commercial products

Galactomannan (mucilage or gum) in fenugreek acts as a thickener or stabilizer in foods such as soups, sauces and ice-cream (Seghal *et al.,* 9). Currently, the food industry utilizes guar gum as emulsifiers, viscosity-builders, thickeners and stabilizers. Presence of galactomannan in fenugreek seed is recognized as the principal source of soluble dietary fibre in the plant. Dietary fibre is known to have the potential to reduce risk of cardiovascular disease and to protect against some cancers through the reduction of low-density lipoprotein (LDL) and total cholesterol. Dill and fennel are being used to blend the alcoholic and non-alcoholic drinks.

Super critical fluid extractions

Carbon dioxide is in its supercritical fluid state when both the temperature and pressure equal or exceed the critical point of 31°C and 73atm can be used to extraction of phytochemicals from spices and other herbs. In its supercritical state, CO2 has both gas-like and liquid-like qualities, and it is this dual characteristic of supercritical fluids that provides the ideal conditions for extracting compounds with a high degree of recovery in a short period of time. By controlling or regulating pressure and temperature, the density, or solvent strength, of supercritical fluids can be altered to simulate organic solvents ranging from chloroform to methylene chloride to hexane. This dissolving power can be applied to purify, extract, fractionate, infuse, and recrystallize a wide array of materials. Because CO2 is non-polar, a polar organic co-solvent (or modifier) can be added to the supercritical fluid for processing

polar compounds. By controlling the level of pressure/temperature/ modifier, supercritical CO2 can dissolve a broad range of compounds, both polar and non-polar.

Super critical CO2 extracts is the answer to the growing demand for pure and natural substances in the food industry. Supercritical Fluid Extracts (SCFE) are often used in highly selective extractions like lilac, nutmeg and essential oils. Its non-toxicity and low critical temperature makes SCFE great for aroma recovery, colour boosting and pesticide removal. Known to be one of the gentlest extraction processes, supercritical fluid extraction has garnered a lot of attention due to its effectiveness in producing exceptionally pure and solvent free extracts.

Encapsulated & spray dried

The right mix of flavours is integral to the taste of food. While cooking at home, we carefully pick and choose ingredients to get the perfect taste and flavour. However, the same attention to detail cannot be replicated in the food industry as it caters to a large number of people at a time. The innovative processes of Spray Drying and Encapsulation have helped manufacturers bring out the right flavours in food and create a savoury dining experience. Encapsulation and spray drying may sound like cold, cheerless terms, when in fact they are bursting with flavour.

Encapsulation describes a process of capturing active compounds of tastes in a more stable form of protective flavour pockets. This process grinds and encapsulates the spices in a closed system so that no volatile oils escape. They are encapsulated by creating an emulsion with modified starch, dextrose and malt dextrin or soluble gum (gum acacia) and spray dried under controlled temperature and humidity conditions. The spice extractives are entrapped in this matrix that protects the flavour from oxidation and high heat and there by provides an extended shelf life. Spray-dried spice flavours or dry soluble spices are created to make liquid spices or extractives more convenient to handle and use in dry applications. These encapsulated spice extractives are used for high temperature applications, such as baked or retorted products. The spice flavours are slowly released into the product. Encapsulated oleoresins retain the fresh notes of spices better than the normal oleoresins. They have no particulates, are completely natural, and like essential oils or oleoresins, have a friendly ingredient label. They are water soluble and allow flavour to be liberated uniformly throughout the food.

The main valued compounds of spices in general and seed spices in particular are volatile oils, responsible for flavour and oleoresin responsible for taste. Apart from this all spices are regarded as traditional household medicines to cure various common diseases (Rathore et al., 2013).

The aim of grinding is to obtained smaller particle size with good product quality in terms of flavour and aroma in case of spices. In the normal grinding process, heat is generated when energy is used to fracture a particle into a smaller size, that generate heat causes temperature rise in the grinder to the extent of 95^{o}C which is responsible for a loss of volatile oil in the tune of about 30% and also produces dark coloured powder. Generally, a continuous operation of grinder is not possible in normal grinding process due to melting of fat and sticking of powder on the grinding surfaces. The normal grinding produces poor quality of powder in terms of uneven particle size, colour and aroma as a result either fetches lower price or not accepted by the importer countries. The temperature rise of the product can be minimized to some extent by circulating cold air or water around the grinder. But this technique is not sufficient to significantly reduce temperature rise of the product.

Cryogenic grinding for retention of flavour and medicinal properties

The main processed product of spices is ground powder. Adding value to the processed product is largely depending on the ability to retain of original flavour and medicinal properties present in the spices. The aim of grinding is to obtained smaller particle size with good product quality in terms of flavour and aroma or colour. Processed spices demand is directly linked with its consumption in food processing industry and this is set to grow in India in coming period with growth of population and fast changing food habits as well as increase in spending power of the middle and upper class in India.Various studies have been done on grinding techniques. The efficient grinding of spices prevents changes with respect to flavour and pungency. The optimum size of the grind for each spice depends on its end use and accordingly the conventional methods normally employ a hammer mill (coarse grinding), plate mills (domestic use) or pin mills (fine grinding). The particle size may vary from 50 microns to 850 microns of soft to medium hard materials according to the standards of comparison of Mohr scale ranged from 1 to 6. The traditional practice of spice grinding in India is done by using plate mills and hammer mills. Both of these mills involve a heavy loss of volatiles and produce inferior quality of the product in term of flavour, colour and particle size. At the commercial scale, spice milling is done using pin mill which is comparatively better than plate mills and hammer mills in terms of quality of the product. But a significant

amount of volatiles is lost in this mill too. During conventional grinding that is grinding without cooling the spices, the temperature increases to over 95ºC can occur in fast rotating mills which leads to substantial losses in volatile oils in the tune of 30% and also produces dark coloured powder, thus loss in quality which do not meet the international standards. The temperature rise of the product can be minimized to some extent by circulating cold air or water around the grinder. But this technique is not sufficient to significantly reduced temperature rise of the product. Conventional grinding with slow rotating roller mills, loss of volatile oils is low but results in lower production rate. Also these conventional methods suffer from various disadvantages like low efficiency, not suitable for heat sensitive and high fat content materials, gumming of grinding walls and sieves resulting in stoppage of mill for cleaning, reduction of grinding rate and consumption of enormous energy.

The loss of volatile can be significantly reduced by cryogenic grinding technique using liquid nitrogen that provides the refrigeration needed to pre-cool the spices and maintain the desired low temperature by absorbing the heat generated during the grinding operation. The extremely low temperature in the grinder solidifies oils so that the spices become brittle, they crumble easily permitting grinding to a finer and more consistent size. Cryogenic grinding of spices was better than conventional grinding in terms of higher retention of volatiles and flavoring components, colour and particle size distribution of ground powder, free and continuous operation of the grinder without any choking, less energy requirement in grinding (Landwehr and Pahl 1986; Wolf and Pahl 1990; Li et al. 1991). The high quality ground product would have domestic as well as international market.

The work on cryogenic grinding of spices was initiated by Singh and Goswami, 1999a, b; Singh and Goswami, 2000). They developed a laboratory model of cryogenic grinding system and carried out some basic studies on the grinding characteristics of cumin and clove under cryogenic and ambient conditions. The cryogenically ground cumin and clove powders retained about 30% more volatiles than that traditionally ground spices. Further, Murthy and Bhattacharya (2008) made a comparison between ambient grinding and cryogenic grinding of black pepper and reported 50% more volatiles in cryogenically ground black pepper. A loss of 36% in volatile oil has been recorded in coriander if grounded by conventional method (Saxena, 2010).

In the process of cryogenic grinding the material is feed into a feeder hopper and dropped into a conveyor where the material to be processed enters the pre-chilled conveyor. Liquid nitrogen is then sprayed and blended directly onto the material. The material is conveyed via a stainless steel special design auger. The auger not only transports the grinding media, but

also mixes it with liquid nitrogen for greater cooling efficiencies. Liquid Nitrogen is added until the temperature of the material is reduced to a predetermined set point. This set point is the glass transition temperature of the material. The extremely low temperature in the grinder solidifies oils so that the spices become brittle, they crumble easily permitting grinding to a finer and more consistent size. Finally, the brittle material enters an impact (pin) mill where it is ground to a desired particle size. Computer controls the entire process of cryogenic grinding system. The high quality ground product would have domestic as well as international market.

At NRCSS, Ajmer extensive work has been done on comparative analysis of cryo and non-cryo ground coriander, fenugreek and cumin. Saxena *et al.* (2014, 2015) took nine coriander genotypes and found significantly more phenolics and antioxidant contents in seed powder ground using cryogenic grinder. They also analyzed essential oil for its constituents of these genotypes. The major constituent linalool was significantly more in seed powder ground cryogenically.

Similar to the coriander, Sharma *et al.* (2016) analyzed the technology by grinding seeds of two contrasting genotypes of cumin, Gujarat Cumin-4 and RZ-209 at ambient and cryogenic temperature. They reported that cumin seeds loose significant proportion of volatile oil (18-19%) while ground at ambient temperature which could be minimize in cryogenic grinding. Recovery of total seed oil also increased 28.28% in RZ-209 by cryogenic grinding. Later, Sharma *et al.* (2016) compared volatile oil and fatty oil constituents of cumin seed oil showed significant effect of cryogenic grinding. The compound cumineldehyde responsible for typical cumin oil flavour is found to increase upon cryogenic grinding. Overall the oil extracted from cryo ground seeds powder was more fresh and pleasant. Similar results were obtained by Barnwal *et al.* (2014) while comparing ambient and cryogenic ground turmeric powder for its biochemical, antioxidant and thermal properties.

Liu *et al.* (2013) also reported non-significant loss in colour, flavour and sensory qualities of different coloured pepper upon cryogenic grinding. The mail flavour constituent is also better in this technology. Sharma *et al.* (2015) evaluated this technology for medicinally important compounds and antioxidant properties of ajwain genotypes. Volatile oil, total oil, total phenolics and free radical scavenging percentage was significantly more in cryo ground powder irrespective of the genotypes. Effect of grinding technology was more in genotype AA-2 than genotype AA-93. Later Sharma *et al.* (2015) also found increased recovery of thymol content in *Trachyspermum ammi* seeds essential oil obtained from cryo ground seeds. Among twenty-five major compounds, recovery of monoterpene, thymol increased from

44.96 to 59.12% in AA-2 and from 39.91% to 60.12% in genotype AA-93 while another major constituent, γ- terpinene decreased from 33.61 to 22.67% in AA-2 and 39.83% to 28.17% in cryo ground samples of AA-93.

In another experiment, fenugreek an important seed spice better known for its medicinal properties was also ground with cryogenic and conventional grinding technology by Saxena *et al.* (2012). They analyzed the ground powder and reported more phenolics and free radical scavenging activity in cryo ground powder irrespective of the genotypes. It is reported that fenugreek seeds contain 0.1 to 1.5% diosgenin. Recovery of this commercially important compound from fenugreek seeds could be increased with cryogenic grinding. Saxena *et al.* (2013) analyzed diosgenin content from seeds of three genotypes of fenugreek namely AM-1, RMt-305 and RMt-1 ground by conventional and cryogenic grinding technology. Diosgenin percentage was significantly more in all three genotypes and ranging from 2.1 to 2.5% in cryo ground samples as compared to 1.3 to 1.5% in normal ground samples. They also found enhanced analgesic and antipyretic activities of *Coriandrum sativum* when ground with cryogenic technology Saxena *et al.* (2014). Methanol seed extracts of coriander genotypes RCr-436 and Sudha administered as drug along with standard drug paracetamol-150. Seed extract cryo ground powder of genotype RCr 436 reduced the rectal temperature at par with paracetamol-150. They suggested that medicinal quality of coriander and similar herbs can be maintained at original level if this technology used in *Ayurveda* and other natural therapies for various ailments. Saxena (2015) also evaluated anti-cholestrolic potency of fenugreek seeds ground by conventional and cryogenic technology. High cholesterol diet were given for 15 days to different group of rats and the difference between various parameters were observed at 16^{th} day. Control group rats were compared with standard drug simvastatin (100mg/kg b.w.) and crude seed extract of fenugreek genotypes**.** The anti-cholestrolic activity was found in both the varieties of fenugreek but it was found more in cryo than in conventional ground extract of fenugreek.

Saxena (2015) also evaluated the acute effect of fenugreek seed extract (Var RMt 305 and RMt 1) *per se* on blood glucose level in alloxan-induced diabetic rats. Glucose level in control group rats with vehicle only was ranging from 92.51 to 93.34 mg/dL while alloxane induced diabetic rats showed maximum (296.86 ± 1.76 mg/dL) level of glucose after 4 hrs of administration. Alloxan (60 mg /kg, bw, p.o.) + Gilbenclamide (2.5 mg/kg bw, p.o.) administration showed lowering of blood glucose level from 279 mg/dL at 0 hrs to 212 mg/dL at 8 hrs. Seed extract of cryo ground seeds of fenugreek genotype RMt 305 was able to reduce the blood glucose level from 283.13± 1.53 mg/dL to 221.48 mg/dL which was

higher than control and at par with common drug gilbenclamide. Ambient ground seeds extract was also producing similar results but with lesser magnitude.

Sharma (2017) conducted experiments with methanol and hexane crude seed extract of cumin and ajwain genotypes obtained after grinding with cryo and non cryo ground technology. He evaluated crude seed extract of cumin and ajwain for anti-microbial, anti-inflammatory, anti-diabetic, hepatoprotective and diuretic activities using albino mice. Findings were suggestive of superiority of cryogenic grinding technology over traditional grinding for retention of mecinal properties of seed spices. For antimicrobial properties, he took two gram-positive (*Staphylococcus aureus, Streptococcus pyogenes*) and two gram-negative bacteria (*E. coli, P. aeruginosa)* and measured zone of inhibition by seed extract and compared with standard antibiotic. The anti-fungal effects of the extracts were investigated using Agar Diffusion test (Sabouraud dextrose agar and PDA test) on two species of fungal strain *Candida albicans and Aspergillus clavatus*. Seed extracts of cryo ground technology proved better than non-cryogenic grinding for both activities. Since cryogenic grinding was able to retain more phenolic, flavonoid and essential oil contents compared to non cryo-ground seeds, thus showed considerably more antibacterial and antifungal properties.

Anti-inflammatory properties of cumin (*Cuminum cyminum* L.) and ajwain seed extract were also found to increase by cryogenic grinding technology. Carrageen induced acute inflammation study was conducted on male or female wistar albino rats-with a body weight between 150 to 200 g by Sharma (2017). Methanol extract of cryogenic ground seeds was more effective in reducing paw oedema volume than non cryo ground seeds extract even at the dose of 200 mg/Kg. Similar results were obtained with genotype RZ-209. Where dose of 400 mg/Kg was able to reduce paw oedema volume up to 3.6 as compared to 6.7 in caragennan treated model. Similar results were obtained with ajwain genotype AA-2.

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Chapter-15

Agri-Silvipastoral Models for Livestock based Entrepreneurship Development

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Introduction

Indian has the highest livestock population in the world with 512.05 million livestock population, which includes 190.90 million of cattle, 108.70 million buffaloes, 135.173 million goats and 65.1 million sheep population and others. There is a huge gap between the production and demand of fodder and other forages to such sustain such a huge population. Presently, nearly 2/3rd of the feed requirement is met from crop residues. Present fodder requirement of the country is 883.95 Mt green fodder and 583.66 Mt dry fodder, while as the present fodder production is only 664.73 Mt green fodder and 355.93 Mt dry fodder. The existing gap of 218.22 Mt green fodder and 227.73 Mt dry fodder has a substantial effect on the livestock productivity and the socioeconomic status of the farming community. It is pertinent to mention that we have only less than 5% of gross cropped area of the land allocated to green fodder production **(Earagariyanna *et al.* 2017)**. Surplus fodders and grasses available in cultivated fields, forest lands and common property resources are harvested for hay making during summers for feeding during lean months. Concentrate feeding, although limited, is also in vogue and mostly well-of livestock owners' purchase wheat straw, feed pellets, bran and cakes for supplementation during lean months. Fortification of fodders, silage making or feeding of mineral mixtures is not much prevalent in the country. Sedentary, semi-sedentary and migratory livestock rearing systems are commonly observed livestock farming systems (**Bhat *et al.* 2021**).

Keeping in view the huge deficit of fodder one hand and the demand of livestock products on the other, it becomes imperative to shift for mixed farming system, with different components occupying the different growing space in the system, mutually and or complementing each other for higher productivity from the system. This has productive, protective and economic benefits, besides being sustainable in long run keeping in view soil health and resource cycling.

Agri-silvipastoral system

The term ‘silvo’ means ‘tree’ and ‘pasture’ means ‘grasses’ or ‘grass + legume’ mixtures. Silvi-pastoral systems refers to the growing of ideal combination of grasses, legumes and trees for producing highly nutritious top fodder and forage, fuel wood, timber and sustainably using the local available resources in the system. Agri-silvi pastoral system is an efficient and integrated land use management system of agricultural crops, horticultural/forest tree species and or livestock simultaneously on the same unit of land, with components arranged spatially or temporally which results in an increase of overall production. If the components are horticulture and forage production, then the system is called Horti-pastoral system. These three systems are called Animal Agroforestry systems, which make livestock rearing productive and provide round the year fodder availability from forage grasses and legumes, agricultural residues, shrubs and tree leaves.

Ideal tree characteristics for Agri-silvipastoral system

The nature of trees decides the productivity, sustainability and adaptability of the system, and should have ideally the following characteristics:

1. The tree should have a sparse small crown.
2. It should re-sprout easily, pollard well, coppicing, pruning, lopping better
3. It should have a deep root system so that there is no competition between the roots of the trees and the agricultural crops.
4. The leaf litter produced by the trees should be easily decomposable.
5. The tree species should preferably be able to fix nitrogen from the atmosphere
6. There should not be any negative allelopathic effect of the tree leaves
7. The tree species should be of soil/water conserving nature, with the high-end use in the market of the tree products.
8. It should be a non-exacting species, able to survive in harsh conditions, and should be easy to establish.

Frequently planted trees and shrubs

Depending on climate and locality facors, there is huge diversity of tree species available. Some major examples of major trees/shrubs used in different silvopastoral systems are *Acacia* species, *Albizia* species, *Aegle marmelos*, *Alnus nepalensis*, *Anogeissus latifolia, Ailanthus excelsa, Areca catechu, Artocarpus heterophyllus, Avicennia marina, Emblica officinalis*, *Eucalyptus* species, *Flemingia macrophylla, Grewia optiva, Leucaena*

leucocephala, Mangifera indica, Madhuca indica, Mallotus philippinensis, Melia azedarach, Moringa oleifera, Morus alba, Pithecellobium dulce, Populus species, *Prunus* species, *Azadirachta indica, Butea monosperma, Bauhinia variegata, Cassia siamea, Casuarina equisetifolia, Coffea arabica, Dalbergia sissoo, Punica granatum, Robinia pseudoacacia, Salvadora oleoides, Santalum album, Shorea robusta, Sesbania* species, *Syzygium* species, *Tamarandus indica, Tecomella undulata, Terminalia* species, *Theobroma cocoa, Ziziphus mauritiana* etc. Many other trees, shrubs, and bamboos are also used under different agro-silvipastoral systems throughout the country **(Bhat *et al*., 2022).**

Interaction among the components

1. Organic matter from tress through decay of leaves, flowers, fruits, branches, and dead roots.
2. Upbringing of elements from deeper soil layers and to the surface, making them more available to the pasture.
3. Fixing of atmospheric nitrogen by trees
4. Creation of a different microclimate by trees, favorable for crops and livestock.
5. Competition for different resources in the system. Appropriate selection of species and the selective pruning helps to ameliorate competition.
6. Trampling and damage of plant cover and soil compaction at establishment stage of the pasture land.
7. Selective grazing by animals and growth of weeds/ less preferred forage grasses/legumes.
8. Animal dung addition improves organic matter in the system.
9. Seed and pollen dispersal by animals

Case studies:

Ahmad *et al*. (2018) evaluated apple-based horti-pastoral systems in Kashmir Himalaya. The performance of fodder crops viz., tall fescue, orchard grass and two legumes viz., white clover and red clover were tested under the 14-year-old established apple orchard of ICAR-Central Institute of Temperate Horticulture, Srinagar, Jammu and Kashmir. It was observed that the growth parameters in terms of increment of plant height, plant girth, plant spread, fruit yield, trunk-cross sectional area and yield efficiency in apple were found to be higher in legume as sole and grass/legume combination treatments than control and grasses as sole, showing a positive impact on an apple orchard. Different grass//legume combinations

significantly influenced forage production and quality. The maximum yield was recorded in tall fescue + red clover (7.35 t D.M./ha) followed by orchard grass+ red clover with minimum weight in white clover + apple (5.32 t D.M./ha). They suggested that given fodder shortage and limitation to expand the area under fodder cultivation on account of demographic pressures, the effective utilization of interspaces of fruit orchards offer a unique opportunity to mitigate the fodder shortages up to a greater extent. There is a massive scope of apple-based Hortipastoral systems in the Himalayan states, including Himachal Pradesh, Uttarakhand, and Jammu and Kashmir's Union territory.

Chavan and Dhillon (2019) evaluated 8-year-old poplar based agri-silvipastoral system in Hisar, Haryana, planted under three spacing geometries of 5×4m, 10×2m and 18×2×2m (paired row) at a constant density of 500 trees ha^{-1}. Two cropping rotations (sorghum-berseem and cowpea–wheat) were intercropped in all three spacing geometries of poplar (up to eight years of rotation) and compared with sole cropping as control. The results showed that the yield of annual crops reduced considerably over the years due to enhancing competition for light, moisture and nutrients. The overall yields of annual crops in various spacing geometries of poplar were reduced by 5.67% in the second year to 45.59% in eight years of plantation. In 10 × 2 m spacing of poplar with sorghum–berseem crop rotation, highest net returns (Rs 1,191,241 ha^{-1}), NPV @ 12% discounting (Rs 409,673 ha–1), B: C ratio (1 : 2.22), IRR (70%),highest land equivalent ratio (2.28) and land expectation value (Rs 2,242,372 ha^{-1}). They concluded that the intercropping of sorghum–berseem and cowpea–wheat in poplar planted at a spacing of 10 × 2 m was more profitable and helpful in doubling farmers' income over traditional agriculture north-western India.

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