SUSTAINABLE AGRICULTURE DEVELOPMENT

Millennium Development Goal

ABSTRACT

A detailed research project that aims to highlight the judicious use of the available resources, integration of factors of production, distribution and consumption for development of a sustainable agricultural model.

Ravi Soni I Sunil Patil I Nisha Chandra

Grus & Grade

Acknowledgements

This report has been prepared by group of Students from IIM Indore to identify the core concepts and develop models for sustainable agricultural development programs, policies, and methodologies.

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We also thank the entire team of librarians in IIM Indore for providing us the research documents and helping us zeroing the search process for timely completion of the report.

Disclaimer

This document does not claim that every theory and model to be original. The logical derivatives, research work, interpretation and findings expressed herein are those of the student(s) and do not necessarily reflect the views of any individual, organization, or institution.

The purpose of this note is purely academic and for creating interest in the academic/intellectual community for further research and innovation in Agriculture for sustainable development of the sector.

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Contents

Abbreviations

ADB	Asian Development Bank
ASIAN	Association of Southeast Asian Nations
ASS	Agricultural Supply Chain
AU	African Union
AVS	Agricultural Value Chain
BLF	Bought Leaf Factories
FPO	Farmer Producers Organization
FTA	Free Trade Agreement
GTA	Global Trade Union
IFC	International Financial Corporation
IFOAM	International Federation of Organic Agriculture Movement
IK	Indigenous Knowledge
IJSR	International Journal on Science and Research
IPCC	Intergovernmental panel on climate change
KP	Kyoto Protocol
MDG	Millennium Development Goals
OECD	Organization for Economic Cooperation and Development
PS	Performance Standard
SHG	Self Help Group
SDG	Sustainable Development Goals
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank

FOREWORD

History dates back to almost ‘ten thousand years’ when mankind first explored the concept of agriculture in the area called ‘Fertile Crescent’ and today’s world of Iraq, Syria & Jordan. These areas were at the confluence of continents of Africa, Asia and Europe and thus became the epicentre where both civilizations and agriculture began.

Thus, the art and science of agriculture has not only evolved but also sustained the vagaries and challenges of time. It has been a witness of rise and fall of many civilizations, but still has been continuum force that unites the boundaries and explores new identity every time the tide of time tries to wipe its shore.

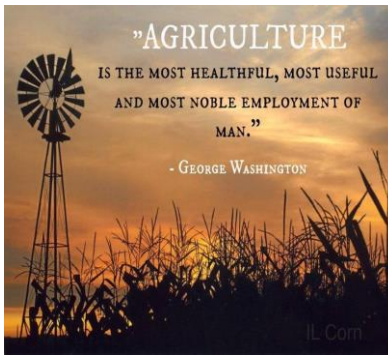
The modern age and time is facing unprecedented level of resource constraint. The anarchic increase in population supplemented with the age of consumerism and resource overutilization has not only put an immense pressure on mankind to explore methods to conserve the available resource but also push the envelope to find ways wherein the resources can be readily made available for the posterity.

Almost three years back World Bank adopted the 2030 Agenda for sustainable development and the 17 Sustainable Development Goals (SDG). This ambitious agenda faces daunting and overlapping challenges such as climate change, conflict, pandemics, political and environmental changes, shirking resources and many others.

The present paper tires to find ways to overcome these challenges and recommend a sustainable mechanism for development of agriculture. The intent of the research work is to find an innovative method to elevate poverty, overcome resource constraint and integrate stakeholders - Farmers, Government, Domestic and International Institutions of repute, NGOs , Corporations and Corporates, Industrial bodies and public in general – for sustainability of agriculture in this dynamic world.

INTRODUCTION

Definition: Sustainable Agriculture Development

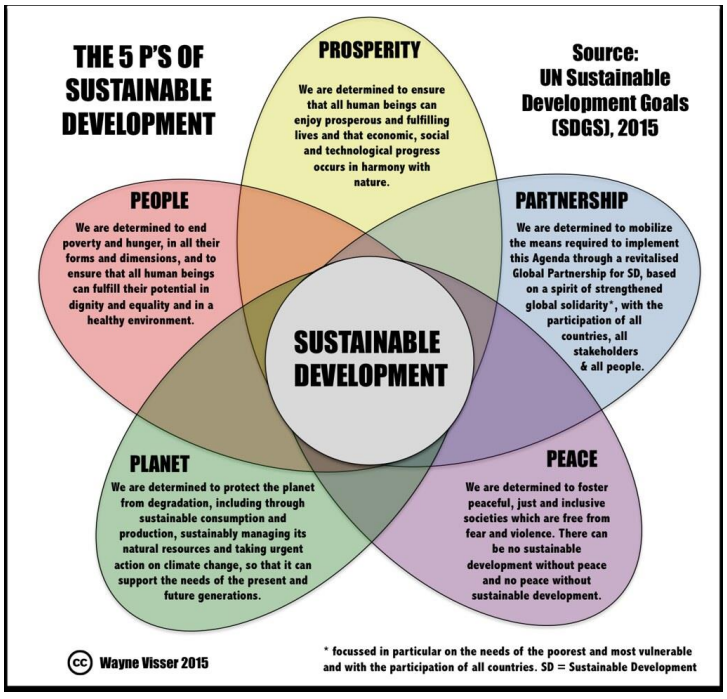


George Washington

What is Sustainability & Sustainable Development?

World Commission for Environment and Development (WECD) has defined sustainable development as "a process of change in which the exploitation of resources, the direction of investment, the orientation of technological development and institutional changes are all in harmony and enhance both current and future potential to meet human needs and aspirations".

The five Ps of sustainable development as per UN Sustainable Development Goal are described in the picture below:



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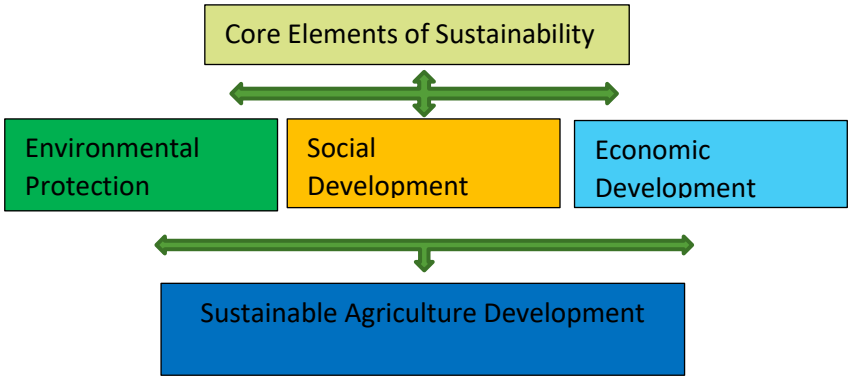
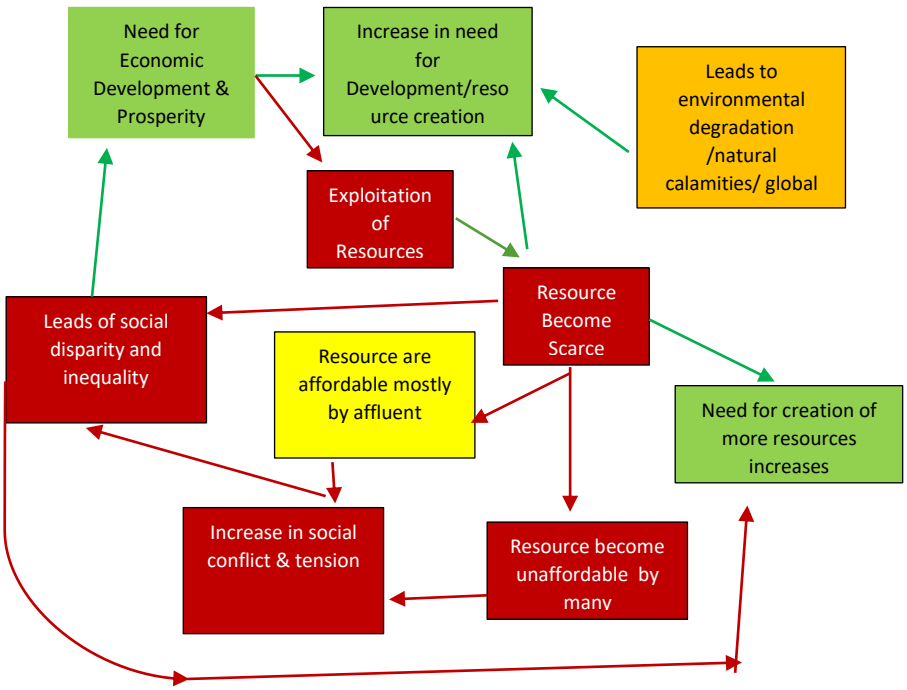


Food is one of the most basic needs for mankind's survival and thus despite the rise and fall of civilizations, the art and science of agriculture has prospered over thousands of years.

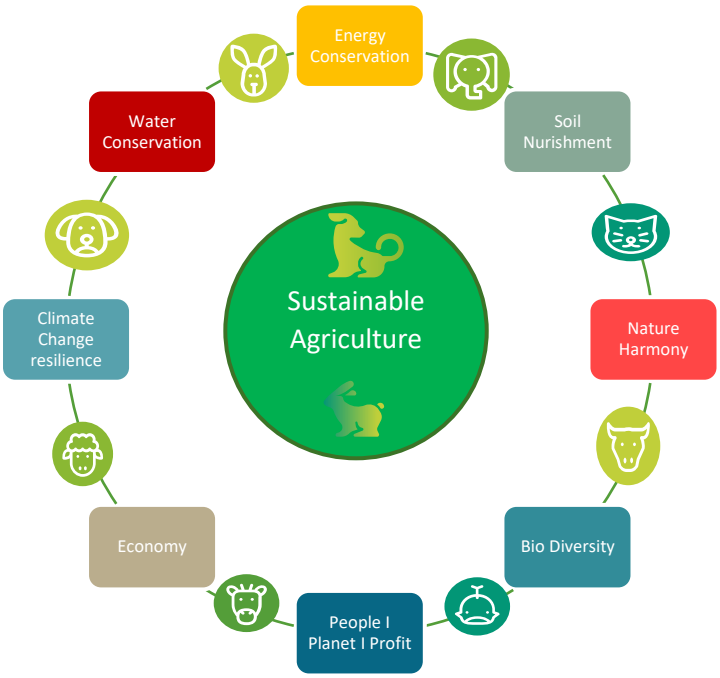
As we grew and prospered, the exploitation of resources increased. The over-exploitation of resources has not only constrained the availability of most of the resources but also posed a serious threat on development and prosperity of mankind in general. This chicken and egg problem of need vs exploitation can be explained by the underlying System Archetype Diagram:

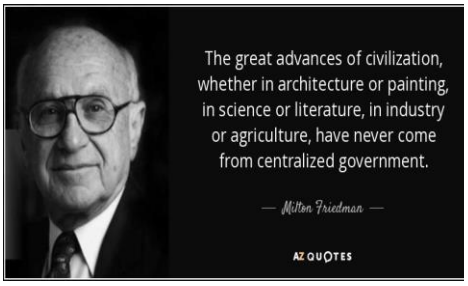


Need for Sustainability in Agriculture

The kind of resource constraints we face today, it has become inevitable that we recreate the complete Agricultural value chain, i.e from pre-production procedures to post cultivation market reach and end consumer utility to make the resources available to our prodigies. The undaunting challenges of draughts, climate change, environmental degradation to shrinking land, productivity and growing demand and consumerism has made it not only imperative but also necessary that we find means to change our behaviourism from traditional and conventional industrial food system to one that is sustainable.

Following are the reasons why we need sustainable agriculture to grow nutritious food for people, maintain the health of the planet, and sustain livelihoods.





1. Sustainable Farming: Soil Nourishment and quality restoration

Milton Friedman

"A sustainable Agriculture does not deplete soil or people".

Wendell Berry

Healthy soil means healthier plants and animals, which in turn provide nutritious food for people. Healthy soil holds in moisture more efficiently than depleted soil does and leads to resilient healthy plants that are not susceptible to attacks from diseases and pests.

2. Sustainability: Harmony with Nature

   Harmony in nature is derived through co-operation and collaboration and least by domination. The overdominance over the years have yielded the environmental distress and disabilities such as floods, draughts, global warming, pollution etc. We need to collectively develop and strategize our energy and thoughts be more in harmony in nature through collective principles of co-operation and collaboration.

3. Energy Conservation for Sustainability

   The primary objective should be judicious use of energy and minimum consumption. Smart energy ecosystem needs to be developed.

4. Preservation, protection, and conservation of water

   Water conservation modern techniques such as mulching, drip irrigation, hügelkultur garden beds, swales on contour, ground water recharge, smart homes for water conservation, drainage, water bodies and natural tanks need to be augmented. Digital irrigation techniques such a augmented vision for irrigation as per plant need, AI to understand co-relation between plant psychology and water need to be studied. Apart from this we need to plant crop that needs less water and focus on perennial crops that has deep roots.

5. Promote and Value Diversity

Crop Diversification, ecological diversification and emotional diversification have triangulated effect on sustainability and maintaining biodiversity and ecological balance. A resilient system that is not only diverse but also integrated are needed to prevent the scourge of draughts, disease, and pets.

6. Sustainability factor: Resilience to climate change

Energy Efficiency and minimum wastage along with reduction in CO_2, CO, SO_2 and other green house gases are cornerstone for sustainability.

7. Support to local farm, community, and economy.

Reinvesting the cash generated in local economy has ripple effect and supports building local community level economy for sustainability and common prosperity.

8. Three Ps of Sustainability: People, Plant and Prosperity

A farming system is sustainable only if it benefits the people, planet and is profitable perpetually to both.

UN Sustainability Goals: Agenda 2030

UN has provided a vision statement and blueprint for attaining sustainable development through the agenda 2030. Though, the achievement of the agenda goals by 2030 seems bit daunting given the number of stakeholders in the global community, but a concentric and coherent approach by the world community at large can bring in a collective change that is not only desirable but a necessity of the time. The sustainability goals as per UN's Agenda 2030 include:

No Poverty	Zero Hunger	Good Health
Quality Education	Gender Equality	Clean Water & Sanitation
Affordable and Clean energy	Decent work and economic life	Industry, Innovation, Infrastructure
Reduced inequalities	Responsible Production and Consumption	Climate Action
Life below water	Life on land	Sustainable cities and communities
Peace justice and strong institution	Partnership	

Sustainability Standards & Protocols

SHRINK WRAPPING: AN INNOVATIVE TECHNOLOGY FOR ENHANCING SHELF LIFE AND QUALITY OF POMEGRANATE

Wrapping of fruits with a heat-shrinkable film (29µm thickness) followed by storage at ambient conditions, (18-30oC, 55-60% RH) for 60 days influence the quality of fruits. Control fruits were found deteriorate at a very high rate, in their physical appearance as well as nutrition quality. Wrapped fruits showed minor changes in nutritional value in respect of total phenols, anthocyanins, and antioxidant activity during 60 days at ambient conditions, whereas non-wrapped fruits deteriorated earlier at similar storage conditions.

Source: Research report by V.R. SAGAR, R.R. SHARMA AND KULDEEP KUMAR

http://www.sustainableagriculture.in

Sustainability standards such as IFCICT, ISEAL etc are voluntary and third party assessed norms and standards relating to environment. Most of these standards refer to triple bottom line of environmental quality, social equality, and economic prosperity.

The ISEAL Alliance has emerged as an authority on good practice on sustainability standards and its codes of Good Practice represent the most widely recognized guidance on how standard should be set and implemented.

Some of the globally recognized sustainability standards include:

- Fairtrade: Adopted environmental objectives as part of their certification system. Guarantees Minimum price & social premium that goes to the co-operatives and not the producers.
- Rainforest Alliance: Committed to conserving rainforest and biodiversity. Key element of this standard is the compulsory elaboration and implementation of a detailed plan for development of sustainable farm management.
- UTZ Certification: It aims to create an open and transparent marketplace for socially and environmentally responsible agricultural products.
- Organic : It is based on IFOAM Basic Standard and is leading umbrella organization for organic farming.
- trustea: This code is designed to evaluate the social, economic, agronomic and environmental performance of Indian Tea Estates and Bought Leaf Factories (BLFs)

IFC: Performance Standards on Environmental & Social Sustainability

IFCs sustainability framework articulates the Corporation's strategic commitment to sustainable development. The performance standards have basic objective of mitigating the risk on account of overexploitation of resources.

The eight performance standards established by IFC include:

1. Performance Standard 1: Assessment and Management of Environmental and Social Risk and Impacts
2. Performance Standard 2: Labour and working condition
3. Performance Standard 3: Resource Efficiency and pollution Prevention
4. Performance Standard 4: Community Health, Safety and Security
5. Performance Standard 5: Land Acquisition and Involuntary Settlement
6. Performance Standard 6: Bio-Diversity Conservation and Sustainability Management of Living Natural Resources
7. Performance Standard 7: Indigenous People
8. Performance Standard 8: Cultural Heritage

Adherence to these basic performance standards in agriculture would lead to attaining slated UN Sustainable Development Goals.

"We are moving urgently to help countries to increase sources of renewable energy, decrease high carbon energy sources, develop green transport system, and build sustainable, liveable cities for growing urban population."

World Bank Group

Agricultural Sustainability : Core Issues, Challenges and Concerns

Identification of core issues and concerns

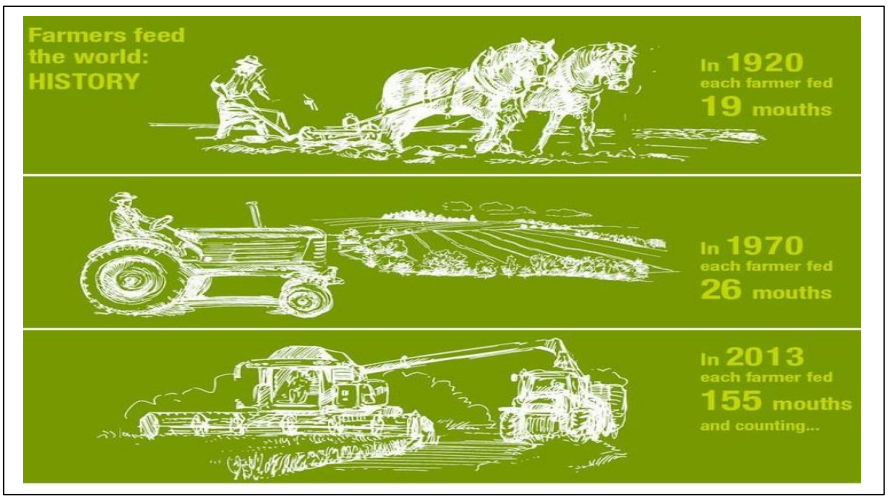
The three basic challenges faced by agriculture include feeding the growing population, providing livelihood to farmers, and protecting the environment.

"To make agriculture sustainable, the grower has got to be made profitable."

Sam Farr

- By 2050 world will have 10 billion mouths to feed.
- As the population and income grow, so will the demand for meat, fish, dairy, and farm related agricultural products will grow.
- The growing population and urbanization have limited the availability of agrarian land.
- Climate change, draughts, and floods, changing rainfall patterns are key factors which may hinder growing demand

- As per a report UN's intergovernmental panel on climate change (IPCC) climate change itself is cutting into the global food supply affecting global wheat and maize supply



- Fish are also taking a hit due to sudden and abrupt climate change and global warming
- The over exploitation of land has resulted into reduced productivity of agricultural land. This is further getting augmented by soil erosion, soil salination, water contamination and deforestation.

- The vicious cycle has resulted into ripple effect of crimping the available resource furthering human suffering and social tensions.

Issues and Challenges of Indian Agriculture Sector

A typical farmer in India faces challenges mainly in three areas

A. Input Gaps: Inefficient backward integration of resource, knowledge, planning and execution.

Resource Constraints

- ❖ Shrinking / fragmented land due to land distribution
- ❖ Financial and monetary constraint before sowing season
- ❖ Unavailability or cost of standard quality seeds & fertilizers
- ❖ Limited livestock's organic manures
- ❖ Lack of modern farm implements and technological inputs
- ❖ Lack of talented and skilled workforce (very limited Engineers, Management school students or agricultural university students take up direct farming as profession)

"THE FARMER IS THE ONLY MAN IN OUR ECONOMY WHO BUYS EVERYTHING AT RETAIL, SELLS EVERYTHING AT WHOLESALE, AND PAYS THE FRIGHT BOTH WAYS"

John F. Kennedy

Knowledge Gaps

- ❖ Lack of skills for modern and innovative farm practices
- ❖ Limited knowledge about incumbent rain, flood, draught, or hails.
- ❖ Lack of understanding and skills related to modern methods of irrigation, cultivation, and plantation.

- ❖ Indian farmers are not integrated to global farmers who have started using latest technology for farm productivity and efficiency

❖ Limited knowledge of soil composition, water and mineral content and matching crops suiting soil, climate, and minerals.

Planning and Execution Gap

❖ Lack of skills to manage the finance/budgets, technology, and advanced knowledge

❖ Limited know how about various factor of production, storage, and distribution. This leads to asymmetry of information.

❖ Disintegrated with techniques of farm analytics and strategic planning for cropping pattern, climatic prediction.

❖ Disintegrated farming leads to limited understanding about demand supply gap. This leads to similar cropping and over production, thus leading to low revenue per unit of production.

Agricultural Value Chain Gap Analysis

1. ***Backward Integration Gaps (Input Gap)***
2. ***Production or Processing Gap***
3. ***Forward Integration***

B. Processing / Production Gaps: Inefficient production techniques

❖Farm productivity is relatively low vis a vis global standard on account of low level of technology, unskilled workforce and poor quality of seeds and other inputs.

❖Outdated techniques are still being applied by most of the farming community, thus leading to low farm output.

C. Output Gap: Forward integration shortcoming

Poor quality of post harvesting Technique

❖ Indian farmers still use primitive or outdated post harvesting techniques due to which there are lots of pilferage and wastage.

PRE-POST HARVEST LOSS

Crop Loss: Difference between potential yield and actual yield.

Pre-Harvest Loss:

According to research report of Dr.Elumalai Kannan the crop loss estimates due to insect pets are estimated to be 25% in rice and maize, 5% in wheat, 15% in pulses and 50% in cotton. The crop loss has increased post green revolution.

Post-Harvest Loss

According to World Bank (1999) stud, post-Harvest losses of food grain in India are 7-10% of the total production from farm to market level and 4-5% at market and distribution level.

Dr Elumalai Kannan in his research report states that

"With the given per capita cereal consumption in India, post-harvest loss would be sufficient to feed 10 crore people."

❖ Lack of farm mechanization during post-harvest seasons leads to increase in total production cost.

❖ With the increase in labour prices, the financial burden has further aggravated.

Post-Harvest Storage & Financial Gap

❖ Lack of proper infrastructure such as non-availability of quality cold storage at affordable price for perishable goods.

❖ Lack of quality storage facilities for other food grains

❖ Due to lack of proper storage facilities, the farmers are forced to sell their products immediately post-harvest at cheap price.

❖ Due to financial constraint and long production cycle of Agri-products, farmers realize the net proceeds of production immediately post-harvest.

Post-Harvest Logistics and Transportation Gap

❖ Sub-Standard basic transport infrastructure such as poor-quality roads in rural & sub urban areas leads to increase in transportation cost and wastage due to accidents.

❖ Unorganized logistics and transport facilities lead to pilferages and cost appreciation for farmers.

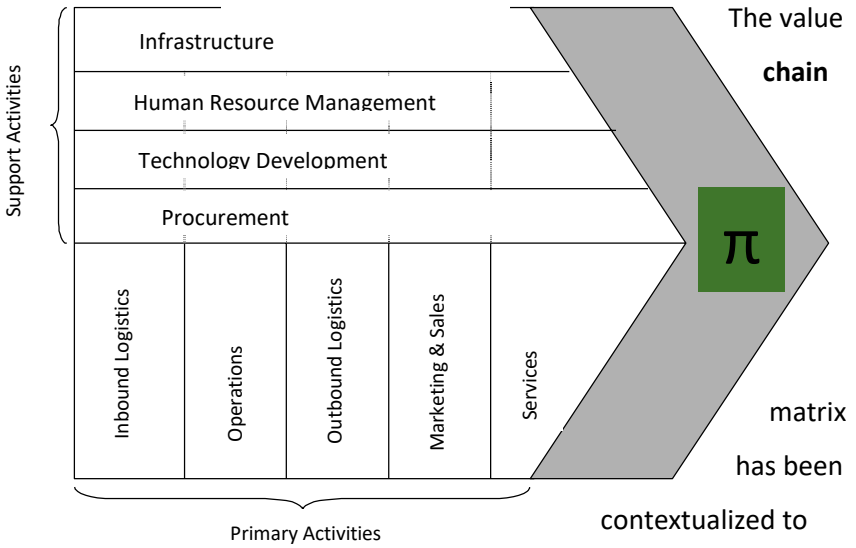
❖ Logistics is one of the most week links in Agri supply chain. Farm to market integrated facilities are missing.

❖ Due to unorganized farming sector as well as distribution network, the bargaining powers are dynamic and asymmetric.

❖ Transportation infrastructure such as linkages between Road, Rail and Waterways are not integrated and well structured.

Based on the assessment of constraints at various levels being faced by the agriculture sector, we have tried to draw the schematic and mathematical model to understand the GAPs in present value chain structure of Agriculture in India.

Figure A



matrix has been contextualized to define present gaps in the system and find a logical solution for development of a sustainable model that can be adopted in future.

The total profit generated in the Agri-Value chain is a function of all the nine variables as shown in Figure A.

Converting the diagram into a mathematical model the net profit generated in Agri-Value Chain is slated as under:

$$\pi = \sum_{i=1}^{i=n} \lambda i HR + \sum_{i=1}^{i=n} \lambda i P + \sum_{i=1}^{i=n} \lambda i T + \sum_{i=1}^{i=n} \lambda i IL + \sum_{i=1}^{i=n} \lambda i O + \sum_{i=1}^{i=n} \lambda i OL + \sum_{i=1}^{i=n} \lambda i M\&S + \sum_{i=1}^{i=n} \lambda i S + \xi$$

Equation - I

ξ is the external Variable (uncertainty) and is a joint function of all the variables of Primary & Support Activities

λi are the direction or incidence of respected variables

HR, P, T, IL, O, OL, M&S, S are magnitude of Support & Primary Activities in Agri-Value Chain

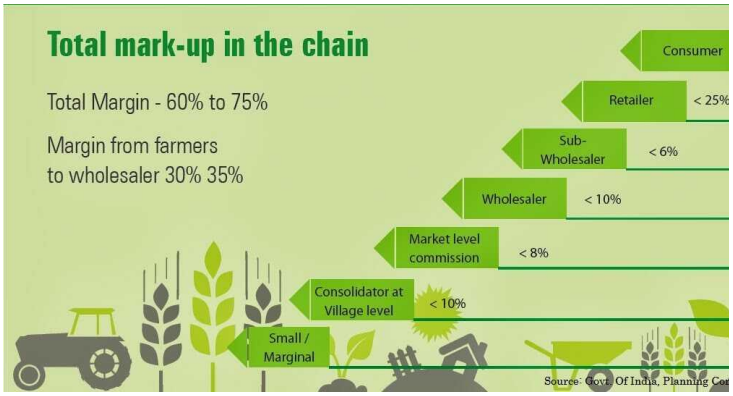
To understand the impact of any single variable to intraplate its interpretation on profit, let us keep HR as single variable and other variables as constant. Partially differentiating the equation, I w.r.t HR

$$\frac{\partial \pi}{\partial HR} = \sum \lambda i \; f'(HR)^R + \xi'$$

The equation can be interpreted as follows:

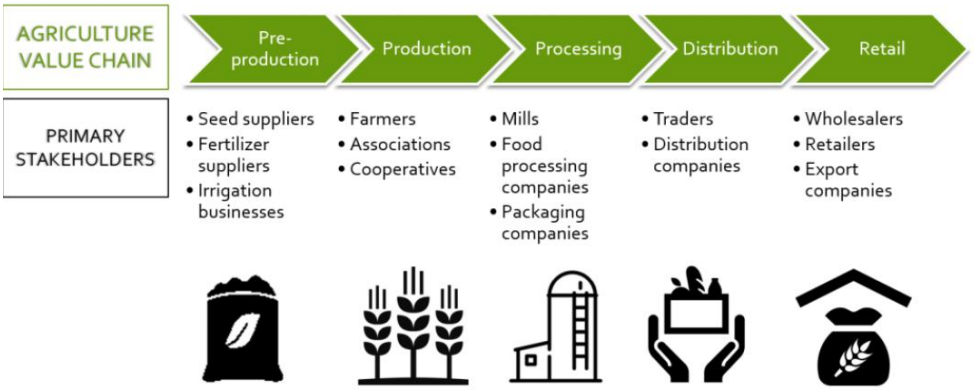
- Given everything other as constant, the profitability of Agricultural system is a function of quantity of human resource supplied along with the direction of labour and some external factors. Direction of labour is synonym of quality of skilled manpower.
- The effectiveness level of farm output can thus be increased even if the number of labour force is reduced but skill development and knowledge augmentation in manpower is enhanced.

Similar interpretation can be derived for all other variables of the value chain. In the present Agri-Value chain the over-all profitability of Agriculture is abysmally low as their age wide gaps in all the segments of Value chain and overall efficiency is getting dampened. This has resulted into low level of activity in the sector, low investment, and below normal enthusiasm by entrepreneurs to venture to become a full-fledged farmer.



Source: Govt. of India, Nity Aayog

The sustainability of agriculture in India at the present level of activity and interest are thus a serious concern.



As per Nity Aayog GOI, the total mark-up value of any farm product is approximately 60-70% of its original production cost. The margin gained by the farmer in this total process are less than 10%. The rest 50-65% are transactional cost gained by various intermediaries in the supply chain of Agri-goods.

The Agri-Sector is grossly unorganized due to which there are sufficient information asymmetry. There exist arbitrage opportunities due to lack of awareness, vast geographical boundaries and inefficient supply chain network. The intermediary and transactional cost are thus as high as 50-60% of the actual value of the product.

This is the core challenge for sustainability in the sector.

Solution Matrix: Sustainable Agriculture Development Model

Sustainability in Agriculture

To determine a Sustainable Agriculture Development model, we have tried to plot the matrix on three bord parameters:

1. Economies of Scale
2. Economies of Scope
3. Economies of Knowledge

Economies of Scale

The basic reason why agriculture has become unviable and economically unsustainable is that the sector is widely unorganized and fragmented. Thus, there are millions of farmers producing in a fragmented land and with primitive or near to primitive technology.

The economies of scale which are function of six broad factors viz.

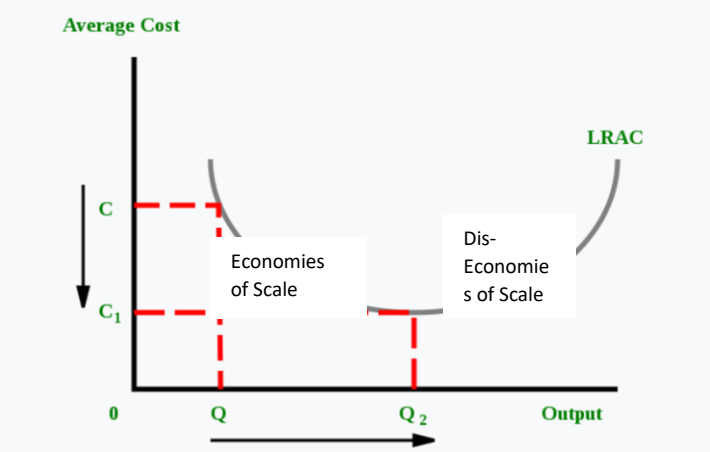
- Bulk Production or Procurement (realizing profit from buyers bargaining power)
- Efficient Production (by integration of skill, knowledge and technology supported by prudent financial system)
- Reduction in production cost, Reduction in Logistical & Distribution Cost
- Cheap Capital and
- Spread of Risk

The economies in scale in Agriculture is one of the necessary conditions for its sustainability. This can be achieved through

1. Institutionalization and corporatization of Agriculture Sector
2. Bringing in land consolidation reforms and legislations. Land Pooling and reformed ownership structure

3. Change in land ownership structure, land inheritance norms and structures
4. Organizing the Agri-Sector into large co-operative or Corporate structure with innovative ownership norms. This can lead to reduced exploitation

Efficiency in Economies of Scale



5. Integration of latest technology in every aspect of Agri-Value chain.
6. Backward and Forward integration of activities & channelization of information to reduce transaction and intermediator cost.
7. Farm Digitization and Farm Mechanization
8. Use latest technologies of production, distribution, storage, marketing, and sales.
9. Planning and Policy making should be aligned for long term sustainability in the sector and achieving economies of scale to make the sector more profitable and viable.
10. Reduce Dis-economies of scale by adopting principles of diversification and knowledge.

Effects of Economies of Scale on Production Cost

a. It reduces the per unit fixed cost. As a result of increased production, the fixed cost gets spread over increased output.
b. It reduces per unit variable cost. This occurs as the expanded scale of production increases the efficiency of production process.

Economies of Scope

All the tools of analysis in general economics are employed in agricultural economics as well. Scope and diversification can be explored in the field of:

1. Agronomics
2. Crop Diversification, Cash Crop, Floriculture, Forti culture
3. Nutritional crop cultivation such as bulk Moringa Cultivation
4. Crop Simulation and iteration for futuristic predictive analysis of market and demand vis a vis future supply
5. Vertical Urban Agriculture
6. Aquaculture & hydroponics
7. Animal Husbandry
8. Sericulture
9. Fish & Shrimp Cultivation
10. Agriculture economies in Applied Science, Digital integration, Artificial Intelligence, Space Technology etc.

Economies of Knowledge

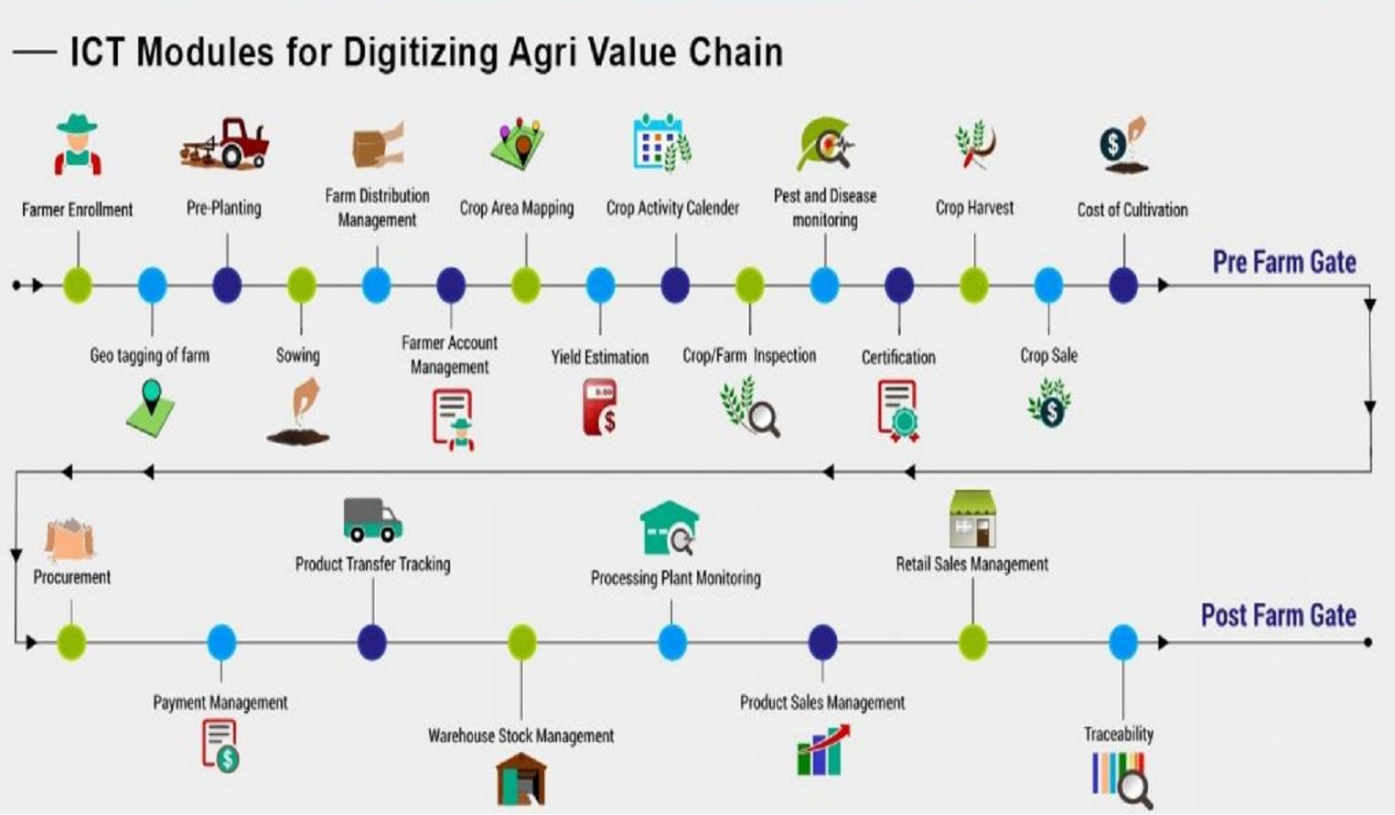
In order to build a sustainable Agriculture Development Model, the economies of knowledge is most vital and key element apart from economies of scale and scope.

The tirade of population explosion, livelihood for all and environmental protection are vital for Agri-Sustainability. To achieve the slated objectives, creating synergies (Positive Effect) or Trade-offs (negative effects) with respect to other objectives- and a single use perspective on any objective can lead to unintended impacts on other objectives. Competing objectives and complex interactions, along with multiple stakeholders with a range of concerns, should make us cautious with specific ideas and lead to higher prices to consumers.

The economy of knowledge encompasses the following domains

- Integration of Planning, Policies and Stakeholders
- Integration of Skill, Knowledge and Technology
- Integration of Finance, marketing, and operations

The new age Digital Revolution can help make a sustainable agri value chain.

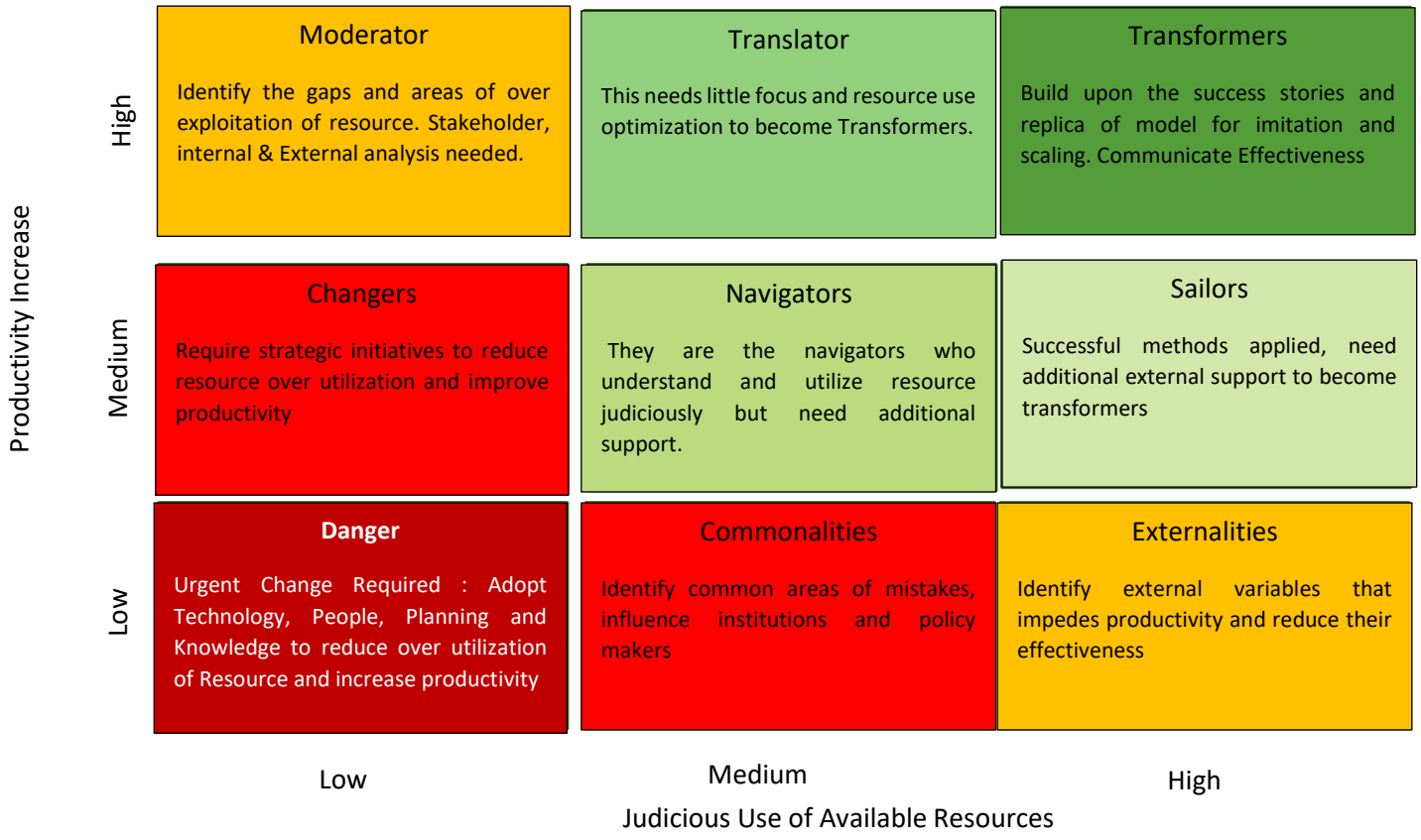


Agriculture Sector: Cultivation Matrix

The granular recommendation for development of a sustainable agriculture model starts with identification of current cultivation methodologies and deriving at a matrix for recommending futuristic cultivation methods.

While the current cultivation methodologies have been explained in the earlier sections, we will focus on developing a new cultivation matrix for sustainable growth:

Sustainable Cultivation Matrix



This the production efficiency is a function of judicious utilization of resource in time horizon. This can be achieved by a multiple factor analysis such as :

1. Soil Testing & sowing as per nutritional value of soil
2. Seed nourishment and deworming before cultivation
3. Prior knowledge of climatic change, weather forecast and monsoon forecast
4. Water conservation and integration of modern irrigation technology for productivity improvement
5. Collective cultivation, land pooling etc to get more bargaining power from seed, fertilizer suppliers.

ETHYLENE SYNTHESIS INHIBITORS AS TECHNIQUE FOR INCREASING SHELF LIFE AND QUALITY OF FRUITS AND VEGETABLES

Ripening is nowadays not only a physiological process, but it is becoming a tool for farmer to manage and sell their produce at a proper stage and quality of the fruit. Physiologically it is defined as the process by which fruits attain their desirable flavour, colour, palatable nature, and other textural properties which ultimately make it more attractive and edible. Ripening is not only associated with the change in internal composition i.e., sugar, TSS, acids, but also external appearance like colour, flavour, texture. Thus, ripening is the process which affect horticulture commodity from the point of view of farmer, wholesaler, trader, and consumer.

Ethylene biosynthesis inhibition for enhancing shelf life

Source: http://www.sustainableagriculture.in

Backward Integration & Forward Integration

Backward integration is the holistic approach driven towards Pre-Cultivation methodologies. The pre cultivation value chain includes

i. Knowledge and Pricing of Seeds
ii. Tie-up with financial institution/ banks for timely supply of cash
iii. Know-how of climate, weather forecasting technique.
iv. Assessment of need of the market, post-harvest estimation and price sensitivity analysis
v. Choosing the crop as per sensitivity analysis and budget, market information, neighbouring cultivation pattern, Govt. or institutional minimum support price etc.
vi. Farm Mechanization, Farm Digitization, AI application and technological intervention for process reengineering
vii. Rainwater harvesting techniques, Irrigation facilities, wate conservation and storage facilities, modern irrigation methodologies
viii. Pest control methods, organic cultivation, Neem etc Plantation in the vicinity
ix. Soil nourishment through organic methods, use of vermi-compost
x. Rearing of cattle and livestock for additional income, use of dungs as manures

ENHANCING CROP PRODUCTION BY ENHANCING WATER EFFICIENCY

Agriculture is the predominant user (75-80%) of the available freshwater resources in many parts of the world. As water resources shrinks and competition from other sectors grows, agriculture faces dual

challenges: to produce more food with less water and to prevent the deterioration of water quality through contamination with soil runoff, nutrients and agrochemicals. Water use efficiency by crops can be enhanced by selection of crop, variety, Agronomic practices like time of sowing, method of sowing/planting, seed rate, plant population, interculture, fertilizer and irrigation, intercropping should be evaluated with the irrigation levels for high water use efficiency and economic yield of crop.

Optimum time of sowing/planting, seed rate, plant population, interculture, herbicide application, fertilizer facilitate better growth and development which resulted in higher crop yield and water use efficiency. Conservation tillage practices like zero tillage; reduced tillage/minimum tillage utilizes more judiciously the plant available water than the conventional tillage when the other factors are similar.

Source: Agriculture for sustainable Development 5(1) :11-117, 2017/Article

xi. Modern and Integrated Transportation and Logistics

xii. Market Information, Demand Supply knowledge and analytical insights post-harvest

xiii. Integrated supply chain, storage facilities, warehousing facilities

xiv. Prevention of pilferage, wastage, and distribution loss

xv. Money supply, credit facilities and integration of prices with market both spot and futures

xvi. Digital integration of Agri-supply and value chain.

Factors of Production

The various factors of production that are integral to development of Sustainable Agri-Value Chain include:

- ✓ Consolidation of land and methods of land pooling
- ✓ Upskilling of work force and reduction in disguised employment. Workforce resource optimum utilization.
- ✓ Adequate and timely support of capital, channels of Agri finance
- ✓ Return on investment analysis
- ✓ Technology updates and latest R & D initiatives integration
- ✓ Formation of SHGs, channels of Government support and utilization of Government led Agri Schemes

Stakeholders

The various Stakeholders in Agri-Value Chain Development include

- ➢ Farmers
- ➢ Government & Semi Government Authorities
- ➢ Traders & Merchants of Agri goods
- ➢ Pesticide and Fertilizer Producers
- ➢ Seed Manufactures and distributors
- ➢ Transport and Logistical support partners

AGROECOLOGY AND 2030 AGENDA

Agroecological approaches address root cause of hunger, poverty and inequality, helping to transform food system and build resilient livelihoods through a holistic, integrated way that balances the three dimensions of sustainability – social, economic and environmental – ensuring no one is left behind.

Ten elements of Agroecology include :

1. Diversity
2. Co-creation and sharing of knowledge
3. Synergies
4. Efficiency
5. Recycling
6. Resilience
7. Human and social values
8. Culture and food tradition
9. Responsible Governance
10. Circular and solidarity economy

Methods

1. Scaling up through farmer field schools
2. Marketing the nutritional goodness of purple and pink rice from the mountains of India
3. Ecosystem Service and bio-diversity
4. Access fuel for cooking

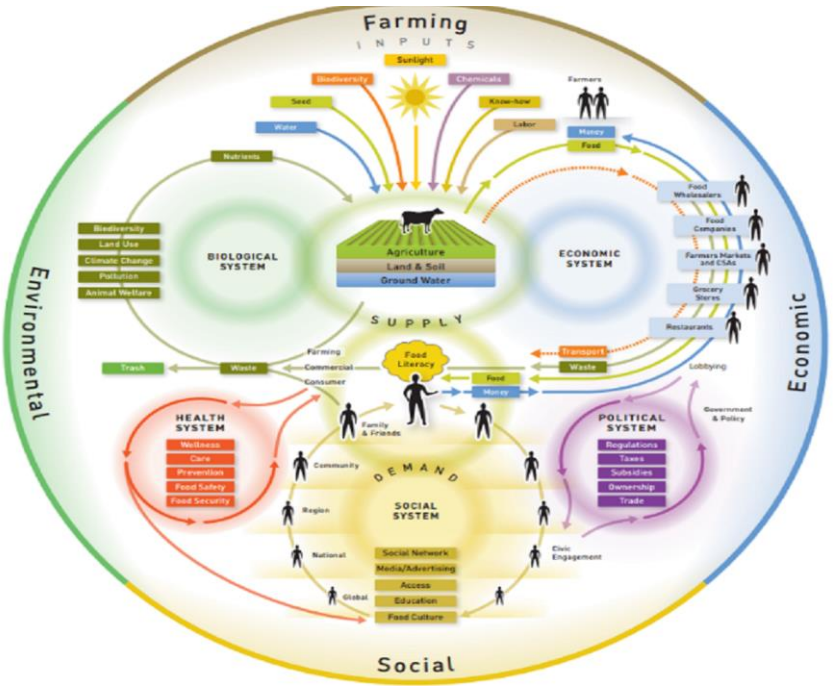
Source : www.fao.org.

- Consumers
- Muti-Model Retailers and wholesalers
- E-trading platform, e-traders and mega retailers
- Banks, Financial Institutions and Money Lenders
- NGOs, SHGs, UN Bodies, World Bank, IFCs etc.

Collective understanding among all the stakeholders for sustainability is most important for a efficient model to work. The planning, execution, policy driving initiative and directional support are provided by Govt. and its agencies.

UN bodies, World Bank and IFC provide a holistic vision and strategic alternative to key challenges.

Reducing the role of intermediaries and overall transaction cost so that the net benefits of value derived are shared by the original producers



Why Bee Matter

The importance of bee and other pollinations for food and agriculture.

Improving pollinator density and diversity boosts crop yields – pollinators affect 35 percent of global agricultural land, supporting the production of 87 of the leading food crops worldwide.

Pollinator-dependent food products contribute to healthy diets and nutrition.

Pollinators are under threat – sustainable agriculture can reduce risk to pollinators by helping to diversify the agricultural landscape and making use of ecological processes as part of food production.

Safeguarding bees' safeguards biodiversity: the vast majority of pollinators are wild, including over 20 000 species of bees

Source: Food and Agriculture Organization United Nations

Key Resources

The resources required for sustainable supply chain in agriculture include:

1. Skilled Workforce
2. Indigenous Knowledge
3. Land & Capital
4. Infrastructure
5. Technology
6. Water, Energy & Biodiversity
7. Producers, Suppliers, Market, Wholesalers, retailers, Govt. Institutions etc.

To build a sustainable supply chain model in agriculture an integration of key resources, and all other stakeholders are pre-requisite condition.

Finance & Capital

The sector is unorganized in India, as such faced multiple layers of capital constraint. The easiest way to secure funding by small and marginalized farmers are through money lenders. This channel has exorbitant rate of interest (sometimes as high as 60% annually).

Apart from this there are other models of SHGs, MFIs, Private lenders, banks as well as grant from Govt. Institutions. The lack of awareness and trust has impended the channel of safe, secured, and easy access of credit flow for millions of farmers.

The sector needs to be organized to get easy and affordable supply of credit flow on time. The following mechanism can be explored to fund long and short term credit to farmers at affordable rates:

1. Floatation of Agri-Sovereign Bonds with different maturity tenors.
2. Credit monitoring and discipline of farmers to reduce Probability of default
3. Database of credit monitoring and disbursements to create a credit profile (rating) of each individual borrower.
4. Institutionalization of Agriculture as co-operatives, corporates.

The farmers can pool their lands, crate co-operative cultivation techniques, common marketing and sales platform, better knowledge of market, dynamics, and technology.

The capital cost of machineries and latest technologies are very high. Collective cultivation or corporatization can increase their ability to invest in long term capital assets.

Corporatization can lead to better information flow, thus increase their bargaining power, technological integration, and access to market. The storage techniques can be further improved. The farmers need not sell their products just after production but can store in warehouses and get fiancé through warehouse receipts.

Infrastructure

Infrastructure and capacity building are essential elements for creating a sustainable agriculture development model. The basic infrastructural facilities needed for sustainability and scalability include:

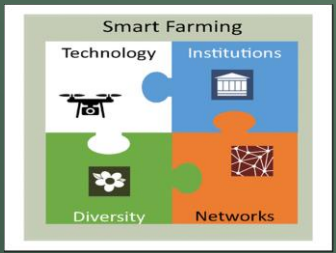
1. Basic infrastructure of irrigation, water storage and water harvesting techniques.
2. Renewable source of power
3. Last mile connectivity through better rail, road, water and air
4. Internet access to last doorstep
5. Mobile network
6. Transportation facilities both local and long distance

SMART FARMING IS KEY TO AGRICULTURAL DEVELOPMENT

Agriculture is undergoing a fourth revolution triggered by the exponentially increasing use of Information and Communication Technology (ICT) in agriculture.

Autonomous robotic vehicles have been developed for farming.

Smart farming reduces ecological footprint of farming. This can make agriculture more profitable and boost consumer acceptance.



7. Safe Storage and cold storage facilities
8. Distribution network, market access and export hubs
9. Social Media, Digital Media, and other new age marketing infrastructure

Knowledge & Technology

Latest technological inputs in every domain of value chain of agriculture can lead to environmentally sustainable agriculture development model.

Some of the latest technological interventions include:

1. **Digital Technologies** in agriculture and rural areas

The research paper of Nikola M Trendov, Samuel Varas and Meng Zeng published Food and Agriculture Organization of United Nations states importance of Digitalization for development of sustainable agriculture. The paper illustrates about the digital agricultural revolution and conditions for digital transformation. Nikola states in the paper

"Market forecasts for the next decade suggest a 'digital agricultural revolution' will be the newest shift which could help ensure agriculture meets the needs of the global population into the future."

They further enumerate the various conditions for digital transformation as under:

- Basic conditions are the minimum conditions required to use technology and include availability, connectivity, affordability, ICT in education and supportive policies and programmes (e-government) for digital strategies
- Enabling conditions ('enablers') are factors that further facilitate the adoption of technologies: use of internet, mobile phones and social media, digital skills and support

for agripreneurial and innovation culture (talent development, sprint programmes including hackathons, incubators and accelerator programmes).

2. in Agriculture and its role in Sustainable Development

   Dr.Tarq K.Hassan and Haidi jamal Abdullah in their research report published in International Journal on Science and Research (IJSR) mentions the key elements of IK as under:

- IK is local based knowledge instead of knowledge that is used across a wide range.
- It is experiential in terms of being based on what people have perceived in their surrounding and what is passed on through generations
- It is very socially constructed
- It is learned via being apprenticed to local experts
- It is pragmatic rather than theoretical
- It is generally orally perceived rather than written document

The indigenous knowledge can be key to solving many challenging and ecologically damaging issues surrounding the world of Agriculture. Preservation of this knowledge and its dissemination to new generation are essential for development of a sustainable supply chain in Agriculture.

3. Use of Robotics, AI and ML for Agri-sustainability and development. Smart farming techniques need to be adopted.
4. Use of ICT in augmenting the supply chain network and reducing the transaction cost.
5. Analytical tools to be applied to forecast demand and risk associated with cultivation, storage and distribution.
6. Modern management science in supply chain and logistical innovation should be applied.

Human Capital

Majority of the agricultural sector is driven by semi-skilled or unskilled labour force. Since agriculture sector has remained grossly unprofitable, most of the qualified talent pool do no prefer to enter the sector.

The Agricultural sector and its entire value chain demands new generation technological and managerial skill sets. In order to be sustainable, corporatization of agriculture is a must. Thus most talented entrepreneurial mindsets needs to be drawn into the sector.

Storage, Logistics Support

One of the key challenges for agriculture supply chain is lack of proper storage, logistics and marketing /sales support for the farmers.

Storage:

Some of the recommendations that can help reduce pilferages and losses both during pre-harvest and post-harvest seasons include:

1. Formation of community based co-operative storage facilities with joint ownership of farmers, communities, government/ semi government institutions as well as corporates and industrial bodies.
2. Digitalization of each storage / warehouse with technology to measure weight, moisture content, nutritional values. The technology to detect pests, infections and worms or bacteria can be detected on real time basis. This can help reduce the wastage.
3. Modulating the storage facilities in Hub-and-Spoke model with near access to major producing centres and easy access to transportation facilities. This would lead to lower cost of logistics and greater reach of farm to market.

Types of Storage

- Underground Storage Structure
- Surface Storage Structure
- Improved Grain Storage Structure
- Warehousing

Some of the major Warehousing in India include

i. Central Warehousing Corporation
ii. State Warehousing corporations
iii. Food Corporation of India

4. Cold Storages for perishable items such as fruits and vegetables with facilities to top solar power.
5. These storage facilities can augment farmers with information regarding demand and supply. Thus improve their cash flow and income levels.

Logistics

Approximately 5-10% pilferages and losses in Agri-goods happen due to shabby logistical support. This includes overloading of tractors, lorries and trucks leading to accidents and loss. Lead time for transportation are high due to lack of basic infrastructure form farm to market. Poor quality of rural roads, lack of dedicated rail lines, poor docking and redocking facilities on rail yards, transportation network not adequately connected to ports and export-oriented units, corruption on roads due to which cost of transportation is high.

Due to these bottlenecks, the logistical cost is not only high but also flow of information and real time tracking of goods and services are not adequate.

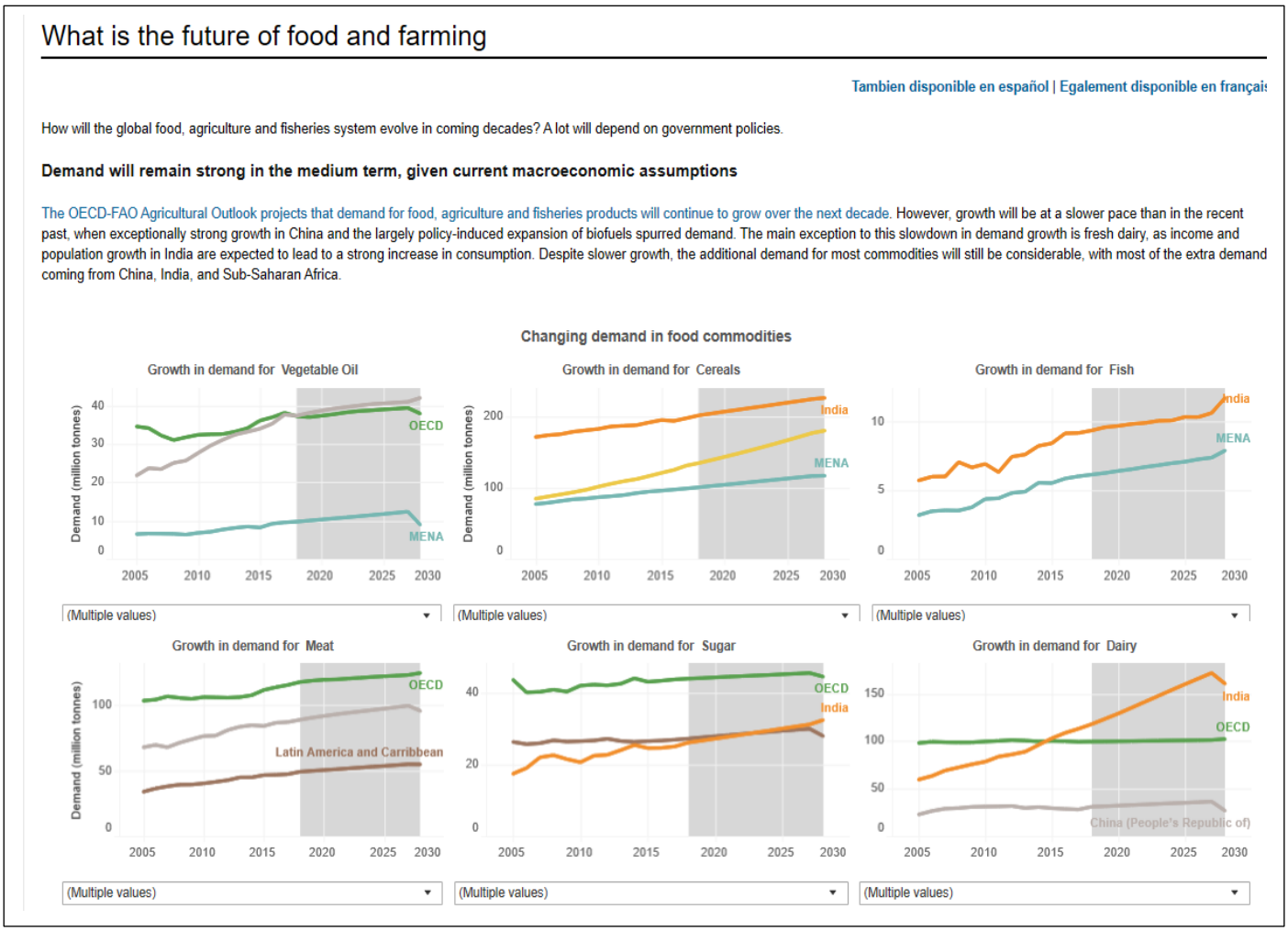
Some of basic solutions suggested including:

- ✓ Community based or e-portal / commerce based local transportation for farmers. Ideas like Ola and Uber can be extrapolated for farmers during crop seasons. This will reduce transportation search cost and search time.
- ✓ Excess loading should be checked, and heavy penalty imposed for violation. This can help reduce loss due to accidents.
- ✓ Block level connectivity of roads and rails
- ✓ Tracking of movement of goods through digital channel and immediate docking of lorry transported goods to rail wagons. This can help reduce the lead time for transport from farm to market.
- ✓ E-lorry receipts and e-way bills for real time and online tracking of goods

Marketing & Sales : Demand Supply Analysis

Integration of Marketing, sales and services in Agri-value chain are critical for development of a model which is not only profitable to all the stakeholders but to mitigate risk due to demand fluctuations and supply constraints.

According to a publication of Organization for Economic Cooperation and Development (OECD) the demand for food and farming will remain strong in medium term given current macroeconomic indicators.



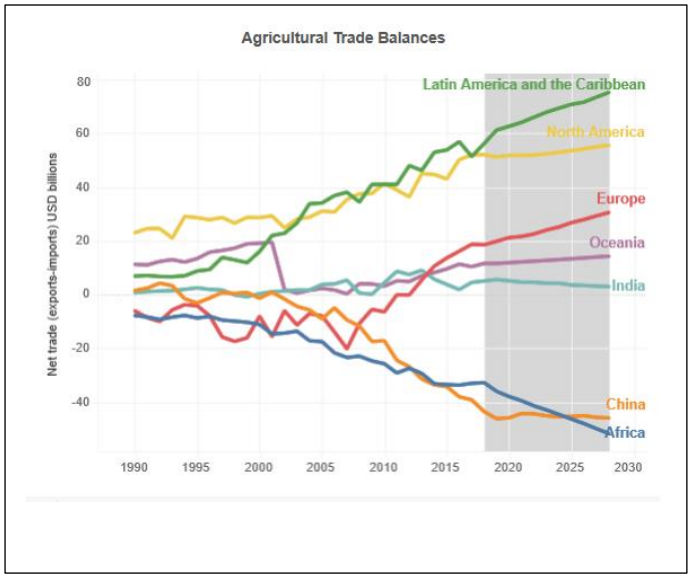
The key recommendations for enhancing Agri-value chain efficiency by way of integrating marketing and sales techniques include:

1. Develop a matrix and insight for demand and supply gap and disseminate the information through a common network to farming community.
2. Continuous market research and surveys along with use of digital, IOT technology, Blockchain and AI technology needs to be implemented for better market analysis, need assessment and creation of knowledge penetration index.
3. Communication is the key for marketing and Branding. A robust communication strategy needs to be launched to make the consumers realize the actual cost of production and value generated by farmers and its sustainability
4. Communication needs to focus on green use of Agri commodities, reduce food wastage and minimize the role of intermediaries.
5. Explore new variants of food, fisheries and animal husbandry/dairy products and reach to market that is untapped.
6. Co-operative style marketing strategy needs to be developed so as to give higher market reach and penetration.
7. Use of social media, digital media and IOT channels need to be integrated.

Strategies and Recommendations for Sustainability in the sector.

Some of the key recommendations for Sustainable Agriculture Development include:

- **Food trade will increase and contribute to building global food security, assuming current policies**: Because of Geographical, Climatic and natural divide, few regions are better suited for producing agricultural goods than others. This creates an opportunity for trade and economic activity. India has a natural advantage being an agrarian county for ages, it has requisite skill and manpower to propel the need for global food security.



- **Technological developments, and digitalization in particular, are evolving rapidly:** The food, agriculture and fisheries sector need to situate itself within the wider framework of economic, trading and digital revolution superimposing political divide and trading restrictions to ensure coherence across policy fields domestically and avoid policy fragmentation internationally.
- **Productivity Growth, sustainable resource use, and climate change require urgent attention:** As the global demand for food, fisheries and dairy product increases, productivity needs to be augmented with minimal use of resources. Thus, the sustainability is the key challenge. The capacity of the system to respond to even unexpected increase in demand remains strong in both developed and developing countries. The use of data and AIs /Analytics can play a pivotal role to give valuable insights in near future.
- **A lot depends on policies:** Government have opportunities to begin to bring back ineffective policies or legacies of the past. In this way scarce resources will be released that can be devote to coherent policy packages that can contribute to productivity, sustainability, and resilience.

a. Remove existing policy dis-incentives to increase productivity, sustainability, and resilience
b. Re-direct food and agriculture and fisheries support to ensure the availability of public services that benefit producers, consumers, and society overall
c. Encourage collaboration on knowledge generation and transfer with public and private actors – nationally, regionally, and internationally
d. Draw on the full range of economic instruments, including information, education, regulation, payments, and taxes, in pursuit of environmental and climate change goals.
e. Streamline risk management policies by clearly defining the limits between normal business risks, risks for which market solutions can be developed, and catastrophic risks requiring public engagement
f. Improve understanding of the financial and well-being situation of farm households to design effective farm-income support measures.

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