BUILDING RESILIENCE IN AGRICULTURE FOR FOOD SECURITY

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LIST OF ABBREVIATIONS

AIR	All India Radio
ATMA	Agricultural Technology Management Agencies
CSA	Centre for Sustainable Agriculture
DA	Development Alternatives
FAO	Food and Agriculture Organisation
FPO	Farmer Producer Organisations
GDP	Gross Domestic Product
GHG	Green House Gas
ICAR	Indian Council of Agricultural Research
ICT	Information and Communication Technology
LQI	Land quality indicators
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
NABARD	National Bank for Agriculture and Rural Development
NMAET	National Mission on Agricultural Extension and Technology
NMSA	National Mission for Sustainable Agriculture
RKVY	Rashtriya Krishi Vikas Yojana
SMAE	Sub Mission on Agricultural Extension
TFP	Total Factor Productivity
WOTR	Watershed Organisation Trust
WTO	World Trade Organisation

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ABSTRACT

India has witnessed phenomenal economic growth with greater technology innovations, booming service sector, accelerated globalisation of the economy. However, facts indicate that India's development trajectory has ignored the role that natural resources play in India's development. With 70 percent of the surface water polluted and 60 percent of groundwater sources expected to be in a critical state within the next decade, the impeding water crisis is one of the major health, environmental and economic issue the country is likely to face. Food security is one of the key priorities of this country that has direct linkages with the use and quality of resources. Food security is dependent on agriculture which accounts for 70 percent of total global freshwater withdrawals and about 30 percent of total energy consumed globally.

The paper is developed under the research project "Transforming the Development Paradigm" supported by Heinrich Böll Foundation. The focus of this paper is to study the challenges and opportunities in agriculture systems in semi-arid rain fed regions of India for increasing capacity of food production systems in a resilient and sustainable manner. Agriculture interventions, related to technology and community models are studied for its impact on three components: food production, income generation and natural resource management. The study focused on semi-arid rain-fed regions regions of the country because rain-fed regions contribute to about 50 per cent of the food production of India while semi-arid regions belong to the most natural resource scarce regions that aggravate the concerns over food production. Further agriculture systems in general and rain-fed regions in particular have trend of growing small and marginal farmers that shows continuous dependence of huge population of the country on agriculture for their livelihoods. A framework for analysis is developed after reviewing the literature. The interventions were analysed on this frame. Analysis of these interventions is done to understand the processes that triggered the adoption of certain technologies and practices that were assessed sustainable.

The study involved secondary research to understand the agriculture production systems and related concerns for food security. The secondary research was substantiated by primary research on models and interventions in various semi-arid rain fed regions that proved to be consequential to the quantity and quality of food production and environmental impact from agriculture in these regions. Ground work of five organisations working in semi-arid rain-fed regions was analysed. The primary and secondary study were continuously supported by deliberation and discussions with government, practitioners, academicians and other stakeholders to bring together perspectives on key issues of the sector – resources, sustainable agriculture and community based models. Two ***trialogue* 2047** and one focused round table discussion were conducted with experts to engage with contemporary concerns in the agriculture systems and potentials of sustainable agriculture. These discussions and deliberations have informed the perspectives put forth in this paper

The analysis is done for the purpose of utilisation for organisations working on agriculture interventions with communities. It is also intended as an input for the policymakers. The paper aims to understand what works, for whom it works, in what respects, and how such that similar efforts in principle can be adopted by organisations as well as government for scaling it up.

The paper, overall, highlights some critical components that can together form the base for a comprehensive agriculture programme. This study must be interpreted as only a foundational exercise that studies the scenario of agriculture systems and the potentials in different models across the country.

Key words: Agriculture, semi-arid, rain-fed zones, technology, community institutions, food security, natural resource management

CHAPTER 1:

AGRICULTURE PRODUCTION SYSTEMS AND FOOD SECURITY: INDIA'S CURRENT SCENARIO

ROLE OF AGRICULTURE SYSTEMS IN INDIA

Agriculture systems designates a set of agricultural activities organised while preserving land productivity, environmental quality and maintaining desirable level of biological diversity and ecological stability. Agriculture system is a resource management strategy to achieve economic and sustained production to meet diverse requirement to farm household, raw agriculture production needs (food and non-food) while presenting resources base and maintaining a high level environmental quality and coping with environmental factors like climate change. The emphasis is more on a system rather than on gross output. (Agriinfo, 2015) Agriculture systems, in this paper, will include natural systems- soil, land, water and air that is used or impacted due to practicing farming activities, social systems of the population dependent on farming for their livelihoods, and economic systems of inputs to the farming and the value chain of reaching the inputs, produced goods from the farm to the market or the end consumer.

India's population of 1.3 billion (Worldometer, 2015) is around 18 per cent of the world's. It is further estimated to reach 1.6 billion by 2030 (Population Division, Department of Economic and Social Affairs, UN, 2015). Clearly, Indian agriculture systems have a huge responsibility to ensure secure access to food by every one of its citizens, now and for the future. Besides, with 58.2 percent of the Indian population dependent on agriculture sector for its livelihood (Committee on Agriculture, 2013), the contribution of agriculture to the country's Gross Domestic Product (GDP), which is 14 percent currently, will determine the economic benefits to the large section of the population.

Agriculture systems, being heavily resource-intensive, interact with natural resources and environment at a large scale. Around 50 per cent of India's total land area is under agriculture, using around 90 per cent of the total water withdrawals in the country (FAO, 2015). Agriculture sector is the third-largest consumer of power in India; it accounted for 19% of the total power consumption in 2011 (D & B). Apart from the high use of resources by agriculture systems, agriculture also contributes to 19 per cent of the total greenhouse gas emissions from India, where by India's greenhouse emissions are the third largest in the world (Ministry of Environment, Forest and Climate Change, 2007). It is one of the sectors that not just contributes to causing climate change but also faces one of the worst impacts from the same due to the variability in weather conditions that can disrupt crop cycles.

WHAT CONCERNS INDIAN AGRICULTURE SYSTEMS?

India needs to ensure availability of food for every citizen, now and for the future. The agriculture systems are responsible for achieving India's food security, ensuring livelihood security for farmers. Both of this will have to be achieved in the paradigm of depleting environment, shrinking natural resource base and climate change impacts on resources and agriculture. Some distinct concerns on Indian Agriculture Systems:

- **Estimated shortage of food:** If current trends continue, India will not have enough food for all by 2030. India's domestic production is estimated to only meet 59 percent of the country's food demand by 2030 at the current growth rate of Total Factor Productivity (TFP) (Global Harvest Intiative, 2014).
- **Increasing vulnerabilities due to climate change:** Food production in India is sensitive to climate change like variations in temperature and monsoon rainfall. Rise in temperature has a direct impact on the Rabi crop and every 1°C rise will reduce annual wheat production by 6 million Tonnes when the total wheat production in India has on an average been 87 million tonnes per annum from 2008-2013, which makes a loss of 7 percent of the total production every year. Another study estimates a 4% fall in the yield of irrigated rice crop and a 6% fall in rainfed rice is foreseen by 2020 due to climate changes (Shetty P.K, 2013). Climate change is also expected to reduce the regional water availability for food production due to rising temperatures, changing precipitation patterns and increasing frequency of extreme weather events (Ranuzzi & Shrivastava, 2012). Agriculture sector itself contributes 19 per cent of the total carbon emissions, being the third largest carbon emitting sector in India (Ministry of Environment Forest and Climate Change, 2010).
- **Shrinking natural resource base for agriculture:** Agriculture sector will witness a resource crunch with shrinking resource base as India already stands at an overshoot of 1.7 times its bio-capacity[1] (Global Footprint Network, 2010). With 70 percent of the surface water polluted and 60 percent of groundwater sources expected to be in a critical state within the next decade (Indo German Environment Group, 2013), the impeding water crisis is one of the major health, environmental and economic issues the country is likely to face. According to Integrated Waste Land Development Programme (IWPD) information platform at present, approximately 68.35 million hectare land is lying as wastelands in India out of which 50% lands can be made fertile again if treated properly. In addition a substantial acreage of individual lands is also left fallow. Most of these lands belong to small and marginal farmers due to factors like non-availability of basic infrastructure, daily compulsion of earning income and negligible remuneration from agricultural activities.
- **Degrading natural resources:** Apart from the shrinking resource scenario, natural resources are also witnessing resource degradation due to various anthropogenic factors that affect the quality of resources available for practicing agriculture. India is losing 5,334 million tonnes of soil every year due to soil erosion because of indiscriminate and excess use of fertilisers, insecticides and pesticides over the years. About one millimetre of top soil is being lost each year due to soil erosion and the rate of loss is 16.4 tonnes per hectare (The Hindu, 2010). Introspection on results from the multiple long-term fertiliser trials in rice-wheat systems have revealed gradual deterioration of soil health and thus long-term productivity due to overuse and imbalance use of synthetic fertilisers (Roy , Chattopadhyay, & Tirado, 2009).

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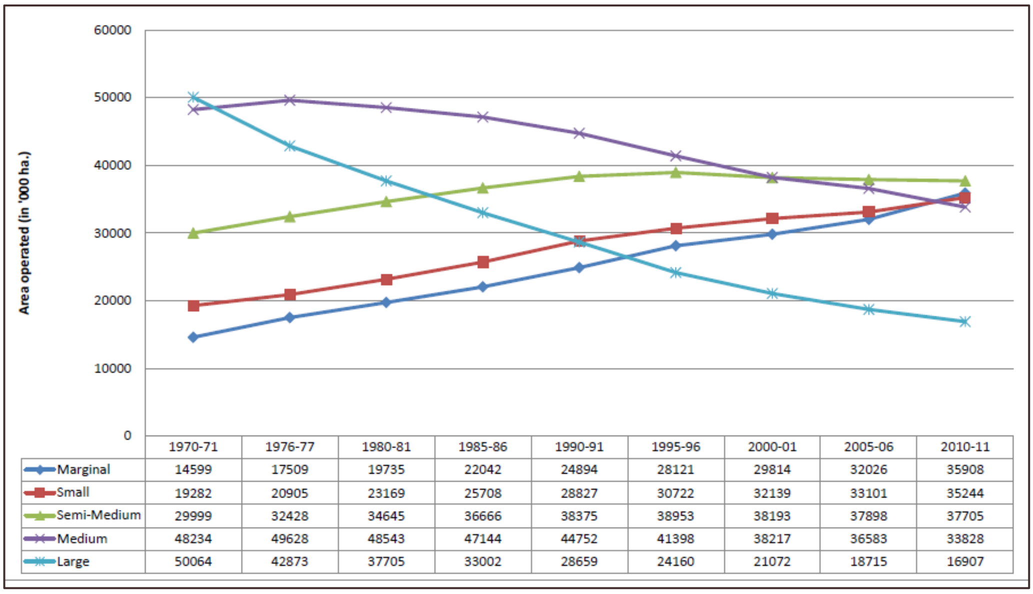
[1] The capacity of ecosystems to regenerate what people demand from those surfaces is called biocapacity. The biocapacity of a particular surface represents its ability to renew what people demand. Biocapacity is therefore the ecosystems' capacity to produce biological materials used by people and to absorb waste material generated by humans, under current management schemes and extraction technologies.

Figure 1: Area operated by operational holdings as per different agriculture censuses (Agriculture Census 2011)



	1970-71	1976-77	1980-81	1985-86	1990-91	1995-96	2000-01	2005-06	2010-11
Marginal	14599	17509	19735	22042	24894	28121	29814	32026	35908
Small	19282	20905	23169	25708	28827	30722	32139	33101	35244
Semi-Medium	29999	32428	34645	36666	38375	38953	38193	37898	37705
Medium	48234	49628	48543	47144	44752	41398	38217	36583	33828
Large	50064	42873	37705	33002	28659	24160	21072	18715	16907

- ***Agriculture is becoming an unattractive sector for livelihood:*** Agriculture is one of the primary sources of ***livelihood and income generation*** for around 263 million or 22 per cent of the population[2] (P, 2013) while is part of the secondary livelihood source of around 70 percent of the population. The small holding character of Indian agriculture is much more prominent today than even before with around 85% of the farmers in India having less than 2 hectares of land for farming. Small size of the land holding prevents the agriculture systems from reaching economies of scale reducing the scope of investment in new agriculture technologies and keeping the farmers' income low. A comparison of incomes, expenditures and savings of different farmers in table 1 explains the concerns raised by small holding character to the food and farmer livelihood security.

Figure 2: Status of marginal, small and large farmer in India (NSSO KI 70/33)

Item	Marginal Farmers	Small Farmers	Big Farmers
Land Holding	Up to 1 ha	1-2 ha	Over 10 ha
Proportion of All Farmers	75%	10%	0.24%
Share of Land Owned	30%	24%	6%
Average Monthly Income	Up to INR 5247	INR 7348	INR 41388
Average Monthly Expenditure	Up to INR 6020	INR 6457	INR 14447
Average Investment in Productive Assets	Up to INR 540	INR 422	INR 6987
Average Savings/Deficits	Up to –INR1500	INR 469	INR 19954

Agriculture systems therefore have the responsibility to produce sufficient and nutritious food for all in the scenario of growing impacts of climate change, and depleting and degrading resources. Besides, agriculture systems also have to adequately cater to the 70 per cent of the population dependent on it for their livelihood and income generation.

[2] This number is only for cultivators (marginal and large) and agricultural laborers and does not include the array of related activities like fisheries.

SEMI-ARID RAIN-FED AGRICULTURE REGIONS IN INDIA

India ranks first among the rain-fed agricultural countries in terms of both extent (86 M ha) and value of produce.(Sharma, Rao, Vittal, & A, 2006) Semi – arid region in India constitutes parts of Gujarat, northern plains and central highlands (Malwa), and the Deccan plateau (Figure 1). The climate of the region varies; some regions are characterised by hot and dry summer and cool winter whereas some regions are characterised by hot and wet summer and dry winter. The main crops in this region are millets, wheat and pulses. Rice and sugarcane is grown under irrigation facilities. In some parts of central highlands, like Bundelkhand, less than 25 per cent of the net cropped area is under irrigation, while the rest is under rain-fed agriculture. In Deccan plateau, comprising most of the central and western parts of Maharashtra, northern parts of Karnataka and western parts of Andhra Pradesh the traditional practice is rain-fed agriculture.

60 percent of the cultivated area in India is under rain-fed agriculture (Ministry of Agriculture, GoI, 2013), producing 44 per cent of the country's food requirement while supporting 40 per cent of human and 60 per cent of livestock population (Venkateswarlu & Prasad, 2012).Further, the human population in rain-fed areas is likely to reach 600 million by 2020 from the present 410 million. Such a kind of increase in population will potentially increase the population dependent on agriculture and will also shrink the per capita availability of land from 0.15 hectares to about 0.08 hectares (Gautam & Rao, 2007).

The environmental systems in rain-fed regions witness high risks and fragility caused due to heavy dependence on rainfall and large amounts of degraded lands (Rockstrom et al 2007). These rain-fed regions have limited access to irrigation that is about 15 per cent compared to 48 per cent in the remaining irrigated sub-regions. The scarcity of natural resources and the vulnerabilities from climate change are further amplified in semi-arid rain-fed regions due to lower ground water levels, poor moisture content in soil and greater incidence of drought years.

The agriculture systems in semi-arid rain-fed areas crease concerns with regard to food production security, farmers' livelihood security and environmental conditions of a large section of the country. This area, because of the huge relevance for the country is also one of the most difficult conditions looking at the mix of economic, social and environmental scenario.

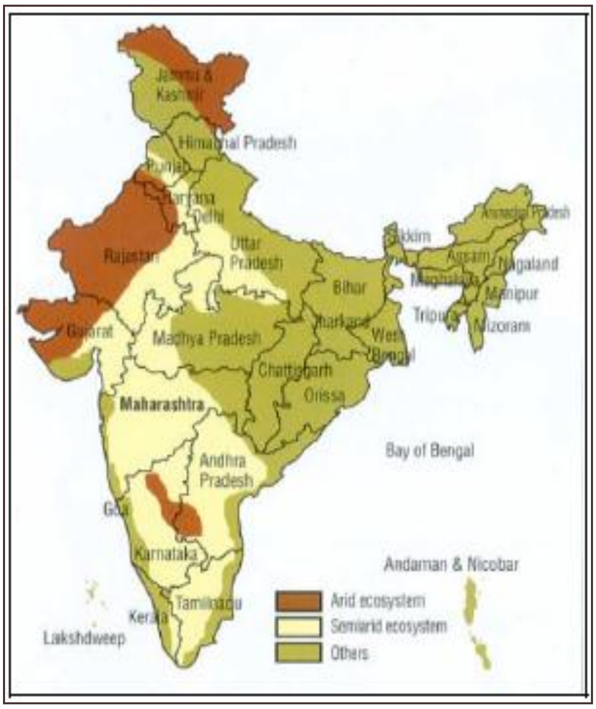


Figure 3: Semi-arid Region in India (Indiaclimateaction)

CHAPTER 2:

FRAMEWORK FOR REVIEWING AGRICULTURE PRACTICES IN SEMI-ARID RAIN-FED AGRICULTURE SYSTEMS

THE COMPONENTS OF SUSTAINABLE AGRICULTURE SYSTEMS

The agriculture systems, as indicated in chapter 1 show significant linkages with the environmental systems, social and economic conditions of the people, especially the ones engaged in agriculture for livelihood. Sustainable agriculture, by its definition takes all these components into account. Sustainable agriculture is defined as a set of practices that meets current and long-term needs for food, fibre, and other related needs of society while maximising net benefits through conservation of resources to maintain other ecosystem services and functions, and long-term human development. It emphasises multidimensional (economic, environmental and social) goals of sustainable agricultural development. (FAO, 1995)

Models for sustainable agriculture must encompass strategies that can produce food for all, now and in the future, in the phenomenon of shrinking land base, dwindling water resources, adverse impact of climate change and meagre income of the farmer. Resilient agriculture systems are the need of the situation and this would mean that sustainable agriculture must (FAO, 1995):

- Ensure basic nutritional requirements of present and future generation, qualitatively and quantitatively, are met while providing a number of other agricultural products.
- Provide durable employment, sufficient income and decent living and working conditions for all those engaged in agricultural production.
- Maintain and, where possible, enhance the productive capacity of the natural resource base as a whole, and the regenerative capacity of renewable resources, without disrupting the functioning of basic ecological cycles and natural balances, without destroying socio-cultural attributes of rural communities, or without causing contamination of environment.
- Reduce vulnerabilities of agricultural sector to adverse impacts of climate change and other natural and socio-economic risk factors.

MEASURING SUSTAINABILITY IN AGRICULTURE SYSTEMS

There are various frameworks developed for measuring the above social, economic and environment components in sustainable agriculture. For the purpose of this paper, frameworks were chosen from the pool of literature with an objective to study agriculture system at the micro level- at the farmers' end to look actions and its impact on social, environment and economic components. The other objective is to connect systems at the ground vertically with policy and market environment at the macro level. There are two broad frameworks that will be detailed in this section: Agriculture Sustainability Framework and Food and Agriculture Organisation's (FAO) Conceptual Framework for Sustainable Crop Production.

AGRICULTURE SUSTAINABILITY FRAMEWORK

This framework has been developed by Rao and Rogers (2006) in order to integrate social, environmental and economic indicators into one framework. This framework integrates elements from 3 frameworks: Sustainable Rural Livelihood for social assessment (Woodhouse, 2000), Drivers-Pressures-State-Impact-Response Framework for environmental assessment (FAO, 1995) and agro-ecosystem framework for agriculture production assessment (Conway, 1997). (Rao & Rogers, 2006) In the agriculture sustainability framework, the driving force indicators (see figure 4) define the context of agricultural production systems. They are grouped under the component agro-ecosystems. The variables that characterise each indicator are also identified in the figure. The social and economic variables and indicators listed in Figure are scalable and can be aggregated from farm and village levels to district, agro-ecological zone or national levels.

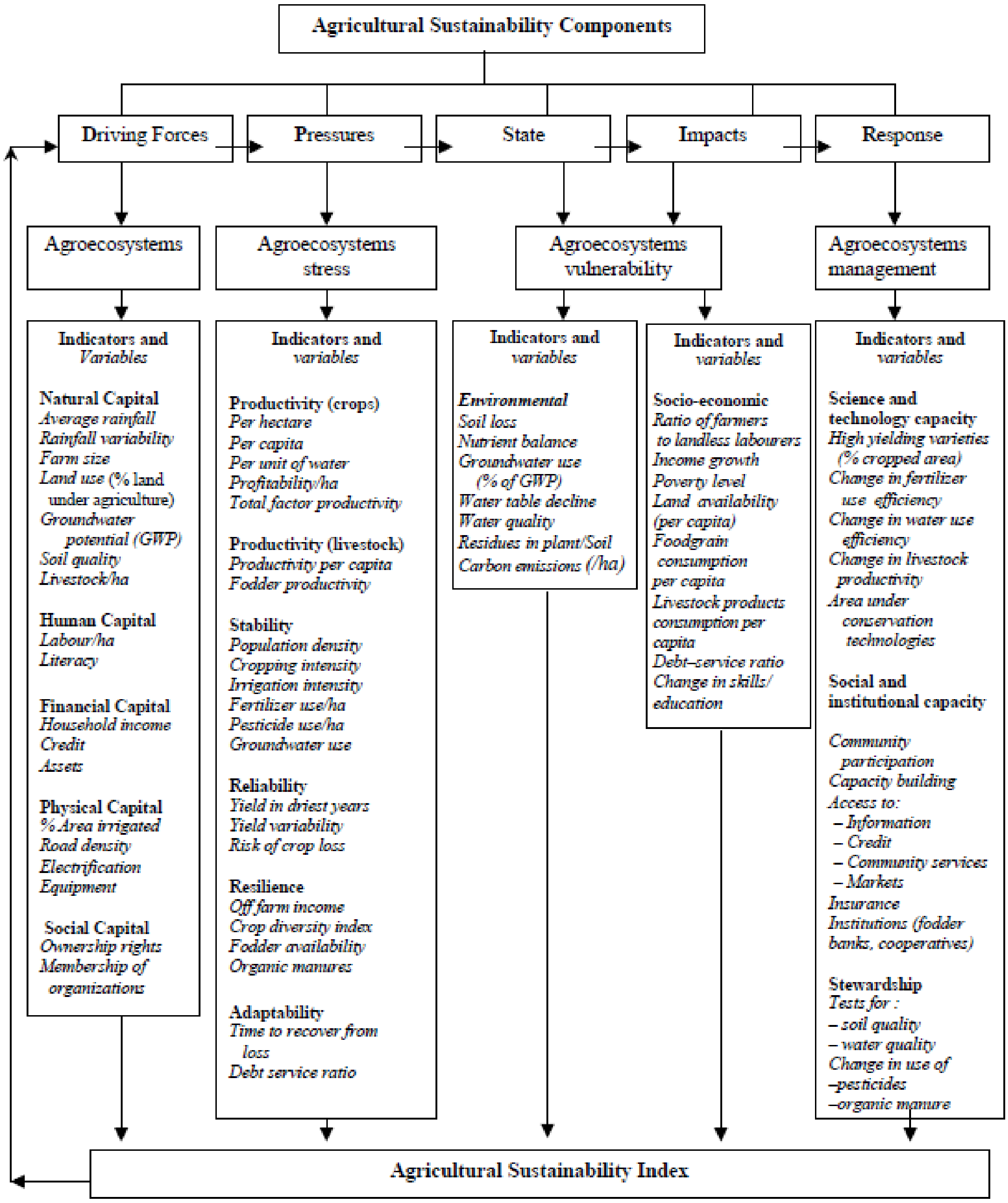


Figure 4: Agriculture Sustainability Framework (Rao & Rogers 2006)

FAO'S CONCEPTUAL FRAMEWORK FOR SUSTAINABLE CROP PRODUCTION

FAO in 2010 developed a conceptual framework for an ecosystem approach to sustainable crop production intensification (FAO, 2010). The main objectives of developing a Conceptual Framework for sustainable crop production intensification are to: *Increase understanding of the importance of biodiversity and ecosystems, and their sustainable management; identify options available for sustainably increased crop production; and provide guidance for decision makers at different levels* (from land users to policy makers). The Conceptual Framework is intended to be flexible, to adapt to evolving situations, new scientific evidence and to incorporate valuable experiences from traditional knowledge. The circles suggest cross-cutting topics: the inner circle comprises farm-level factors; the mid-circle comprises the regional level (ecosystem boundaries or watershed-level factors); and the outer circle refers to national policy dimensions.

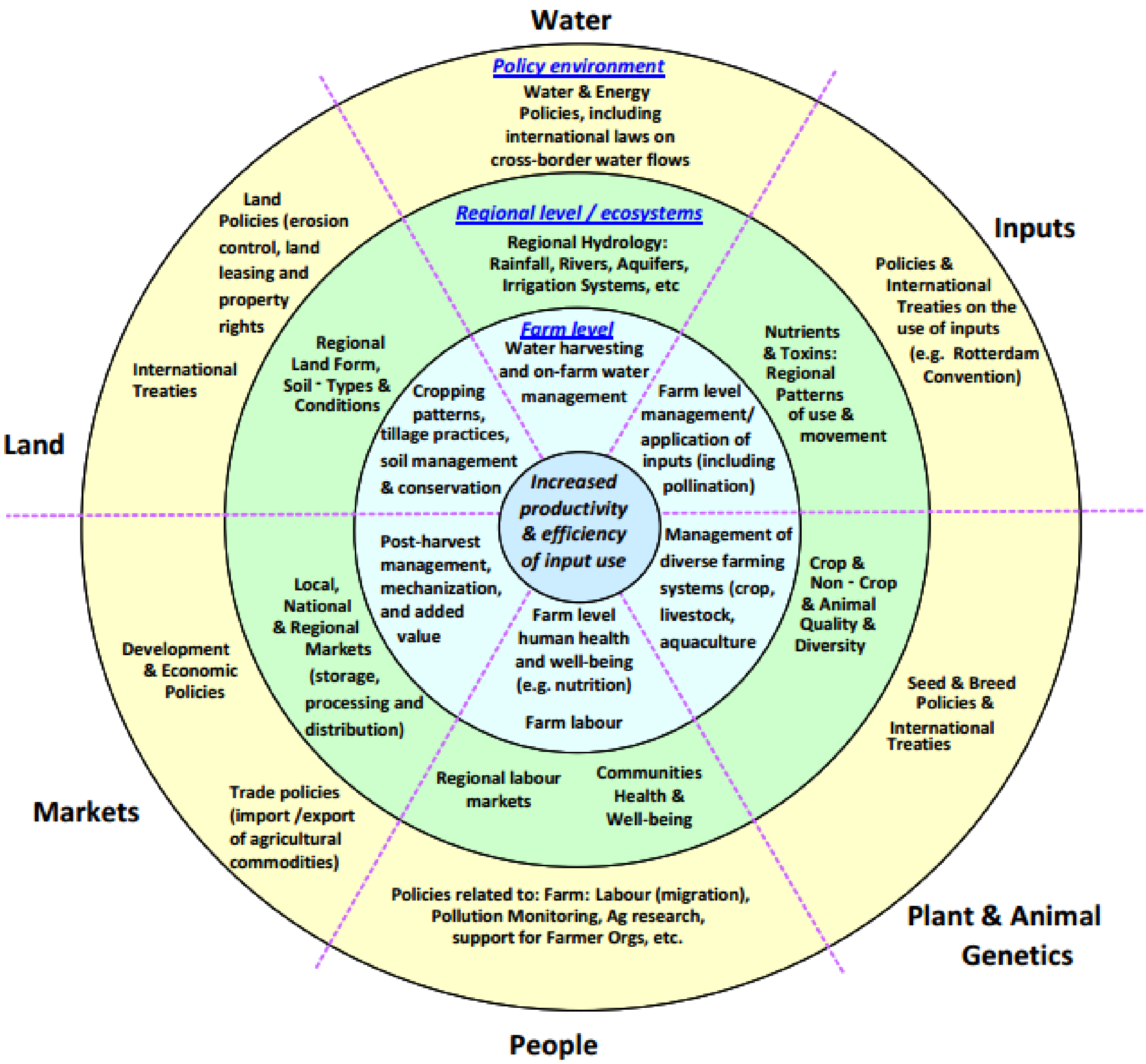


Figure 5: Sustainable Crop Production intensification overview (FAO, 2010)

THE APPROACH OF THIS STUDY

This study aims to review the ground interventions in agriculture systems and their potential impact on agriculture systems. For this purpose, this section develops a frame that includes indicators of sustainable agriculture systems at the farm/village level, informed by the study of the two frameworks mentioned above. *The Agriculture Sustainability Framework studies the environmental, social and economic components of the agriculture systems and is used in assessing the ground actions in agriculture. The FAO Conceptual framework for sustainable crop production is utilised to assess the vertical linkages of the farm system with markets and institutions and hence indicates merging of action at the farm to policy and other actions*. For this study, the indicators are categorised under three broad components of sustainable agriculture systems: Food production, livelihood security and environmental sustainability. This frame will assess the interventions through following indicators:

a. Food Production Security

Agriculture systems are responsible for ensuring adequate food production for the country's food requirements. The Agriculture Sustainability framework (Rao & Rogers, 2006) discussed above details the pressures on agriculture systems by measuring the agro-ecosystem stress points. The pressure indicators define stress on the system as characterised by trends in major multidimensional attributes of agricultural sustainability (productivity, stability, reliability, resilience and adaptability). In the light of the same, the features that highlight food production security are:

- ***Productivity:*** Productivity, as the capacity of the system to produce specific outputs is looked with overall production systems and total output from farm which includes food, fuel, fodder, manure and bio-inputs. Any positive change in productivity per unit resource shall be recorded as positive.
- ***Resilience:*** Resilience is the capability of the system to return to stable equilibrium after facing shocks or disturbances (e.g. drought, flood, markets), to reduce risk and vulnerability of the system. Any intervention that builds shock bearing mechanism in an agriculture system thus ensuring stable food production during disturbances will be taken as positive development under this component.
- ***Adaptability:*** Adaptability refers to the ability of the system to adapt its functioning to an entirely new set of conditions (e.g. climate change, World Trade Organisation (WTO) regime). The interventions that allow the farmers and agriculture systems to adapt to the changing climate will be studied under this component.

This study does not take stability and reliability under the food production security indicators. The stability indicator measures the impact of agriculture practices on natural resource management and will therefore be covered under the component of environmental sustainability.

b. Sustainable Livelihoods

In the Sustainable Rural Livelihood Framework (Rao & Rogers, 2006), the sustainable livelihood strategies of individuals and households depend on access, use and development of five different types of assets – natural capital (land, water, biodiversity), physical capital (infrastructure, machinery), human capital (labour, skills), financial capital (savings, disposable assets), and social capital (rights, support systems). The components that define sustainable livelihoods are:

- ***Natural Capital*:** Any positive changes in land size, land use, fodder availability, water availability, ground water shall be considered as positively affecting livelihoods.
- ***Human Capital*:** Increase in the knowledge and capacities to perform agriculture with higher benefits shall be accounted under this component as positive impact on livelihoods.

- ***Financial Capital:*** Access to finance for investment, increase in farm incomes shall be accounted here as positive impacts on livelihoods.
- ***Physical Capital:*** Availability and access to infrastructure, electricity, and agriculture equipment shall be accounted as positive under this parameter.
- ***Social Capital:*** Membership to community organisations, institution building shall be taken as positive indicators under this component.

c. Environmental Sustainability

Stability, one of the five components of agro-ecosystem stress in the Agriculture Sustainability framework, is the ability of the system to reproduce processes needed to attain specified outputs (e.g. input use efficiency). Stability in this sense is derived from ecology and refers to preservation of the natural resources base. The state indicators determine the vulnerability of the agro-ecosystems and are characterised by environmental impacts indicators. The crop-ecosystem balance shall be assessed under this section. This includes any practice or input that impacts the health of environment- soil, air and water will be included:

- *Water resource:* The study will assess change in the use of water per unit hectare. It will also account the change in the source of water amongst irrigation, ground water and rain-fed. This component will also take into account the water levels of ground water during extreme dry seasons.
- *Soil:* Change in the use of fertilisers per hectare, pesticides per hectare shall be taken into account under this component. Any changes in the soil moisture witnessed as a result of a change in practice or intervention will also be taken in to account.
- *Air:* Any changes in the amount of fossil fuel used for farm machines and the quantity of fertiliser used (since it uses fossil fuel for its production) shall be documented to study the impact on air from agriculture systems. The carbon emissions due to animal husbandry are beyond the scope of the study.

Interventions: The response indicators, in the agriculture sustainability framework define policy instruments, management and institutional strategies adopted for ensuring sustainability of agro-ecosystems in the long run. This framework will assess technological and institutional interventions on the indicators mapped for measuring food production security, sustainable livelihoods and environmental sustainability. These technological and institutional interventions will be assessed at different stages of agriculture value chain.

Figure 6: Sustainable Agriculture Framework (Source: Author)

Components→ Interventions ↓	Food Production Security	Sustainable Livelihoods	Environmental Sustainability
Science and Technology Capacity Social and Institutional Capacity	**Productivity** (per hectare, per capita, per unit water, TFP) **Resilience** (Crop diversity, use of organic manure, yield variability in drought and extreme conditions) **Adaptability** (Time to recover loss, debt-service ratio)	**Resources at disposal** *Natural Capital* (land use, fodder availability, water availability, ground water) *Human Capital* (knowledge, capacities) *Financial Capital* (Farm income, access to finance) *Physical Capital* (electrification, equipments) *Social Capital* (membership to community organisation)	**Stability/Regeneration ability** *Water Resource* (Water per unit hec, source of water, ground water levels) *Soil* (fertiliser use/hec, pesticide use/hec, soil loss, soil moisture) *Air* (carbon emissions, fossil fuel used – fertilisers and farm machines)

CHAPTER 3:

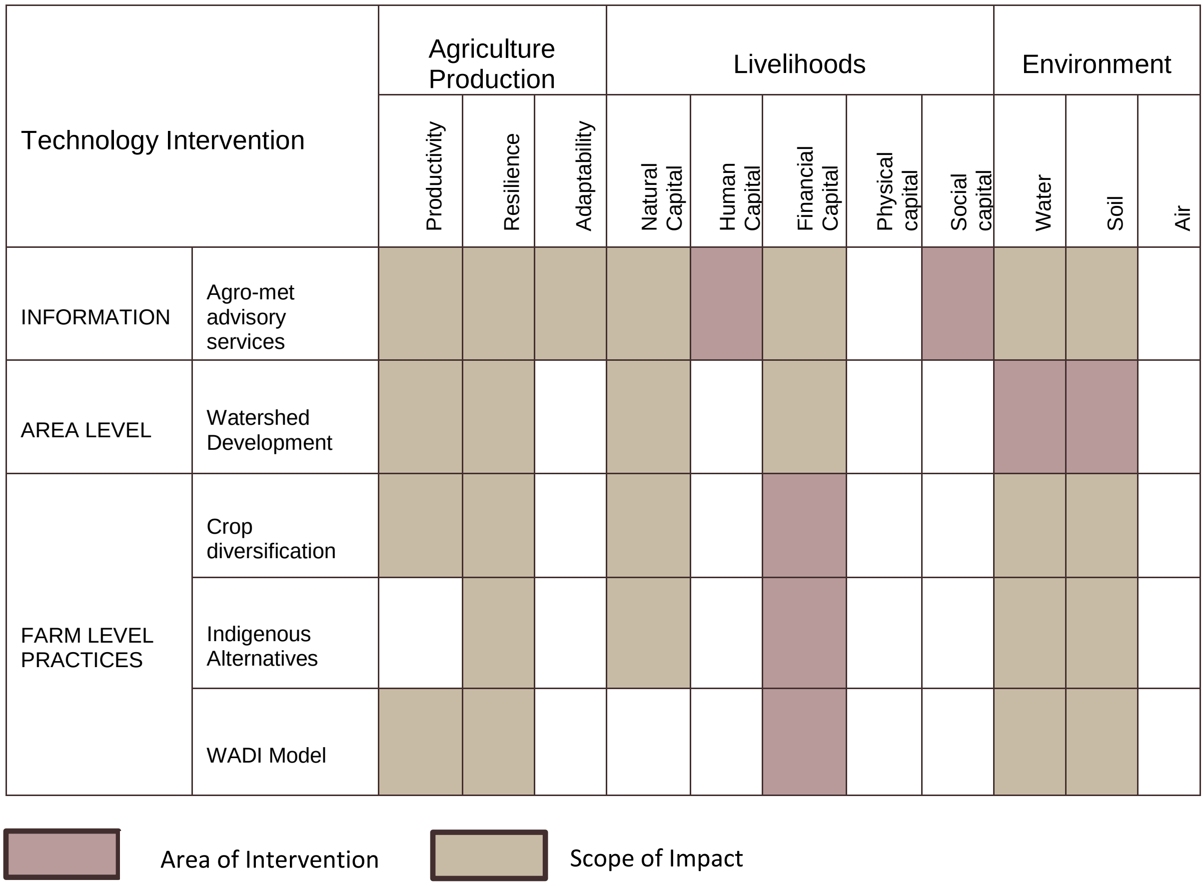
ASSESSING ROLE OF SCIENCE AND TECHNOLOGICAL INTERVENTIONS ON AGRICULTURE SYSTEMS

Science and technology interventions broadly include various technology packages for farm inputs, farm implements, farming techniques, risk reduction systems and Information and Communication Technology (ICT) systems. This section will analyse various technology pilots across the semi-arid rain-fed regions of the country to study their impact on agriculture productivities, farmers' livelihoods and health of the environment. Broadly, the technologies studied here are in three categories:

1. Technologies for information access on weather and decision making support to the farmer
2. Technologies for area level systemic intervention
3. Technologies for farm level agriculture practices

The three sections of this chapter study the contemporary concerns and opportunities in the above three technology categories. It provides a case study under each of these categories and assess the same on the sustainable agriculture framework developed and used in this paper.

Figure 7: Summary analysis of technology interventions on sustainable agriculture framework



I. TECHNOLOGIES FOR INFORMATION ACCESS ON WEATHER AND DECISION MAKING SUPPORT TO FARMER

Background

Farmers face new challenges due to lack of information on how to deal with the issues of climatic variability, new technology etc. For example, a farmer is producing wheat on his field for generations, now faces new changes of weather, temperature, soil moisture, soil quality, and biological factors. This has resulted in emergence of new types of weeds, pests, and diseases that can significantly affect the health, and thus yield and profitability, of the crop. It is difficult for a farmer to find information on these new challenges from conventional sources of information, to maintain or improve the yield (Mittal & M, 2013).

Farmers need to adapt to these challenges with information about the advanced techniques and methods that are relevant to their local environment. Information empowers farmers to respond to different types of risk, market incentives and competition more efficiently (Mittal & M, 2013). Information about technology may include harvesting time, optimal planting, right method of diseases control, storage and processing methods, soil control methods, storage and processing methods and many more (Mathur & Goyal, 2014). Further, information about possible precautions and actions can ensure *resilience* and *adaptability* of food production. Resilient agriculture systems will further ensure stability in the farmers' income due to timely and relevant information available for making agriculture choices accordingly. *For information to be useful to the farmers and utilised for decision making in agriculture, it is necessary for information to be:*

a. ***Timely:*** Information must reach farmer on time for him to take adequate action in accordance to the information. A study on information needs of farmers in Maharashtra, India tells that 40.58 per cent of the farmers surveyed need daily information, while 47.43 per cent of the farmers surveyed feel the need for information sometimes (Bachhav, 2012). Timely information about rainfall predictions, drought and other extreme weather conditions if provided to farmers well before time, supports their choice of crop, choice of seed, practice, etc. thus enabling more resilient agriculture systems.
b. ***Comprehensive:*** Information provided to the farmer must be in a manner that is easily understood by the farmer, in order to use it as knowledge in decision making. Modern information technology is extensively used in India to promote communication between researchers, extension workers, and their farmer clients to transfer technologies and information more effectively. Since most of the initiatives are using computer based web portals for delivery of information or through local internet kiosks, these initiatives have not been very successful, as farmers were either illiterate or not culturally attuned to access information through the Internet. Information needs to be easily understandable to the farmers and channeled via the right medium to reach the farmer. (Ganesan, Karthikeyan, Prashant, & Umadikar, 2013)
c. ***Reliable:*** Information provided must be authentic and precise. Meteorological expertise and computing power to make forecasts are required, as also expertise in agriculture. Information generated must be meaningful to farmer and results-oriented agricultural knowledge management and extension system (that includes on and off-site advisory generation).(WOTR, 2012)
d. ***Relevant:*** Provision of information which is locally relevant is crucial for raising awareness, eliciting and incentivising effective adaptation responses. Since adaptation is local it needs local level climate information, current and future, to enable effective decision-making at the individual and community level. Local adaptive capacities are enhanced when local weather information is analysed and appropriately communicated. (WOTR, 2012)

Current scenario of information access to farmers in India

Indian Government has launched various missions and schemes for enhancing the information access to farmers on relevant agriculture data. The Support to State Extension Programmes for Extension Reforms Scheme was launched in 2005-06, aiming at making the extension system farmer driven as well as accountable to farmers by providing for new institutional arrangements for technology dissemination. This has been done through setting up of Agricultural Technology Management Agencies (ATMA) at district level to operationalise the extension reforms. Certain other schemes which support agriculture sector are mass media support to agriculture focusing on Doordarshan infrastructure and All India Radio (AIR) broadcasting agriculture related information; kisan call centres to provide agricultural information to the farming community through toll free telephone lines, and information dissemination through agri fairs (Government of India, 2011). To ensure last-mile connectivity, the extension and IT schemes were strengthened, expanded, and scaled up appropriately and implemented as components of the Sub Mission on Agricultural Extension (SMAE) under the National Mission on Agricultural Extension and Technology (NMAET) in the 12th Five year plan. (GoI, 2014)

However, according to the 2003 survey (NSSO, 2005) access to information from any source increases with farm size and only 5.7% of surveyed respondents used public sector extension as source of information. Further, Marcel and Bart (2012) reported that the main source of information for agricultural prices, weather forecast and advice on agricultural practice is the farmer's own observation and experimentation followed by a conversation with other farmers. Radio and television are also common sources of information particularly for weather aspects.(Ganesan, Karthikeyan, Prashant, & Umadikar, 2013). Apart from Government extension systems, newspaper, radio and television, there are initiatives by businesses and civil society organisations for developing sustainable information delivery models for easy, timely, reliable and relevant information to farmers. ITC's initiative of e-Choupal is one such example. Lead farmers are chosen who receive extensive training on the e-Choupal system are provided Internet-connected computers at their homes by ITC. These lead farmers, in turn, help the neighboring farmers to access information through the specially designed web portals in their local languages. Such information includes local & global market prices, crop management know-how customised to the local agro-climatic conditions, timely and relevant weather forecasts, transparent discovery of prices for their produce, and much more. Farmers gather at these kiosks (Choupal means "meeting place" in Hindi) regularly for the latest information. It thus provides real-time information and customised knowledge to the farmers and supports them in agriculture decision making. (Shivakumar, 2013) Investing in some farmers, enabling them to use computer and access information is one of the many ways to allow easy access to information to farmers. A case study on the Agro-Meteorological Advisory Services promoted and supported by WOTR in Maharashtra (refer box) throws light on the ways of information access and the drivers of sustainability of the long run of such a mechanism of information access to farmers.

AGRO-METEOROLOGICAL ADVISORY SERVICES

Organisation: Watershed Organisation Trust
Location: Maharashtra

Dissemination of weather data, forecast through wall papers

Need

- ***Climate change vulnerabilities***: Changes in weather and rainfall patterns affect the crop production, water availability thus affecting agriculture production.
- ***Information deficit and knowledge gap***: Farmer's indigenous knowledge do not have response-solutions due to unpredictable weather patterns.

Objective

To provide access to information about weather and sustainable agriculture solutions for enabling informed decision making

Response

A local and crop specific weather based agro-advisories have been set up to help farmers adapt and respond to observed climate variations. Automated weather stations have been installed in the villages that transmit local weather data on hourly basis. The data is analysed by meteorological experts of Indian Meteorological Department to generate locally customized weather forecast against which crop advisories are designed and disseminated to farmers through SMS, wall papers and public announcements.

Drivers of Sustainability

- Community contributions into a common development fund was invested in establishing such services. This approach builds capacity of institutions for enabling their independent management.
- Farmers pay a subscription of 100 rupees to get crop advisories for a single crop in a season. This helps in financial sustainability of a service based model like this.

Since climate adaptation is local it needs local level climate information to enable effective decision-making at the individual and community level. Local adaptive capacities are enhanced when local weather information is analyzed and appropriately communicated. Field and extension oriented agro-meteorology requires the coming together of high-end technology and local knowledge, which requires multi-stakeholder partnerships at all the levels.

Photo Credit: WOTR, Maharashtra

Assessment on the Frame of Analysis

The Agro- Meteorological Advisory Services that provides access to timely, comprehensive and reliable information to the farmers, when assessed on the framework developed in this paper, shows an investment in the social and human capital of a community. A community run advisory unit enables technology use by community for access to meteorological information and the related action required for saving the crop during extreme weather to increasing productivities through right use of inputs and practices. This case study shows that technology intervention for information access, like conducted by WOTR invests on the social and human capital of the community.

1. Impact on food production security

The second section of the assessment looks at the scope of impact of investing on social and human capital by technology intervention for information access. The scope of impact is visibly seen in the building resilience and adaptability for food production security. The timely useful information about weather forecast and assistance on preventing potential damage to crops strengthens adaptability of farmers to react to changes in weather due to climate change and other factors. Information on drought and other extreme weather conditions and possible ways to use the available resources to best address the extreme conditions increases resilience capacity of the community. Impact on productivity may not be directly visible but information provided on agriculture inputs and practices by the agro-met services have helped in increasing the productivity of crops over time, according to some of the farmers using this service in Maharashtra. So it can have a potential impact on productivity, which depends on the nature of information shared and the ways of using it.

2. Impact on farmers' livelihoods

The impact of technology intervention for information access on components of livelihoods can have potential increase in natural and financial capital availability. The information about climate and weather aberrations and dissemination of knowledge for judicious use of natural resources can ensure better ground water levels and soil quality. Methods and ways to prevent damage to crops from weather changes and judicious use of natural resources can ensure stable and higher incomes relative to a scenario whether weather aberrations harming the food production of the region. Impact on physical capital is not immediately visible in the present case study except for the development of a centre with scientific tools that can be used to forecast weather and related information. Agro met advisory services intervention area also opens space for financial capital where the credit packages from Banks, self-help groups becomes highly important. For small holding farmers many of them start sowing late as it takes more time for them to arrange finance for agriculture inputs and farm investments which are crucial at different phases of agriculture interventions. Various studies suggest that agro met services have helped farmers and local financial institutions to access and provide financial services at right time.

3. Impact on environment

The technology intervention for information access also impacts the environmental components, specially water and soil as the information on climate change adaptation and resilience building revolves around natural resource management strategies as natural resources are most directly affected by adversaries of climate change.

II. TECHNOLOGIES FOR AREA LEVEL SYSTEMIC INTERVENTION

Background

Widespread and continuing degradation of India's natural resource base is now reflected in increasing difficulties in achieving growth rates in agriculture. Over 120 million ha have been declared degraded soils. In addition, the water resources primarily groundwater are declining at a greater pace threatening the sustainability of Indian agriculture (12th Plan Working Group, 2011). The land degradation in rain-fed areas has resulted from climatic variations and unplanned over-exploitation of natural resources by human activities, and increasing pressure of human and livestock population. At present nearly 70% of rain-fed area is affected by wind erosion and sand deposition.(Gautam & Rao, 2007)

Watershed management is one of the popular and successfully tested ways of natural resource management in the country which addresses concerns of land degradation and water depletion. It involves protection of land from all forms of degradation, restoration of degraded land, sediment control, pollutants control, prevention of floods, etc. (Singh, Behera, & Singh, 2010).

A meta-analysis conducted by International Research Institute for the Semi-Arid Tropics (ICRISAT), Indian Council of Agricultural Research (ICAR) and partners of 636 case studies on watershed projects revealed that 32% of watersheds are performing above average of the sample. Watersheds recorded an average benefit to cost (B:C) ratio of 2 (ICRISAT, 2009). These results reconfirm that watershed projects are able to meet their initial costs and generate substantial economic benefits. (Joshi , Jha, Wani, Sreedevi, & Shaheen, 2008)

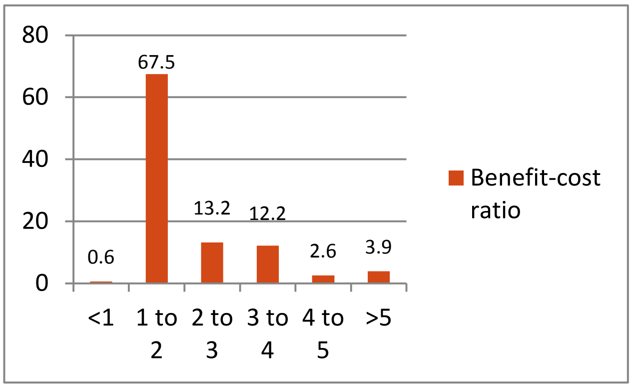


Figure 8: Distribution (%) of watershed according to benefit-cost ratio (BCR) (ICRISAT,2009)

Assessment studies ((Suryawanshi & Kamble, 2012)(Gautam & Rao, 2007)(Singh, Behera, & Singh, 2010)(ICRISAT, 2009)) on watershed programmes have indicated concerns over certain concept, science and process of the natural resource management programmes. Certain key findings that emerge are:

- Watershed and other natural resource management programmes can only be successful and sustained in a long run with participation and ownership of the local community from ideation to development to implementation and monitoring of the programme.
- Natural resource management programme should incorporate the social aspects apart from the physical and biological achievement of such a programme.
- Natural resource management is beyond the capacity of an individual farmer or even a community without adequate financial, technical and capacity support. Institutions at all levels need to be strengthened in order to successfully implement and manage natural resource management programs.
- Integrated watershed management demands a multi-disciplinary approach. It is essential to synergise local knowledge and modern science for devising the most suitable programme for natural resource management in any area.

INTEGRATED WATERSHED MANAGEMENT

Organisations: Development Alternatives in Bundelkhand, Pravah in Jharkhand, Watershed Organisation Trust in Maharashtra

Loose bolder structure for minimizing water and soil run off

Need

Across the country, ground water levels have been falling at an unprecedented rate. This may be largely blamed on the over-extraction of ground water coupled with a reduction in recharge potential due to deforestation. Crop yields and farmers' incomes have been adversely affected resulting in further stress on farmers. With climate change, rainfall patterns are expected to get more erratic thus further aggravating the water stress.

Objective

To provide a sustainable solution for restoring ecological balance and productive potential of the land through conservation of soil, water and regeneration of the vegetative cover.

Response

Watershed activities were conducted using an integrated ridge to valley approach of soil and water conservation measures through farm bunding and development of conservation structures such as gabions, west weirs and check dams. WOTR also promoted afforestation activities with indigenous trees on wastelands. DA used GIS based village level planning systems that enabled the hydrologists to ensure water management and soil conservation in the watershed.

Drivers of Sustainability

- ***Community Partnership for Investments:*** The sharing of costs especially labour costs by community in cases of all three organisations has allowed greater ownership and commitment for protecting the infrastructure.
- ***Convergence with Government schemes and policies:*** Using the funds from MGNREGS, assets that were considered useful by the community were developed.

Rain-fed areas benefit greatly from watershed development in terms of enhanced water security, reduced soil erosion, reduced climate vulnerability and improved agricultural productivity. A participatory model for Watershed development, integrated with other government schemes allows maintenance and ownership of community in watershed programmes.

Photo Credit: Development Alternatives

Assessment on the Frame of Analysis

The watershed management programme conducted by organisations studied has diversified impact on the frame of analysis developed. Following are the impacts assessed:

1. ***Impact on food production security***
   Watershed programme enables better use and management of the available natural resources. By its interventions in efficient use of natural resources, it has impacted the agricultural productivity in the region where it has been implemented. Estimations of Pravah's watershed activities tells that the total yield of wheat from 50 acres of land in village Dhanwe increased from 40 to 1200 quintal per crop cycle due to watershed related activities. Watershed management programme also builds the resilience component of the food production, as management of natural resources through watershed, increases the capacity of the system to withstand extreme conditions like drought. Experiences of watershed programmes by the DA, Pravah and WOTR shows increased resistance of agriculture food production to rainless periods.

2. ***Impact on Farmers' Livelihoods***
   Activities of watershed management programme increases the cumulative natural capital available to farmers, specially the quantity of water and soil moisture.
   The Integrated Watershed Management experience of DA proves that it is possible to make agriculture on small farms a profitable so that such farmers can break free from the vicious cycle of poor production, poverty and debt. The average investment required for integrated watershed management is in the range of INR 10,000 per hectare which includes cost of infrastructure, capacity building and establishing institutional systems and linking farmers and watershed committees to government departments and public programmes. Within two years of the intervention, a farmer registers an annual productivity increase of 20-25% resulting from both enhanced productivity per acre and an increase in cropping intensity.
   As observed in the semi-arid Bundelkhand context, farmer with 1 hectare of land and cultivating only 60% of it can improve the cropping intensity from 120% to 182% and in addition bring 10% of the previously uncropped land under cultivation. This translates into an improvement in the annual income to the tune of about INR 30,000 making the initial investment completely recoverable.

3. ***Impact on Environment***
   And this does not even begin to take into account the range of invaluable ecosystem services such as soil nutrient recycling, erosion control, ground water level rise, flood management, biomass and biodiversity enhancement that are gradually restored. Technologies for area level systemic interventions mostly have focus on conservation works along the water channels which can improve the soil and water health. With watershed approach ground study also shows a positive mindset change among the communities as well. The earlier feeling of absolute dependency on rainfall has gradually developed a positive trend of conserving water for life saving irrigation to save the crops.

III. TECHNOLOGIES FOR FARM LEVEL AGRICULTURE PRACTICES

Background

Most good agricultural land has already been farmed and the region has exceeded the safe limit, the natural resources availability for further farming expansion is practically exhausted. Data shows agricultural land being increased by 13 per cent in the last 30 years at the expense of lowland forests and their rich biodiversity. Furthermore, the pressure from worldwide urbanisation, manufacturing and population growth necessitates a renewed commitment to clean energy and environment solutions. The need is a balanced mix of alternative energies and the development of new technologies. There is no controversy in developing agriculture to obtain higher yield and increased income of the farmer without affecting the environment. *The technology is a link that connects sustainability with enhanced productivity, where natural resource productivity is efficiently maintained by carefully planning the conservation and exploitation of resources such as soil, water, plants and animals.* The ideal technology should be efficient, practical, cost effective and free from pollution. The sustainability factor should be looked at as the ability of agricultural land to maintain acceptable levels of production over a long period of time, without degrading the environment. (UN-APCAEM, 2008) A technology at the farm level should serve various purposes:

- ***It must ensure optimum food production:*** With growing population, estimates of food shortage in the long run and shrinking natural resource base, technologies that increase food production will safeguard India's food security.
- ***It must be environment-friendly:*** Technologies that are used by the farmers must take care of the health of the soil and use the land, water and other resources efficiently for the high productivity from the constrained resource base available.
- ***It must make a good investment case for farmers:*** Technologies that increase food production and are environmental friendly in nature should at the same time be cost effective in order to ensure higher profits to farmers than the status. As the choice and decision of technique or technology is that of the farmer and more than 50 per cent of all the Indian farmers are small and marginal, it is important that technologies in the market are profitable at the scale at which a small/marginal farmer is practicing agriculture.
- ***Climate resilient technologies:*** Technologies should enable farmers to fight with adversities caused by changing climate. Technologies in agriculture should enable farmers to cope up with changing weather patterns, resource availability, extreme weather conditions and ensure stability in farmers' income and food production.

Technologies at the farm level are inputs, techniques and equipment that change the agriculture practice of a farmer or a community. There are various technologies which support in achieving the above mentioned purposes. Some of them are change of inputs from short duration crops to long duration crops at the drought prone region, crop diversification, systems of crop intensification, deep ploughing, ridge and furrow farming, line sowing and multi crop seed drill for multi cropping.

There is no one-size-fits-all or silver bullet technology approach that will work in all of the diverse circumstances and farming systems in India. If technologies are to be taken up by farmers and have a substantial impact on reducing poverty, the technologies must be profitable in a relatively short time, must not substantially increase risk and, ideally, should help reduce risks, and must be consistent with the endowments of farmers in knowledge, management skills, land, labour and other assets.(Pender, 2008)

Farmers' decision for technology adoption is influenced by (DFID, 2004):

- ***Economic profits from adoption of new technology:*** Farmers' will be incentivised to choose technologies that are economically profitable for them. This means any technology that reduces the cost of agriculture or increases productivity via efficiencies and thus increases income of the farmer will drive the decision of the farmers.
- ***Secure output markets:*** A readily available reliable output market for selling the produce from agriculture allows farmer to innovate and efficiently produce. A city demanding cash crops like vegetables and spices will incentivise the farmer to invest his energies in producing the desired output. Similarly, access to a ready organic market allows farmers to switch to organic farming and get higher prices for their produce from consumers who value organic produce.
- ***Effective input supply system:*** For any technology to be adopted by farmers at scale, there is clear need for regular access to inputs required for the same. Without the supply of organic alternatives in the market or easily availability locally, it may not be possible for farmers to shift to sustainable technologies.

Figure 9: Assessment of farmers' profits while using indigenous inputs

According to Babu Miyan and Venkatesh Ji, two farmers from Adavi Masjid with whom Centre for Sustainable Agriculture has been working, they used to use 2 bags of Diammonium Phosphate (DAP), 2 bags of Urea, 2 bags of Potash and 2 bags of *Thimet* (pesticide) per acre of land under rice production. The approximate cost of one bag of DAP, Urea, Potash and *Thimet* is INR 250, INR 330, INR 250, INR 250 respectively. This means an approximate cost of INR 3160 per acre per rice season. At the same time, in an organic based agriculture, it required 1 truck of cow-dung for 3 acres of land for one year. The cost of one truck of cow dung is around INR 7000. So the cost of cow dung for one season (6 months) for rice for one acre is INR 1150. Therefore it took 2 acres of land to produce 30 quintals of rice with fertilisers while it took 3 acres of land to produce 30 quintals of rice with organic inputs only.

ESTIMATES OF INCREASE IN PROFITS OF FARMERS AT ADAVI MASJID FOR ONE CYCLE OF PADDY PRODUCTION

	Farming practiced before Intervention *(with fertilisers and pesticides)*	**Farming practiced after intervention *(with manures and bio-agents)***
Costs of Production of 1 Quintal Rice		
Area for 30 quintal prod	2 acres	3 acres
Cost of inputs* in 1 acres	INR 3160	INR 1150
Cost of inputs* for 30 quintals	INR 6320	INR 3450
Cost of inputs* for 1 Quintal	INR 211	INR 115
Price of Selling 1 Quintal Rice to Sahaja Aharam		
Price per quintal	(@ market price)	(10 % higher of market price)
@market price INR 40/kg	INR 4000	INR 4400
@market price INR 50/kg	INR 5000	INR 5500
@market price INR 60/kg	INR 6000	INR 6600

*Inputs include fertilisers and pesticides and organic manure. It does not include cost of seeds and labour. According to the farmers at Adavi Masjid village, while the cost of labour in both the circumstances has remained constant, costs for buying seeds have reduced as farmers are developing nurseries to revive indigenous varieties of rice and other vegetables. Other input costs of electricity, water etc. have also been assumed to be constant.

ON FARM SUSTAINABLE AGRICULTURE TECHNIQUES

Babu Miyan preparing natural pesticide with cow dung, urine and ghee.

Organisations: Development Alternatives in Bundelkhand, Pravah in Jharkhand, Centre for Sustainable Agriculture in Telangana

Need

Changing weather patterns, frequent occurrence of drought and limited information increases the risks involved in farming specially in the country's semi-arid rain-fed areas. This has aggravated crop failures, thus inducing high risks in practising agriculture. Income of small, marginal farmers from agriculture are less than 18 percent than that of large farmers and only covers around 87 percent of their total monthly expenditure. (refer table x)

Objective

To diversify risks in agriculture, increase farmers' income while maintaining healthy soil and water conditions of the area.

Response

- ***Diversified Food Basket:*** A traditional Duck-Fish-Vegetable Model was promoted by Pravah, Jharkhand for breeding duck and fish in the irrigated rice fields as additional income streams. Additionally, vegetable pockets were promoted that included production of crops like sweet potato, brinjal, etc. for diversifying risks and increasing income through cash crops.
- ***Internalise Inputs in agriculture:*** Dissemination of knowledge and products which were *i*ndigenous alternatives to fertilisers and pesticides were conducted by setting up Natural Pest Management Shops, Capacity trainings, etc by CSA in Telangana.
- ***Increase input output efficiencies:*** WADI Model, a scheme of NABARD is promoted by DA in Bundelkhand. Fruit or other utility trees like guava, anwla etc are planted with the agricultural crops for higher outps and increased income for farmers.
- ***Climate Resilient Technqiues:*** Drought resistant and short duration varieties of soyabean, wheat, mustard and groundnut were promoted by DA in Bundelkhand.

Drivers of Sustainability

- Assessing local needs and traditional techniques enables sustainability
- Farmer groups for knowledge, training for use of technology enables higher adoption
- Developing market access to cheaper and environmental friendly technologies enable their adoption.

Environment friendly technologies have high adoption rate if it makes a good investment case for the farmer. Traditional agriculture practices and techniques of the locals are key to sustainability.

Photo Credit: Development Alternatives

Assessment on the Frame of Analysis

The adaptive sustainable agriculture techniques for farm level agriculture practices at all locations under study have two things in common, firstly they focus on improved crop practices which includes mix cropping, crop rotation, crop cycle, inter cropping, multi-tier farming using optimum use of water through drip irrigation and other energy efficient approaches. The second approach focus on maintain energy flow within the farm using integrated farming practices where the external input costs are gradually reduced with internal inputs, the waste of one farming subsystem being used as input to the other farming subsystem.

1. ***Impact on food production security:***
   By growing of diversified crops especially in rain-fed lands reduce the risk factor of crop failures due to drought or less-rains. (Hazra) Further, crops that complement each other in their growth and production allows for preventing the crop from failure of pest attacks. The onion-tomato-coriander model for instance is a popular way of preventing pests in tomoto crop, due to high odour of onion and coriander that prevents the growth of the pests. Crop diversification also builds adaptability in the agriculture systems. Changing weather patterns and other impacts of climate change increases the vulnerability of the produce cycle. Diversifying crops allows comparative stability of food production due to diversifying the possible sources of income and food which would be differently impacted by the climate change. The impact of food diversification on the productivity is not established as a part of this study. Interventions on the field on inputs on farm also have evident impact on productivity, resilience and adaptability of the agriculture system. An intervention of internalising inputs- fertilisers and pesticides, for instance shows a trend of loss in productivity in the short run, in one of the cases studied (See Box X). Internalising inputs, however has positive impact on the resilience and adaptability of the system. The quality of the soil and the long term food production security is affirmed to be positive by the use of indigenous alternatives to agriculture. (Roy , Chattopadhyay, & Tirado, 2009) The WADI model allows for optimising farm productivity levels by using an appropriate species mix that allows different agro-ecological niches to be utilised. While the fruit trees grow by tapping into water and nutrients at greater soil depths, the usual seasonal crops get their water and nutrients from more superficial soil levels.

2. ***Impact on farmers' livelihoods:***
   The most powerful motive behind choice of technology on farm is the opportunity to gain additional income by either reducing cost of production or increase in the selling quantity or price of the produce (Myers, 2000). Technologies ranging from crop diversification, internalising inputs, Agro-forestry model base their niche in the ability to generate extra income benefits to the farmer. Diversifying the number of crops on the farm particularly for different markets – food vs feed vs oil seed use offset fluctuations in market price for a given commodity area. The objective of internalising inputs- replacing insecticides, pesticides and fertilisers with indigenous alternatives substantially reduces the inputs costs of production in the case studied and therefore allowed higher financial net assets to the farmers (See figure 9). Figure 9 highlights how internalising inputs, developing market linakges for targeted 'organic' consumers has led to increase in income of the farmers.

3. ***Impact on environment:***
   Crop diversification can be beneficial in reducing the amount of fertilisers, pesticides and/or water required for irrigation. Rotation of crops allows soil to rejuvenate in its content and not loose on only one of the components. Nitrogen fixing crops allows for increasing nitrogen fertility if used with other crops. The wadi intervention leads to reduced soil erosion, improved rain water capture and soil nutrient retention. The pruning of the wadi trees and the bio-fencing plants provide the family with a sustainable supply of fuel and fodder leading to reduced extractive pressures on the local forests allowing ecological regeneration.

CHAPTER 4:

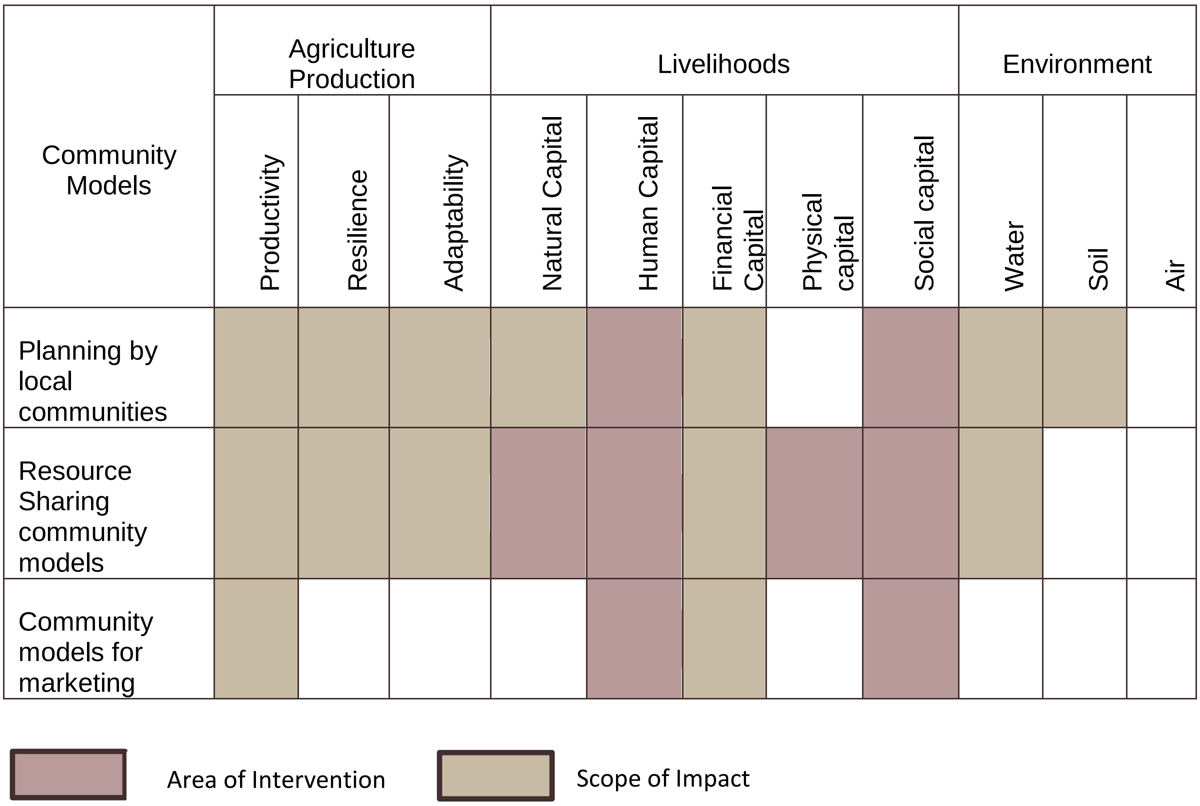
ASSESSING ROLE OF COMMUNITY MODELS ON AGRICULTURE SYSTEMS

Community Agriculture Models, in their simplest of definitions are “an arrangement of resource (land, water, human, finance, etc) pooling by farmers at different parts of the value chain for increasing agriculture productivity, farmer incomes and/or ensuring sustainable resource use”. Community based models, with its feature of resource pooling potentially increases the efficiency in the system by reaching economies of scale across various actions in the value chain. It can allow judicious use of water by sharing it optimally amongst the community; it can further allow efficient use of labour by aggregating the tasks and performing at optimal level. Interventions in community models in agriculture can include different activities across the value chain. Under this chapter, the models studied are on the following themes across the value chain:

1. Community models to enhance planning capacity of farmers and the community as a whole
2. Resource sharing/asset sharing groups to increase resource efficiency in agriculture
3. Community models for processing, marketing to reach consumers

The three sections of this chapter study the current development and opportunities in community models in agriculture systems. It provides a case study under each of these categories and assess the same on the sustainable agriculture framework developed and used in this paper.

Figure 10: Summary analysis of community models interventions on sustainable agriculture framework



I. PLANNING CAPACITY OF A FARMER COMMUNITY

Background

Practicing agriculture involves planning and decision making potential from choice of seeds and inputs, weather forecast, climate adaptive choice of inputs, seeds, techniques of farming. It also includes efficient management of resources for maximising social, economic benefits, while ensuring environmental well-being. All of this involves regular updating of knowledge and investment in institutions and systems that can enhance the capacity of farmers and the community for informed decision making on agriculture decisions.

Currently, the planning processes in India are undertaken at various levels from Agriculture Division, (Former) Planning Commission at the Centre, state level and district level planning for allocation of funds to various activities in agriculture. The assessment of the agriculture programme is done in terms of productivity while dealing with subjects of extension, research, technology, finance, etc. Assessment of needs and gaps currently follows a top-down approach where enhancing planning capacity of community indicates huge potential in aligning the top-down with a bottom-down approach and allowing regular feedback and need-gap assessment from the major stakeholders i.e. the farmers.

There are success stories of community models for climate adaptive planning by DA, micro planning by Pravah, community engagement by WOTR by conducting exercises of vision mapping wealth ranking, water budgeting and mapping community's commitments for overall well-being.

The investments in building community models for planning and evaluation from the experience of the organisations' work highlight various purposes:

a. A community level institution allowed planning and decision making at a village level for managing natural resources and area level systemic interventions.

b. Community models for planning in the studied areas allowed dissemination and adoption of sustainable resilient agriculture practices by learning from experiences of each other.

c. Community's participation in planning processes allowed vertical linkages between district and village planning. This increases motivation and self-esteem of the community by having knowledge of planning processes. The climate adaptive planning conducted by the community with support from DA in Bundelkhand gave its feedback to the state climate planning and is one important example in this case.

PLANNING CAPACITY OF THE LOCAL COMMUNITY


Local community of Datia, M.P. discussing for climate planning

Organisations: Development Alternatives in Bundelkhand, Pravah in Jharkhand, Watershed Organisation Trust in Maharashtra

Need

A need for local communities to understand the increasing climate vulnerabilities and the resource base at disposal is felt. The need is felt to move beyond understanding towards active participation and voice of the locals in developing, owning and working for desired outcomes in agriculture and development plans for the village. A need for integration of local needs to government plans and action at the local and district level, preventing alienation of local people to development plans was also felt.

Objective

To enhance planning capacity of the local communities for addressing agriculture concerns specially related to climate change and resources at disposal.

Response

- DA initiated a project for increasing the climate change understanding of communities to helping them design climate adaptive plans. These locally developed climate plans guided district officials to design climate proof plans at the district level. The participatory exercises with communities used three guiding factors (i.e. problems, solutions and means of implementation) for development of local climate adaptive plans.
- An exercise in micro-planning was conducted by Pravah, Jharkhand to assess the requirements and inclinations of the farmers of each cluster. Investments and interventions by Pravah were guided by the aspirations of the village.
- WOTR, at the beginning of its project, conducted a vision mapping exercises, facilitating the community to describe its aspirations and expectations and to develop a roadmap for achieving the same. This enabled the community to own their vision of development for the village and become the drivers of change instead of being mere beneficiaries.

Drivers of Sustainability

- Consultative, bottom-up planning helps to create a horizontal convergence in on-going schemes at the panchayat level and create a vertical link in different levels of planning
- Planning capacity of local communities enable convergence of indigenous knowledge with modern techniques.

Enhancing planning capacity of local communities increases ownership and allows convergence of local knowledge with modern science. At the same time, it increases self-esteem and motivation amongst stakeholders to participate in development interventions.

Photo Credit: Development Alternatives

Assessment on the Frame of Analysis

1. ***Impact on food production security:***
   Depending on the capacities building of communities in making informed decisions of inputs, techniques of crop produce and use of natural resource management, such community models have the scope of impacting the productivity, resilience and adaptability of agriculture systems. Micro planning and vision mapping exercises conducted by ground organisations showcase the benefit of knowledge about what crop variety to use for increasing production while ensuring climate resilience. Similarly use of natural resources of the region, which are not in the hands of individuals alone are also managed at the community level and increases the efficiency of use of inputs for increases food production.

2. ***Impact on farmers' livelihoods:***
   The planning capacity of the farmer community is an investment in the human and social capital of the community. It builds the knowledge and capacities of farmers and thus enhances the human capital in the system. At the same time, community models for planning bring the community together and devote value in the act of collective action. This in turn, allows better management of resources (human, financial and natural) amongst the community. Interventions at the community level reduce the cost per unit head of the information and capacity building that an organisation/resource person puts in the community. At the same time, it increases the scope of efficiency of community resources which are porous of farm boundaries can be discussed and managed at the community level.

3. ***Impact on environment:***
   As planning capacity includes planning and management of natural resources at the local level, cases from the field, show evidence of its impact of the natural resource management of the area and thus impacting the soil and water health of the system. The decision of use of natural resources, as well as adopting practices of agriculture like water efficient crops as well as water efficient practices for ensuring proper management of water use allows a holistic scope for holistic planning of the community's natural resources.

   Since models for planning capacity and decision making of the local community are soft knowledge development, the scope of its impact can vary on the exercise, approach and context of practice. One of the critical achievement such processes can achieve is the vertical link that can be created with the decision making processes that happen at the district, state and national level. Such models, can allow decision making at meta level, to be informed of the demand of the communities as well as initiate processes of feedbacks on what schemes and programme show positive impact and what is the scope of improvement in other cases.

II. RESOURCE/ASSET SHARING FOR PRACTICING AGRICULTURE

Background

The Indian agriculture production system is trending towards continuous fragmentation of land. Nearly 88 percent of the farmers have less than 2 hectares of land, and account for about 44 percent of the operated area contributing about 51 percent in the total value of agricultural output (Srivastava, 2008).

With the trend at which India's average agriculture land size is decreasing, it raises serious concerns over distribution of resources like water, energy, soil which may not be equitably distributed according to land divisions. Small farmers generally witness situations of limited resource accessibility, low resource efficiency, low agriculture productivity, high climate risk, low incomes from the food production. This is not just a concern for India's food security but also puts forth a challenge on the economic viability and environmental sustainability of the agriculture systems. The scale of farming plays a role in the effective, efficient use of resources. Due to variability in availability of resources- water, land, energy, there are instances of shortage and excesses that are prevalent in the same system.

Further there are capital infrastructure and human labour whose use can also be optimised by increasing the scale of agriculture model. WASSAN and Pravah have demonstrated the ways in which communities can share their resources by forming teams for collective buying of inputs from market, develop water sharing, electric motor sharing groups and therefore using the available resources most optimally for maximising profits.

Building asset sharing groups for practicing agriculture serves the following purpose:

a. It allows efficient use of land, water and other natural resources available because of management at a larger area level over farm level.
b. It creates a social system that prevents ill-practices that harms the environment or livelihoods of other farmers as everyone collectively owns and manages the system and thus is mutually responsible for collective gains and care of their environmental systems.
c. It uses the man power more effectively by aggregating the work, accomplishing task at a community level rather than household level and therefore cost effectively using the manpower at disposal.

These resource sharing groups makes way for three kinds of provision. It allows resource access provision (with optimal use of resources), management provision (community responsibility of efficient resource use) and market provision (allow easier access to markets with better bargaining power). Such community based resource sharing models are posing as a good alternative to the popular contract and corporate farming which have been criticised for lack of ownership, risks involved for the farmer and environmental concerns.

RESOURCE SHARING COMMUNITY MODELS

Farmer water sharing group at Malkaipet, Rangareddy District

Organisations: Pravah in Jharkhand, Wassan in Telangana

Need

Natural resources are not equitably distributed, instances of overuse of water at one place and crop failure due to unavailability of water are common stories. Competitive digging of wells results in water dis-balance specially in water scarce semi-arid rain-fed areas. Small and marginal farmers in the region also face financial constraints for investing in expensive capital of motors, lift irrigation systems. Moreover, most of the small farmers are not functioning at the economies of scale in terms of resources incurred and value achieved.

Objective

To enable resource sharing (natural, human, capital resource) amongst farmers for increasing efficiency in agriculture systems

Response

- WASSAN initiated groundwater sharing by developing a design to pool available bore-well water, and distribute outlets through a pipeline network. The intervention enabled community executed, managed and monitored ground water resource, providing protective/ critical irrigation, stopping competitive digging of bore wells.
- Various asset sharing groups like Lift Committee, Motor Sharing Committee, SHGs were formed with support from Pravah for sharing different resources like water, capital assets like motor, finance, etc. These committees allowed collective decision, management for judicious use of available resources at disposal.
- Farmers were organized by WASSAN in teams, balanced with youth and experienced members to take care of different tasks in agriculture. The Agriculture Team, takes care of buying agriculture inputs for all the farmers collectively. The Marketing Team is responsible for collecting, sorting and selling seasonal produce. Similarly, a fishing team breeds fish for village consumption and sells at 20 percent less thanthe market price.

Drivers of Sustainability

- Resource sharing models must provide adequate incentive for resource surplus farmer to share his/her resources with resource scare farmers. A level of trust and community spirit enables higher adoption and success of such initiative.
- Collective buying of agriculture inputs and aggregated selling of produce resulted in increased bargaining power, reduced labour costs and individual transportation costs.

Resource sharing enables efficient resource (natural, human and capital) management, which further promotes environmental sustainability, higher food production and higher farmer incomes.

Photo Credit: WASSAN, Hyderabad

Assessment on the Frame of Analysis

1. ***Impact on food production security:***

   The resource sharing community models aim to efficiently and equitably use the resources at disposal by the community. These resources range from natural resources- water to physical and human resources available at community's disposal. The use of limited set of water resource in WASSAN's case that is shared by the community allows for increasing efficiencies and hence allowing more food production per drop.

   The system of resource sharing, especially natural resource allows building resilience in the system. The sharing of water resources for critical irrigation to prevent crop failure builds resilience and sustenance capacity of the agriculture system.

2. ***Impact on Farmers' Livelihoods:***

   The resource sharing models studied largely intervene in the natural, human, social and physical capital of the farmers. The natural capital available to every farmer, largely water is shared by the community for efficient and effective use. In the process, there will be farmers which will have net loss in the total amount of natural capital available while some will have net gain in the natural capital available to them. The net natural capital of the community will remain the same in this case. However, community resource sharing models, if taken along with activities of conservation and management of water resources can impact in a net gain of the natural resources for the community. The resource sharing models intervene to enhance the social capacity and bring in value of collective decision making and working for community development. It, therefore brings value of resource pooling in order to enhance food production, income generating and environmental well-being outcomes. The area of intervention, in some cases also include physical capital where physical resources like motor, lift is shared by the community that helps in reducing short term costs and hence allowing higher profits to the farmers.

   The scope of impact of resource sharing models in agriculture ranges from gains in natural and financial capital for the farmers and the community as a whole. Natural resource sharing models allows for efficient resource use that increases productivity and enhances income of the farmers. Other models studied that share human and physical resources allow the community and group, together, reduce costs of farming by efficiency in the division of labour and increase bargaining power and buying of inputs in bulk. All this allows for reducing the costs and increase in the selling price of commodities thus allowing for higher income generation.

3. ***Impact on Environment:***

   The natural resource sharing community models makes water a public good. This brings responsibility and ownership of use and misuse of the commodity on the entire community. The example of WASSAN shared here tells of the regulations made by the community of not growing certain water intensive crops in the region for maintaining water balance in the region. Such regulations and community involvement in managing of water resources allow for increasing efficiency and effectiveness of water resource management.

III. COMMUNITY MODELS FOR PROCESSING AND MARKETING

Background

Small and marginal farmers in India have been vulnerable to risks in agricultural production. Several organisational prototypes are emerging to integrate them into the value chain with the objectives of enhancing incomes and reducing transaction costs. One such alternative is Farmer Producer Organisations (FPOs). The paper explores the potential of FPOs as collective institutions through a case study of Sahaja Aharam Farmer Producer Company Limited. Research increasingly shows that smallholders would be able to substantially increase their incomes from agriculture and allied activities if they participate in markets. As a result, the focus of development has shifted from enhancement of production to market connectivity. Small Farmers' Organisations such as cooperatives and FPOs are expected to enhance incomes, reduce costs of input purchases along with transaction costs, create opportunities for involvement in value-addition including processing, distribution and marketing, enhance bargaining power, and provide access to formal credit. (Bikkinna, Turaga, & Bhamoriya, 2014)

Some of the common concerns faced by small farmers[3] include high production risk (susceptibility to pest attack and crop failures due to climatic adversities) and price risk associated with fluctuating market prices and limited information acess about prices across the vertical value chain. Lack of access to resources, inefficiencies in using available resources coupled with inadequate market and crop knowledge often restricts shifts to new enterprises and investments options in agriculture available in market (Gulati, Joshi, & Landes, 2008). For addressing the concerns, after several amendments, a comprehensive Central legislation called the Multi-State Co-operative Societies Act, 1984 consolidated various legislations governing cooperative societies. Cooperatives focus on welfare rather than on commercial operations. Cooperatives tend to operate as political rather than economic entities with underrepresentation or a total lack of representation of small holders who often do not even receive credit from cooperatives. Political and administrative control in general and the overriding powers of the Registrar of Cooperative Societies to regulate the function in particular have compromised the functioning of cooperative institutions. A large number of these cooperatives in the country currently are in a state of financial crisis and are growing increasingly dependent on state subsidy for survival. (Bikkinna, Turaga, & Bhamoriya, 2014)

Addressing the issues and concerns from the legal framework and functioning of Collectives, a concept of Farmer Producer Company developed. The basic purpose envisioned for the FPOs is to collectivise small farmers for backward linkage for inputs like seeds, fertilisers, credit, insurance, knowledge and extension services; and forward linkages such as collective marketing, processing, and market-led agriculture production. The Department of Agriculture had issued a policy document titled "Policy and Process Guidelines for Farmer Producer Organisations" in 2013 to encourage the formation of FPOs and laying out indicative guidelines for the formation and performance of these collectives. The policy guidelines propose an organisational structure of FPOs that is aimed at collaboration with academia, research and extension agencies, civil society organisations and corporations (Bikkinna, Turaga, & Bhamoriya, 2014) FPOs have enabled farmers to collectively minimise costs and maximise profits from their produce. With support from Centre for Sustainable Agriculture in Telangana, 16 farmer collectives of different villages have formed a producer company- Sahaja Aharam Producer company. The company aggregates produce from these farmer cooperatives, processes, adds value and directly sells to urban consumers and thus connecting the farmer directly to the consumers of their produce.

[3] Small Farmers refer to farmers with less than 2 hectares of land in this context.

COMMUNITY MODELS FOR MARKETTING

Packaged cumin and turmeric packet from Sahaja Aharam Producer Company Ltd.

Organisation: Centre for Sustainable Agriculture, Telangana

Need

Profits from agriculture have been reducing due to high input costs of seeds, fertilizers, pesticides and marginal increase in the Minimum Support Price over the years. Limited access to urban markets due to high costs in transportation with respect to little produce per farmer further restricts income of the farmer. Raw agriculture produce without graded and processed earns marginal profits to farmers at the first transaction of produce in the agriculture value chain.

Objective

To increase income of farmers from agriculture by community model of processing and marketing to raise profits for the farmers.

Response

A farmer collective was formed with 16 farmer cooperatives. They promoted eco-friendly agriculture using organic manure and bio-agents instead of fertilisers and pesticides. Further, Sahaja Aharam Producer Company Ltd. was set up to initiatie an F2C (Farmer to consumer) and F2F (Farmer to Consumer) and F2F (Farmer to Farmer) initiative to create a meeting ground for nature friendly consumers and farmers. The company increased the share of producer in the consumer price.

Pricing Benefit: Sahaja Aharam offers a premium price of 10 to 20 percent higher than the local marker price subject to the fact that products are organic. With direct linkage with urban consumer demand, farmers are able to benefit with higher price for their produce.

Opportunities with value addition: Apart from raising prices of the products, value addition activities have generated local employment opportunities.

Drivers of Sustainability

- Community models of processing and marketing can allow the system to run on economies of scale and thus allow for higher profits for all farmers
- Linking consumer to farmer allows farmer to realise better price and ensures safe food to the consumer

Community models that increase capacity of farmers to reach markets and consumers allow for higher incomes of the farmers.

Assessment on the Frame of Analysis

1. ***Impact on food production security:***
   The community models for processing and marketing do not have any direct linkage with productivity, resilience and adaptability of the agriculture production system. There can however, be changes in the choice of crop produced, quality of food production and choice of seeds dependent on the market demands from where the farmer cooperative are linked or associated with.

2. ***Impact on farmers' livelihoods:***
   Community models for processing and marketing have its intervention and largest scope of impact on the farmers' resources and livelihood opportunities. Such models are building the knowledge and capacities of farmer communities to collectvise for reducing costs and increasing prices of the commodities produced at their end. They do it by various activities of bulk buying; bulk graded selling, value addition ventures, packaging and many more. It therefore invests in the social and human capital of the community.
   The scope of impact of such models is most on the financial capital enhancement of the communities. By secured markets linkage, reduced costs of transportation, value addition and packaging, the farmers are securing additional income benefits from such ventures. It un-debatably reduces the scope of middle man in the agriculture value chain. At the same time, new job opportunities rise with activities of value addition and packaging further increasing the economic enhancement of the community in the cases studied.

3. ***Impact on environment:***
   There is no direct impact on environment that was identified by community models for processing and marketing farm produce. However, market demand can influence the choices of farmers that can impact the environment. The most popular example is the growing demand of organic food and the resultant impact on the practices of the farmers to practice organic farming. Organic farming practice reduces the use of fertilisers and pesticides and thus showing positive impact on the environment of the region.

CHAPTER 5:

LEARNINGS AND WAY FORWARD

The paper studied different role that technology and community models can play across the agriculture value chain for promoting indicators that measure food production, farmers and environmental well-being. There are certain functions associated with both technology and community models and work by various ground organisations throw light on the opportunities to explore, study and expand further. To summarise use of the technology and community models interventions, following are some key points:

1. Technology Interventions:

Science and technology interventions broadly include various technology packages for farm inputs, farm implements, farming techniques, risk reduction systems and Information and Communication Technology (ICT) systems. Some emerging learnings from various functions of technology interventions are summarized as follows:

a. For information access on weather and decision making support

Technology interventions for information access allow greater planning and decision support to farmers. Timely, comprehensive, reliable and relevant information can allow farmer to make decisions in farming that not only enhance the productivity, resilience and adaptability of the crop but also understand and choose for practices that are good for the environment. Further, stable food production via information access will influence the farmers' financial stability and income generating ability. *Local adaptive capacities are enhanced when local weather information is analysed and appropriately communicated. Field and extension oriented agro-meteorology requires the coming together of high-end technology and local knowledge, which requires multi-stakeholder partnerships at all the levels.*

b. For area level systemic interventions

Rain-fed areas benefit greatly from area level interventions like watershed development in terms of enhanced water security, reduced soil erosion, reduced climate vulnerability and improved agricultural productivity. Various assessment studies (Suryawanshi & Kamble, 2012) (Gautam & Rao, 2007) (Singh, Behera, & Singh, 2010) (ICRISAT, 2009) and experience of ground organisations have indicated positive impact of natural resource management on food production and farmers' income and thus become important component of sustainable agriculture. *A participatory model for Watershed development, integrated with other government schemes allows maintenance and ownership of community in watershed programmes.*

c. For farm level agriculture practices

Farm level choice of technology from inputs like seeds, techniques of mixed-cropping, irrigation means, inputs like fertilisers and pesticides are direct cost to the farmer and have direct link with food production and the impact on health of soil and water of the area. *Environment friendly technologies have high adoption rate if it makes a good investment case for the farmer.* Traditional agriculture practices and techniques that internalise inputs, reduces costs are potentials of good economic case for farmers while ensuring environmental sustainability.

2. Community Models:

Community Agriculture Models are "an arrangement of resource (land, water, human, finance, etc) pooling by farmers at different parts of the value chain for increasing agriculture productivity, farmer incomes and/or ensuring sustainable resource use". Some of the opportunities identified in community models interventions are as follows:

a. For planning capacity of the community

Agriculture is heavily dependent on soil and water and collective community action is essential for maintaining the health of soil and water in a certain region. Further, planning capacity at the community level allows better understanding of the agriculture policies to the farmer and open doors to mechanism for feedback of the farmers and an input by farmers in the district and state planning processes. *Enhancing planning capacity of local communities increases ownership and allows convergence of local knowledge with modern science. At the same time, it increases self-esteem and motivation amongst stakeholders to participate in development interventions.*

b. For resource asset sharing for practicing agriculture

Natural resources are not equitably distributed; instances of overuse of water at one place and crop failure due to unavailability of water are common stories. Competitive digging of wells results in water dis-balance especially in water scarce semi-arid rain-fed areas. Small and marginal farmers in the region also face financial constraints for investing in expensive capital of motors, lift irrigation systems. Moreover, most of the small farmers are not functioning at the economies of scale in terms of resources incurred and value achieved. *Resource sharing allows for judicious and efficient use of the resources at disposal by the community. Efficiency in use of resources allow for higher economic gains for the farmers and in some cases also impact food production.*

c. For processing and marketing

Limited access to urban markets due to high costs in transportation with respect to little produce per small farmer restricts agriculture income. Raw agriculture produce without graded and processed earns marginal profits to farmers at the first transaction of produce in the agriculture value chain. Community models of collectives, farmer producer companies play a critical role in enhancing farmers' income by increasing the profit margins from the farm produce via various activities of value addition and reaching out to wider customers. It can potentially have impact on crop choice and environment depending on the consumer demand. *Community models increase capacity of farmers to reach markets and end-consumers with graded products and thus allow for higher incomes of the farmers.*

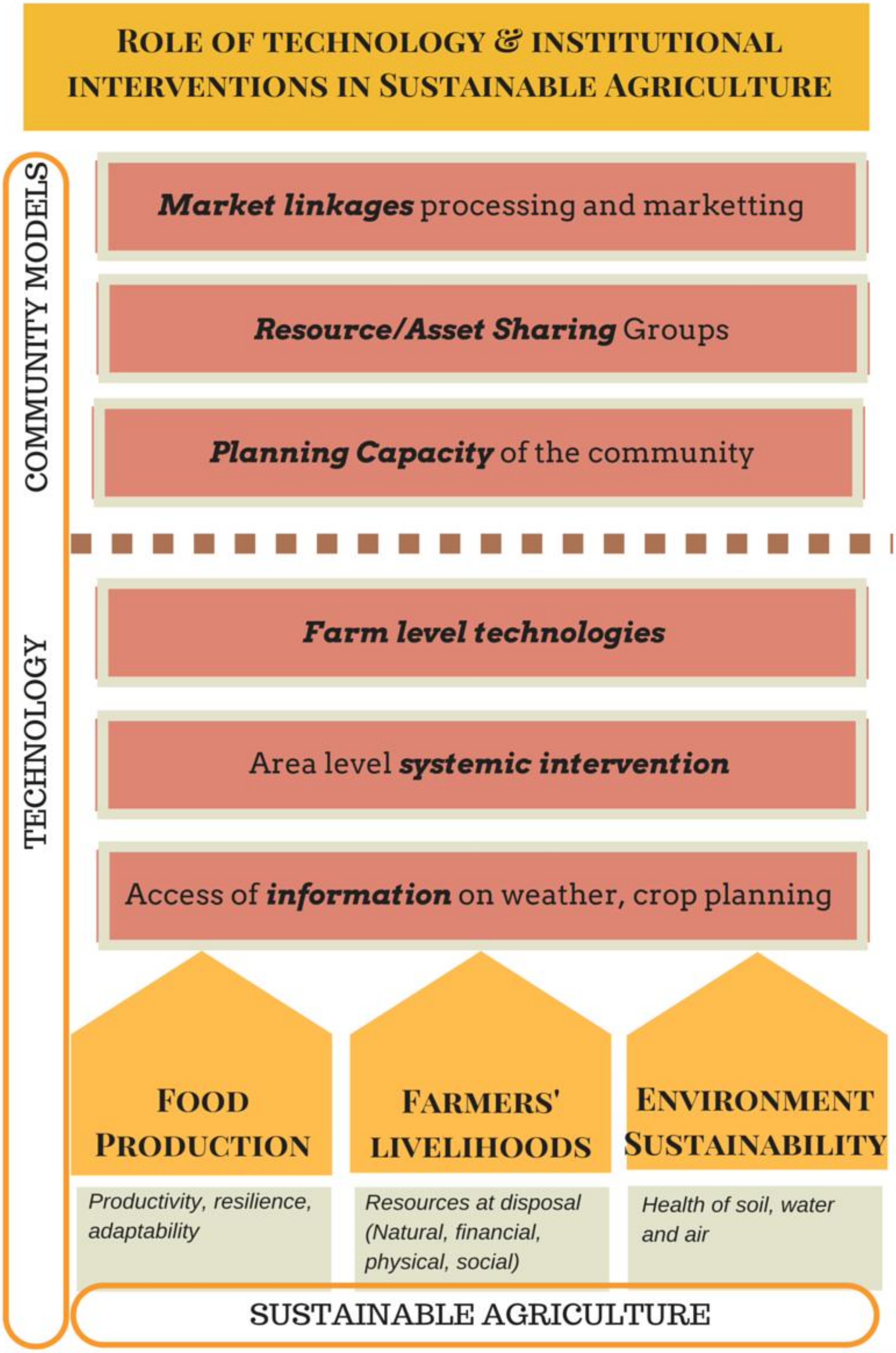


Figure 11: Key components of a comprehensive agriculture programme

Various typologies of cases studied from information access, natural resource management, on farm technologies, planning capacity, resource sharing and aggregation for market linkages cannot be seen in isolation. They however, represent a framework for developing an agriculture programme. At each step of the agriculture value chain, there are various needs and gaps and study indicates a huge potential in appropriate technology interventions and community models for addressing the needs and gaps. Such a study sets base to developing a comprehensive programme for agriculture.

The paper is an initial exercise that takes lessons from experiences of civil society organisations work on the processes for agriculture interventions in semi-arid regions of the country. It looks at what are the processes and elements that enable higher adoption, greater food production, farmers' well-being while ensuring healthier environment. It aims to provide a direction for the agriculture policies, investments by private sector and to support the work for various other civil society organisations working on the ground. This is a starting point on exploring the roles that government, corporates/private sector and civil society organisations can play in the agriculture systems.

There is a potential mapped that can strengthen India's position in securing food for all in the long run with farmers' and environmental well-being. The Government is in the process of revamping the extension services, developing irrigation policies and looking at systems of increasing agriculture productivities and potentials to making farming remunerative. While this paper gives insights to what can such policy developments learn from ground practitioners, the next steps will need to study these policies and look at the alignment and possible emergence of lessons from the ground in these policies and thus build a strong practice-to –policy connect. Further other mission for Integrated Development of Horticulture, National Mission for Sustainable Agriculture (NMSA), Rashtriya Krishi Vikas Yojana (RKVY), Partcipatory Gaurantee Scheme for farmers are some programmes that also need to be studied in order to assess how well geared are these programmes for the learnings of this study.

BIBLIOGRAPHY

12th Plan Working Group. (2011). *Natural Resource Management and Rainfed Farming.* Government of India.

Agriinfo. (2015). *My Agriculture Information Bank*. Retrieved January 25, 2016, from AgriInfo: http://www.agriinfo.in/?page=topic&superid=1&topicid=643

Arjun, K. M. (2013). Indian Agriculture- Status, Importance and Role in India Economy. *International Journal of Agriculture and Food Science Technology*, 343-346.

Bachhav, N. B. (2012). Information Needs of the Rural Farmers : A Study from Maharashtra, India: A Survey. *Library Philosophy and Practice*, 866.

Bikkinna, N., Turaga, R. M., & Bhamoriya, V. (2014). *Farmer Producer Organizations as Farmer Collectives: A Case Study from India.* IIM Ahemdabad.

Birthal, P., Khan, M., Negi, D., & Agarwal, S. (2014). Impact of Climate Change on Yields of Major Food Crops in India: Implications on Food Security. *Agricultural Economics Research Review*, 145-155.

Committee on Agriculture. (2013). *Demands for Grants. Forty Sixth Report.*

Conway, G. (1997). *The Doubly Green Revolution.* New York: Cornell University Press.

D & B. (n.d.). *India's Energy Sector*. Retrieved December 21, 2015, from Dun and Bradstreet: https://www.dnb.co.in/IndiasEnergySector2012/demand.asp

Department of Economics and Social Affairs. (2013). *World Population Prospect.* UN.

DFID. (2004). *Technology and its contribution to pro poor agriculture development.* DFID.

FAO. (1995). *Application of the pressure-state-response framework for the land quality indicators (LQI) programme*. Retrieved January 25, 2016, from FAO Corporate Documentary Repository: http://www.fao.org/docrep/W4745E/w4745e08.htm

FAO. (1995). *Trainers Manual.* FAO.

FAO. (2010). *AN ECOSYSTEM APPROACH TO SUSTAINABLE CROP PRODUCTION INTENSIFICATION.*

FAO. (2011). *Energy Smart Food for People and Climate.* FAO.

FAO. (2014). *The State of Food Insecurity in the World.* UN.

FAO. (2015, Feb). *AQUASTAT*. Retrieved December 21, 2015, from FAO: http://www.fao.org/nr/water/aquastat/countries_regions/ind/index.stm

Ganesan, M., Karthikeyan, K., Prashant, S., & Umadikar, J. (2013). Use of mobile multimedia agricultural advisory systems by Indian farmers: Results of a survey. *Use of mobile multimedia agricultural advisory systems by Indian farmers: Results of a survey*.

Gautam, R., & Rao, J. (2007). *Integrated Water management- Concepts of Rainfed Agriculture.*

Gautam, R., & Rao, J. (2007). *Integrated Water Management- Concepts of Rainfed Agriculture.* CRIDA, IARI.

Global Footprint Network. (2010). *The Ecological Wealth of Nations.*

Global Harvest Intiative. (2014). *Global Agriculture Prodcutivity Report.* Global Harvest Initiative.

GoI. (2014). *Economic Survey of India.*

Government of India. (2011). *Economic Survey of India.* Government of India.

(n.d.). *GREEN TECHNOLOGY FOR.*

Gulati, A., Joshi, P., & Landes, M. (2008). Corporate Farming in India. In A. Gulati, P. Joshi, & M. Landes, *Corporate Farming in India.*

Hayati, D., Ranjbar, Z., & Karam, E. (2010). Measuring Agriculture Sustainability. *Biodiversity, Biofuels, Agroforestry and Conservation Agriculture*, 73-100.

Hazra, C. R. (n.d.). *Crop Diversification in India*. Retrieved January 2015, from FAO Corporate Document Repository: http://www.fao.org/docrep/003/x6906e/x6906e06.htm

ICRISAT. (2009). *Integrated Watershed Management in India:Strategic Policy and Institutional Options.* ICRISAT.

Indo German Environment Group. (2013). *India's Future Needs for Resources: Dimensions, Challenges and Solutions.*

Joshi , P., Jha, A., Wani, S., Sreedevi, T., & Shaheen, F. (2008). *Impact of Watershed Programme and Conditions for Success.* ICRISAT.

K. M. , S. M., & Damani, O. P. (2014). *A Stock and Flow Based Framework for Indicator Identification for Evaluation of Crop Production System.* IIT B.

Mathur, A., & Goyal, M. (2014). Role of Information Technology in Indian Agriculture . *International Journal of Applied Engineering Research*, 1193-1198.

Ministry of Agriculture, GoI. (2013). *Pocket Book on Agricultural Statistics.* Government of India.

Ministry of Environment Forest and Climate Change. (2010). *India: Greenhouse Gas Emissions 2007.* Government of India.

Ministry of Environment, Forest and Climate Change. (2007). *India GHG Emissions.* MoEF.

Mittal, S., & M, M. (2013). *Agricultural information networks, information needs and risk management strategies: a survey of farmers in Indo-Gangetic plains of India.* Mexico: Socioeconomics Working Paper 10 D.F.: CIMMYT.

Myers, R. L. (2000). *Diversifying Agriculture with Alternative Crops.* Encyclopedia of Life Support Systems.

P, S. (2013, May 2). Over 2,000 fewer farmers every day. *The Hindu*.

Pattanayak, A., & Kumar, K. (2013). *Weather Sensitivity of Rice Yield: Evidence from India.* Madras School of Economics.

Pender, J. (2008). *Agricultural technology choices for poor farmers in less-favoured Areas of South and East Asia.* IFAD.

Ranuzzi, A., & Shrivastava, R. (2012). *Impact of Climate Change on agriculture and food security.* ICRIER.

Rao, N., & Rogers, P. (2006). Assessment of Agriculture Sustainability. *Current Science*, 439-448.

Roy , D., Chattopadhyay, P., & Tirado, D. (2009). *Subsidizing Food Crisis.* Greenpeace India.

Sharma, B. (2012). *Unlocking Value out of India's Rainfed Farming Area.* IWMI-TATA.

Sharma, B., Rao, K., Vittal, K., & A, U. (2006). *Realizing the Potential of Rainfed Agriculture in India.*

Shetty P.K, A. S. (2013). *Climate Change and Sustainable Food Security.* NIAS.

Shivakumar, S. (2013, October 18). Among India's Rural Poor Farming Community, Technology Is the Great Equalizer. *Huffington Post*.

Singh, D., Behera, D., & Singh, A. (2010). *IMPACT AND EFFECTIVENESS OF "WATERSHED DEVELOPMENT PROGRAMMES" IN INDIA.* Centre for Rural Studies, LBSNAA.

Suryawanshi , S., & Kamble, A. (2012). *Watershed management in India.*

The Hindu. (2010, November 26). *India losing 5,334 million tonnes of soil annually due to erosion: Govt*. Retrieved June 2015, from http://www.thehindu.com/sci-tech/agriculture/india-losing-5334-million-tonnes-of-soil-annually-due-to-erosion-govt/article915245.ece

UN-APCAEM. (2008). *Green Technology for Sustainable Agriculture Development.* UN.

Venkateswarlu, B., & Prasad, J. V. (2012). Carrying capacity of Indian agriculture: issues related to rainfed agriculture. *Current Science, Vol 102, No 6*, 882-888.

Wikipedia. (2015, December 14). *Projections of Population Growth*. Retrieved December 21, 2015, from Wikipedia: https://en.wikipedia.org/wiki/Projections_of_population_growth

Woodhouse, P. H. (2000). *A framework for research on sustainability indicators for agriculture and rural livelihoods.* DFID.

Worldometer. (2015). Retrieved December 21, 2015, from Worldometers: http://www.worldometers.info/world-population/india-population/

WOTR. (2012). *Agromet- Weather-based, Crop and Locale-specific Agro-Advisories serving farmers of rural rain-fed regions.* WOTR.

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