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Sitaram Rao Livelihoods India Case Study Competition 2018

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Sitaram Rao Livelihoods India Case Study Compendium 2018

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Preface

Vulnerability to climate change can be correlated to poverty, as the poor have fewer financial and technical resources. They are heavily dependent on climate-sensitive sectors such as agriculture and forestry; they often live on marginal land and their economic structures are fragile. Climate change also affects all the three aspects of food security: availability, access and absorption. When production decreases, availability of food decreases. The poor don't have income to buy the food, so their access to it is affected. This, in turn, has an impact on health and affects absorption.

India's agricultural sector faces a significant threat from climate change as scientists' record rising temperatures and erratic rainfall patterns. According to India's Economic Survey 2018, the change in agricultural productivity patterns as a result of climate change could reduce annual agricultural incomes by between 15% and 18% on average, and between 20% and 25% particularly for unirrigated areas. Economists estimate that climate change has led to a loss of 1.5 percent of India's GDP. Agriculture continues to remain hugely important for India's economy, as it accounts for nearly 15 percent of India's GDP, and employs 47 percent of the nation's labor force. Given the dramatic impact climate change will have on the agriculture and Indian Economy it is crucial to promote innovative and sustainable Climate-Smart Agriculture (CSA) practices to mitigate risks and reduce losses.

The international geopolitics and current economic trends have made the government position India has repositioned itself as a responsible player in the global environmental regime in the recent past. Therefore, it is befitting that during the current year the Sitaram Rao Livelihoods India Case Study Competition will highlight cases that through CSA have had an impact on the community while sustaining the environment through their Climate Smart approaches on the ground.

The Sitaram Rao Livelihoods India Case Study Compendium 2018 has brought together 9 such cases that provide evidence of CSA practices that have impacted at ground. Overall 25 cases were received. The cases were put through a rigorous evaluation process and were assessed by an eminent jury who shortlisted the top case studies. The cases bring forward new knowledge, experiences, practices and innovations from programmes relating to CSA.

The Jury of the Case Study Competition comprised of sector experts such as Ms. Raji Gain, Director, BIRD; Dr. A K Padhee, Director, Country Relations, ICRISAT; Mr. Rajeev Ahal, Director, Natural Resource Management, Environment, Climate Change and Natural Resource Management Program, GIZ; Ms. Meera Mishra, Country Co-ordinator, IFAD and Narsanna Koppula, Aranya Agriculture Alternatives

On behalf of ACCESS, I thank the eminent Jury for critically examining the cases and collating the final list. I'm sure the rigour put in by them and their expertise has contributed to bringing the best cases to the fore. I would also like to thank those who have shown interest in the case study competition and submitted their cases.

I would like to take this opportunity to thank Vikram Akula and Vaya Trust for their invaluable support that helped resume the Case Study Competition after a gap of one year and perpetuate the memory of Sitaram Rao who was both his mentor and also a founding Board Member of ACCESS.

I express my gratitude to the Livelihoods India Advisory Group and our CEO, Vipin Sharma for their guidance in the conduct of the Competition. Last but not the least I would like to thank my small team of Shruti, Lalitha and Aastha for facilitating the 3-stage process in a seamless manner.

I hope this compendium will prove to be a useful resource on models for CSA and prove to be of value to the sector.

Puja Gour
Vice President
ACCESS Development Services

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Catalysing Competitive Irrigation Service Markets in North Bihar: The Case of Chakhaji Solar Irrigation Service Market

Neha Durga and Gyan Prakash Rai

Competitive Irrigation Service Markets (ISMs) have bypassed Bihar due to lack of affordable electricity. Even though past and present governments promised affordable electricity for irrigation, it seems a distant dream given that the state is still struggling to provide reliable electricity to even the domestic sector. In the wake of climate change, lack of affordable irrigation increases the risk associated with agriculture as a livelihood and makes resource poor farmers even more vulnerable to its impacts. Solar pumps if promoted by catalysing competitive irrigation service markets can not only generate climate proof income for the Solar Irrigation Service Providers (SISP) but can have large distributive benefits for the water buyers. The current case presents one such Solar Irrigation Service Market (SISM) catalysed by supporting five solar entrepreneurs in Chakhaji village and discusses its relevance in the present times and its contribution to agriculture growth of the village.

1. Background

Despite having deep and under-developed aquifers, the eastern region of India, comprising of eastern Uttar Pradesh, Bihar, Jharkhand and Assam has not been able to utilize the irrigation potential and yield benefits of the same, primarily because of lack of affordable and reliable irrigation options (Shah 2009). Even today, most of the irrigation in Bihar is done through diesel pumps and majority of farmers buy expensive irrigation from these diesel pump owners (Durga et. al. 2016). This lack of access to affordable irrigation makes their livelihood more vulnerable to climate change. Affordable and reliable irrigation can provide the bare minimum resilience needed in times of climate change.

High cost of irrigation not only inhibits the adoption of high value water intensive crops but also leads to lower productivity of wheat-rice systems as farmers under-irrigate their crops. This is evident from the fact that despite having similar soil quality and water resource endowment, the productivity of paddy in Bihar is 64 per cent of what it is in the neighbouring state of West Bengal, primarily because majority of farmers in West Bengal have shifted to Boro (summer) paddy that gives much better yield but has high irrigation requirement. Farmers could shift their production as the agriculture power supply scenario in West Bengal was significantly better than in Bihar and has improved even further in the recent years (Shah *et. al* 2017). The well-developed infrastructure and reliable electricity supply provided farmers the option of shifting the crop to the dry season. In contrast to this, most of Bihar does not even have a summer crop season. Historically, it was argued that the reason for not having summer crops stems in cultural factor, as summer is the wedding season in Bihar. During a fieldwork, some farmers told the authors that onset of regular floods was also one of the reasons for not growing any crop in summers, as it would get washed away.

But researchers have argued that it is the lack of affordable irrigation, an absolute necessity for growing a summer crop, which has resulted in a cropping calendar in Bihar which cannot accommodate an additional crop (Shah 2009, Kishore 2014, 2015) in a year. Negligible area is cropped under summer paddy despite having higher yields of the crop compared to Kharif paddy in Bihar and UP (Table 1)

Table 1: Yield, cropping months and area under paddy in different seasons for Bihar, Uttar Pradesh (UP) and West Bengal (WB)

	Monsoon/Kharif (Paddy)			Summer Paddy		
	Cropping Months	Average Yield (1990-2000)	Yield (2015-16	Cropping Months	Yield (2015-16)	% Area of Kharif grown in summer
Bihar	July-Dec	1170	2258	April-June	2472	3.1
UP	May-Oct	1935	2130	April-June	2728	.4
WB	June-Nov	2094	2743	March-June	3375	33

The role of competitive groundwater ISMs in democratising affordable irrigation is well researched (Shah 1993, 2009, Mukherjee 2004). ISMs did flourish in Bihar owing to high land fragmentation and very high marginal productivity gains due to irrigation, but they largely remained monopolistic in nature (Shah 1997). In his field study of seven villages in Muzaffarpur district in 1997, Shah described that despite being inefficient, where in pump owners generated large monopoly rents, the overall impacts of ISMs were highly beneficial which was explained by the increased crop yield and cropping intensity achieved by water buyers viz-a-viz non-irrigators. Lack of reliable power supply and affordable fuel (diesel) were found to be the main reasons inhibiting expansion of efficient ISMs. Primarily, because the incentives of water sellers using diesel pumps to extract water are much lesser to sell irrigation aggressively compared to water sellers who face much lesser marginal cost for pumping. As the marginal cost of operating diesel pump is very high given the high maintenance cost and lesser life span of the machine, diesel pump owners largely sold irrigation to cover the cost of irrigating their own land. Therefore, higher the price charged per irrigation by the water seller, lesser number of transactions were required to cover the cost. Since, land fragmentation, land scarcity and poverty has remained historically higher in the state, not every farmer owned a well or could afford to dig a well, therefore monopolistic ISMs remained a way of irrigation in Bihar.

In other parts of the country, especially in western India, ISMs became highly efficient owning to subsidized farm power policy which not only led to mushrooming of electric pumps, but zero to negligible marginal cost of pumping incentivised electric pump owners to take up water selling as an income generating side business alongside farming (Shah 2009). Farmers invested in long underground pipelines and outlets to increase the command area, which was possible with submersible electric pumps unlike diesel pumps, that are usually used to extract water from shallow depths. The flat tariffs of electricity which were fixed monthly or annual charges based on the size of the pumps boosted ISMs. The experience from Gujarat, where ISMs thrived and became indispensable village institutions, shows that when farmers were under pressure of paying high annual flat tariff, they tried to maximize the utilization of pumping capacity (Shah 1993). They invested in water distribution systems to reach more number of buyers. During fieldwork in 1980s in Naveli village in Gujarat, Shah found 60 km of buried pipeline constructed in the village. Such extensive water distribution network created with farmers' private finance served farmers having no wells or electricity connections with with affordable irrigation. As applying for an electricity connection was easier, many farmers applied and got electric connections in Gujarat. As per 4th minor irrigation census (2006-07), there was one pump in every 3 hectares of irrigated land in Gujarat. This must have increased with one lakh pumps being added every year, especially after the expansion of Jyotirgram Scheme in 2005 (Shah & Verma 2012).

But Bihar did not see this farm power revolution even though tube-well revolution did happen and the density of tube-wells increased in 1980s which did contribute to increase in cereal yields. But this growth was short lived and despite the aggressive shallow tube-well expansion policy, the agricultural growth stagnated in 1990s (Kishore 2004). Unlike the experience of Punjab, Haryana and western UP; even though tube-wells became ubiquitous, lack of investments in infrastructure such as electricity grid and generation, inhibited their use to full potential (Kishore 2004). The steady increase in diesel prices and constant prices of output increased the unaffordability of irrigation and therefore vulnerability of agriculture as a livelihood in the state. Thus, when private cost of irrigation was falling in other states of India on account of free and subsidised power supply in 1980s and 1990s, farmers in Bihar incurred increasingly high cost for irrigation and higher risk of reduced yields and crop failure. Therefore, unlike in other parts of the country competitive and pro-poor ISMs nearly bypassed the state because of lack of affordable and reliable farm power supply and so did the incentives for pump owners to aggressively expand their market and compete in ISMs.

2. Will Solar Pumps Break the Agrarian Impasse in Bihar?

The reduced cost of Solar PV panels increased affordability of solar pumps drastically in the last few years. Also, under the National Solar Pumping Program, different state governments have been topping up the Ministry of New and Renewable Energy sponsored 30 per cent capital cost subsidy to promote solar irrigation. In Bihar, the scheme is called Bihar Saur Kranti Sinchai Yojna (BSKSY), which started in 2012 and offers 2-3 HP/kWp solar pumps at 90 per cent subsidy (Durga et.al 2016). Till 2017, close to 1800 solar pumps have been installed in the state under different MNRE sponsored schemes (MNRE 2017) including BSKSY.

Substituting solar pumps with diesel pumps reduces the cost of irrigation drastically for pump owners therefore, it is not very difficult to find their takers in electricity scarce or diesel pump dominated areas; especially when the capital cost subsidy is to the tune of 80-90 per cent. But there are multiple issues with high capital cost subsidy driven promotion scheme. Firstly, high capital cost subsidy limits the number of pumps to be allocated, which self-selects more influential farmers who are well connected with the district administration[1]. Secondly, higher subsidy limits the size of the pump, which can be acquired. This in turn limits the use of solar pumps and often they are not able to substitute diesel pumps and end up being back-up pumps with low utilization rate (SSEF 2018) in pre-monsoon season when irrigation requirement is highest. Thirdly, smaller pumps do reduce the cost of irrigation for pump owners, but the small size and less surplus energy left after fulfilling their own irrigation needs, fail to incentivise pump owners to invest in water distribution/sale network or aggressively participate/catalyse ISMs. So, the benefits of high capital subsidy remain concentrated with the pump owners. But logistically, it is convenient for the government to offer higher subsidy to smaller number of beneficiaries, compared to lower subsidy to a large number of beneficiaries, even though the benefits of the latter will be much spread out.

Deviating from the government scheme, IWMI-Tata Program[2] designed a Solar Irrigation Entrepreneurs Scheme, which was implemented in partnership with Aga Khan Rural Support Program (India) in Chakhaji village of Samastipur block and district, towards the end of 2016.

3. The Chakhaji Model: Solar Entrepreneurs Catalysing Competitive Solar Irrigation Service Markets

Members of Kushwaha community, who are well known for vegetable farming, constitute majority of the population of Chakhaji village. Earlier a predominantly diesel irrigated village, it has close to 65 hectares of cultivated land, divided into more than 2,400 smaller parcels. Average landholding per household in the village is around 0.5 acre in 7 to 8 parcels in different locations in the village. Due to high land fragmentation, even the well owners are water buyers for some of their parcels, which is a usual trend in North Bihar. Owing to smaller land holdings, there is a common trend of leasing in land and about one third of total cultivated land is exchanged through different type of leasing agreements. The terms of exchange (primarily leasing in rates) depend on multiple factors such as elevation of land, irrigation facility, and proximity to village etc.

There were only diesel pumps for irrigation before December 2016 in Chakhaji village. Even today, 18 pumps, mostly Chinese made are operational in the village. Having a life of not more than 3-4 years, that too with high annual maintenance cost of around

[1] The solar pumps are allotted on first come first serve basis so, a more informed and connected farmer, usually the sarpanch or the elite of the villages get the information and apply for the pump before others. The poor targeting of solar pump beneficiaries has been reported in a recent evaluation done by Shakti Foundation (SSEF 2018)

[2] A coequal partnership between International Water Management Institute and Tata Trusts

INR 5000, they are an expensive water extracting mechanism. The farmers who buy water from diesel pump owners, are worse off than the pump owners as they have to pay around INR 120-150 per hour of irrigation which translates to INR 2600-3300 for irrigating an acre per season. Annually, diesel irrigation expenditure amounts to 20 per cent of the annual revenue generated per acre. Also, lack of reliable (even though expensive) irrigation in pre-monsoon season (as diesel pumps cannot pump water from greater depths) not only exposes crops to production risks but also discourages farmers doing pre-monsoon sowing of kharif crop.

In December 2016, IWMI-Tata Program along with AKRSP(I) offered five solar pumps of desired size[3] (5 HP) at 60 per cent subsidy to farmers who were willing to contribute 10 per cent upfront payment and also agreed to pay 8 per cent of the capital cost each year for four years. Also 1000 ft of buried pipeline was to be given in the desired direction to the interested farmers. The cost of 5 HP solar pump was around INR 5 lakh[4], which meant farmers who were willing to become solar irrigation service providers (SISP) had to contribute 50,000 as upfront payment and INR 30,000-40,000 annually for four years. The hypothesis behind the offer was that an adequately sized pump with buried pipeline network could not only offer a farmer an opportunity to sell irrigation and earn a decent income but may also catalyse an equitable and competitive irrigation market (Durga et. al 2016). It was expected that upfront cost and annual payment would mimic a high flat tariff to be paid by the SISPs, which will push them to earn enough from the irrigation sale, in order to pay the annual instalment of the pump. They could increase revenue by charging much higher price than their marginal cost (which is negligible in case of solar pumps) but since it was not just one farmer having a solar pump but few more farmers and all with buried pipeline network to reach longer distances, they could compete with each other. Thus, it was expected that competition among SISPs to acquire more market share to maximise revenue would keep the irrigation prices low, hence resulting in a pro-poor irrigation service market.

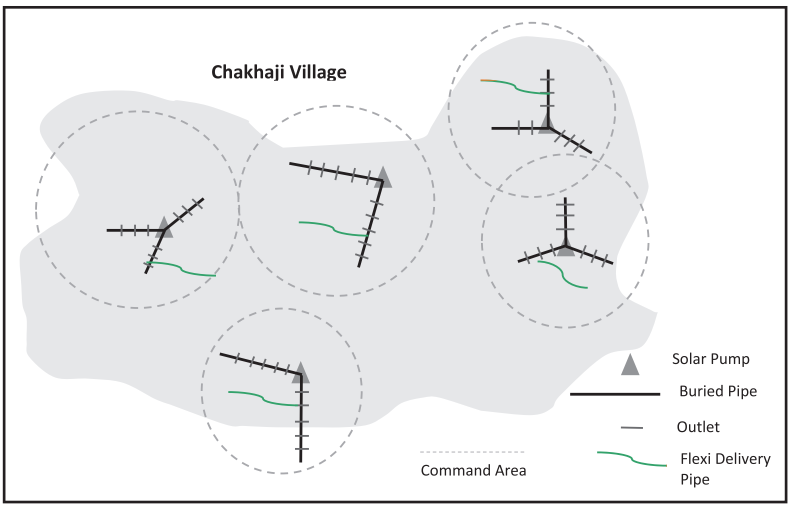

Figure1: Schematic diagram of Chakhaji ISM

[3] The subsidy offered was INR 40,000/kWp and farmer could opt for higher size (7.5 HP) pumps also but they opted for 5 HP pumps

[4] 1 Lakh = 0.1Million

Five farmers namely Neelkamal, Sanjeet Singh, Yatin Kumar, Rajkishore and Lalan Singh formed the first cluster of SISPs in Chakhaji village. They paid upfront payment of INR 50,000 in two instalments and gave an undertaking that they will be paying annual instalments for the coming four years. They also finalized the network of 1000 -1200 ft pipeline (Fig 1) and began operations in mid-December 2016.

Table 2 lists different parameters showing the individual performance of SISPs and also provides a snapshot of the ISMs in Chakhaji. The five SISPs are serving close to 400 farmers and providing irrigation to close to 75 Ha of area against the designed command of 55 Ha. Together they have earned a revenue of INR 9,34,291 by providing 9,497 hours of irrigation. This also includes their self-consumption which is less than 5 per cent for four SISPs and 8 per cent for the fifth one.

Table 2: Solar irrigation service market at Chakhaji

	Designed/ Expected Command Area (Ha)	Net Area Served (Ha)	Total Customers/ Water Buyers	No. of Operational Days b/w 31st Dec'16 to 30th Sep'18	Total Hours of Irrigation Sold (Hr)	Average Hours/ Day	Area (Ha irrigated once)	Total Revenue Till 30th Sep'18	Rs/Ha/ Watering	Asset Utilisation
Yatin Kumar	10	14	100	461	1463	3.2	83	1,41,140	1,700	56%
Lalan Singh	9	13	104	322	1490	4.6	70	1,44,724	2,077	57%
Sanjeet Singh	10	15	91	398	2527	6.3	142	2,48,981	1,753	96%
Rajkishore Singh	12	17	132	400	1783	4.5	100	1,77,989	1,778	68%
Neelkamal Prasad	14	15	124	422	2234	5.3	147	2,21,457	1,509	85%
Total	**55**	**75**					**542**	**9,34,291**		

The asset utilization is arrived by assuming the standard value of 1500 kWh/kWp of annual solar electricity production in a year as the maximum possible use of the solar pump. We can see that Sanjeet Singh has performed the best and Yatin Kumar has performed the poorest in terms of asset utilization and therefore revenue realization, even though the latter operated his solar pump for a greater number of days. But since Yatin Kumar's average hours of operation per day are half of Sanjeet Kumar's, he is earning much lesser than him. But if we see the number of farmers served, Yatin Kumar served more farmers than Sanjeet Kumar who served the least number of farmers. This is because the plots around Sanjeet Kumar's pump are relatively larger and the soil is dryer compared the plots and soil around Yatin Kumar's pump. The other reason is that Yatin Kumar is also engaged in other livelihood activities unlike Sanjeet Kumar who is full time doing farming and irrigation selling. Lalan Singh has performed marginally better than Yatin Kumar. He is the only one charging significantly higher rates of watering per hecatre. As per the fieldwork done by Kumar and Goel in June 2018, it came across that Lalan Singh has been losing his customers to the neighbouring Sanjeet Singh and Neelkamal due to his poor yet expensive service. Neelkamal is the second-best performer and the one who is charging least per hectare for watering. He is involved in irrigation service business full time and does little farming. He admitted that earlier he was not utilizing his time well for generating income as there were not many avenues or options in the village but after becoming an SISP, he has secured a reliable income which is proportional to the time and hard work, which he is ready to put in. Yatin Kumar realized over time that he was losing on an opportunity therefore he hired an operator to run his irrigation service business. The operator charges INR 20/hr for his time and labour in servicing the customers, which includes turning the pump on and off, opening the valve of specific outlets, laying down the delivery pipes from outlets to the buyer's field and rolling back the delivery pipes when the watering is done. The practice of keeping an operator was slowly adopted by all SISPs except Neelkamal as they figured out that day time is an important resource in solar irrigation and having an operator hedges the risk of losing the productive time due to any reason.

Also, the operator is usually a local farmer, who can spare his labour and earn close to INR 160-180 per day.

As still the density of solar pumps is low in the area, the competition between the SISPs is negligible. Each SISP has enough untapped market to expand into, and are not bothered about the little overlaps in command areas. As the density of the solar pumps will increase[5], the competition between the SISPs will increase and the service may improve further for buyers.

4. Subsidy Trickle Down to Buyers

By the end of June 2018, solar irrigation operation completed four agriculture seasons and resulted in multiple changes in the agriculture practices and income from the same, for SISPs and their customers. Even though, the five farmers got subsidy in acquiring solar pumps and water distribution network, the benefits were not concentrated in their livelihoods but they got distributed among all their customers, who are largely resource poor and marginal farmers. The diesel irrigation costed the buyers close to INR 120/hr and they could irrigate only two katha[6] in an hour due to poor efficiency of diesel pumps. Also, diesel pumps could not provide reliable irrigation during the pre-monsoon time, when sometimes the water table drops below 30 feet. With solar pumps, they could irrigate close to 5 katha in one hour which costed them INR 90-100. Therefore, a decrease of 60-70 per cent in the cost of irrigation happened for the water buyers. If they had to buy diesel pump irrigation for the area they had irrigated with solar pump, they would have had spent INR 21 lakh since January 2017; when they actually spent INR 9 lakh. They also saved on time as

[5] In 2017 and 2018, three new solar pumps have been added and eight more are in the pipeline.

[6] 22 Katha = 1 acre

they could irrigate twice as much land as they were irrigating earlier in the same time. And all of it in the day time which is a luxury for farmers who having subsidized grid electricity in the electrified regions of the country.

The other major benefit accrued to water buyers was availability of irrigation on credit which was not possible with diesel irrigation because of the marginal cost of running diesel pumps. Water sellers, in case of diesel pumps, usually transfers the cost to water buyers because the fuel cot is high. But with solar pumps, since the fuel cost is zero, water sellers are able to provide credit to the marginal farmers who are unable to prepay for the irrigation. This way solar pump-water sellers expand their market further since their capacity of holding larger account receivables is better than diesel pump- water sellers.

The other component of the Chakhaji model which impacted the livelihoods of the marginal farmers positively, is the buried pipeline network, which each SISP possesses. The buried distribution network has relatively much lesser chance of leaks compared to the delivery pipes. These leakages increase the time for water supply time, which has to be borne by the water seller as the irrigation pricing is on hourly basis. Delivery pipes are still used as the last leg in the distribution network but the initial network of 1000-1200ft is of PVC pipe buried underground. Owning to the large fragmentation and smaller sizes of the plots, delivery pipes will remain to be the essential component of a water distribution network. But lesser their length in the network, lesser would be leakages and faster and more efficient would be the irrigation service.

5. Early Impacts Reported at Village Level

Fieldwork done by Goel and Kumar in July 2018, revealed positive early impacts of Solar Irrigation Service Markets at village level. Two major impacts, which are somewhat cascaded and related, are increased cropping intensity and increased gross value of output from agriculture in Chakhaji village.

5.1 Increase in Cropping Intensity

Increased cropped area, especially in the summer season, is a direct result of availability of affordable and reliable irrigation. In figure 2, we can see that the irrigation cost in each season has almost halved after the solar irrigation service market was catalysed in Chakhaji. Still the area cropped in summer is least because i) the relative cost of irrigation is higher in summer than is 44 per cent higher than in Kharif and ii) the cropping calendar in the village has been such that it could not accommodate an additional crop (see Figure 3)

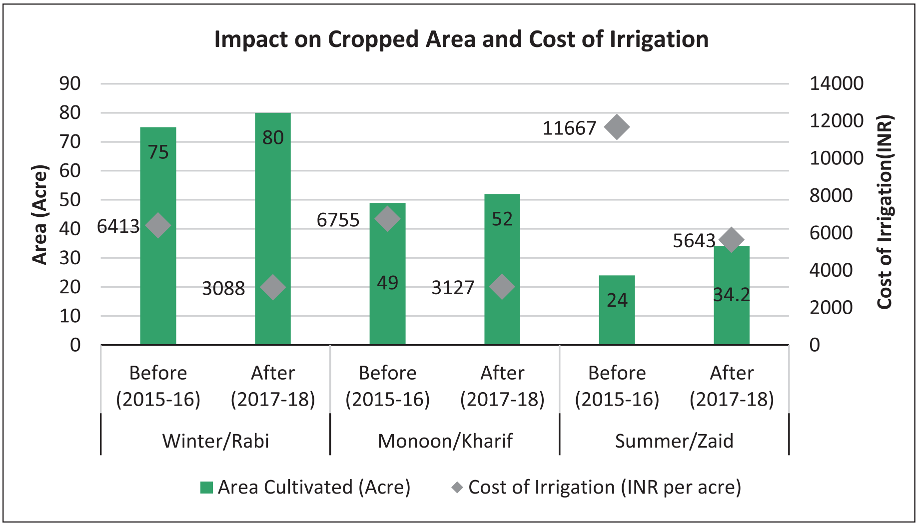

Figure 2: Impact of solar irrigation service market on village cropped area and cost of irrigation in different seasons

Earlier, when farmers were using expensive diesel irrigation, they could not do pre-monsoon sowing, as irrigation requirement is critical and high in that practice, and relied on rains for sowing paddy. This resulted in late harvesting of the kharif crop and therefore later sowing and harvesting of rabi crop leaving no room for a summer crop and farmers left the land fallow for a month or longer. But as the access to affordable and reliable irrigation improved, few farmers did pre-monsoon sowing in 2017 resulting in some room in 2018 to take a summer crop, which resulted in increased cropped area in summer.

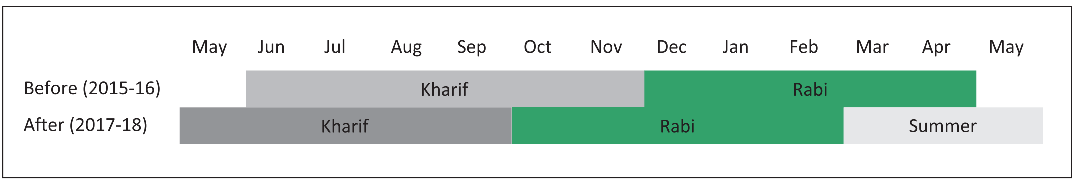

Figure 3: Cropping calendar of Chakhaji village pre and post solar irrigation service market

5.2 Increase in Gross Value of Output

Yields of major crops across the village improved with the increase in access to affordable irrigation, with maximum increase of 30 per cent in potato crop, primarily because of timely and adequate irrigation.

As a result of increased yields and areas across crops and seasons, the gross value of the output for all the seasons cumulatively increased by 46 per cent with maximum per cent and absolute (change in INR) change in the summer season. We envisage that this will further increase because of the shift in the cropping calendar and already established skill of the farmers as vegetable growers.

Table 3: Increase in yield(kg/acre) of different crops

Yield (Kg/Acre)	Before (2015-16)	After (2017-18)	Percentage Change
Paddy	1496	1804	21%
Wheat	1386	1518	10%
Maize	1672	2244	34%
Potato	7370	9592	30%
Cauliflower	6754	8316	23%

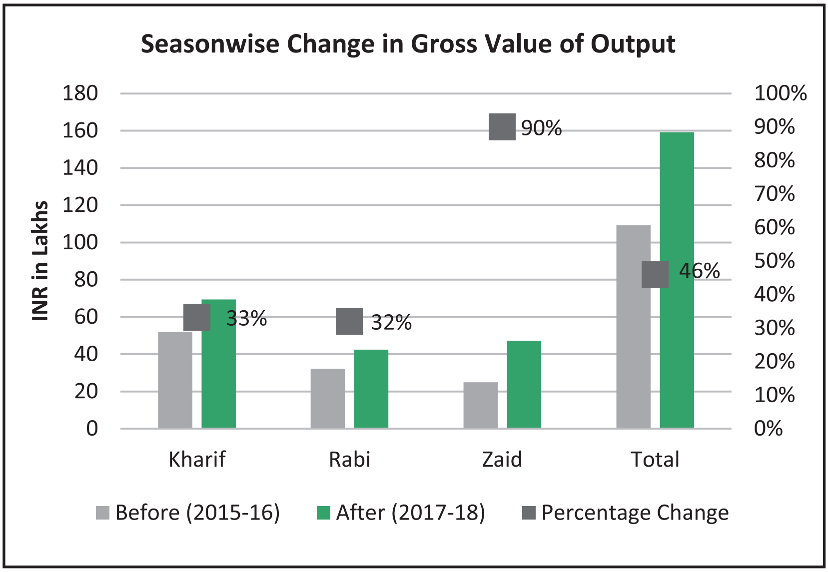

Figure 4: Season-wise and total gross value of output before and after the intervention

6. Conclusion

A competitive ISM catalysed by supporting multiple SISPs has shown positive early changes in the Chakhaji village and the adjoining area. It has boosted the income of both water sellers and buyers by allowing them to produce more from the scarce land resource they possess. Also, solar pumps provide an irrigation assurance for many years and is free from market risks of prices like diesel pumps. This strengthens the resilience of farmers in the times of climate change i.e. in case of less rainfall, they can irrigate their crops more without increasing the expenditure exorbitantly and therefore maintaining the crop viability.

Also, the distributive impacts of ISMs will make agriculture more viable as farmers having access to market will be able to change crops frequently given that irrigation will be assured.

Thus, framers will have more flexibility is choosing the crops. Also, the increase in cropping intensity because of affordable irrigation will result in more labour requirement throughout the year, thus generating more employment for the landless farmers also.

At the same time, farmers who have lesser land and entrepreneurial capability can become an SISP. Providing irrigation service can be a full-time employment but there will some seasonality affects as the water requirement reduces in the rainfall season. Also, there is some surplus energy generated in solar pumps in the monsoon season as the irrigation requirement is high. There can be additional ways of using this additional energy. One of the SISP used the monsoon season to provide pumped water for fisheries at a bulk rate which was lesser than the usual charge (INR 100/hr). More such innovative ways can be devised to tackle the lack of demand in the monsoon season.

Catalysing competitive irrigation service market requires a lucrative financial deal which can be/should be offered to around 5-8 farmers (or more) in village. Promoting SISPs in a clustered approach not only provides climate-smart employment to the farmers owning the pump but also generates jobs across the value chain. As it becomes viable for the solar pump companies to invest in building the capacity of local technicians and providing them employment to deliver the O&M services if a greater number of solar pumps are located near each other. In the current scheme, the solar pumps are so sparsely located, that companies not only find it difficult to provide after sale service (Durga 2016) but also hesitate in employing a local individual (as usually the number of solar pumps in a village is not more than 2).

Competitive and effective SISM can transform the energy-irrigation of the Ganga-Brahmaputra-Meghna basin and can impart the much-needed dynamism in its agriculture which will have multiple cascading benefits. In-fact this model of catalysing ISM by supporting multiple SISPs is relevant for all the regions having scarcity of affordable electricity and abundance of groundwater. Expanding grid electricity and supplying high quality electricity to agriculture at tariffs viable for both farmers and electricity utilities is a long-standing dream and the political economy associated with tariffs make it even more distant. SISPs can bypass the messy and slow route of electrifying agriculture, as the ultimate objective is to provide affordable and reliable energy and therefore irrigation to farmers which bolster their capabilities to adapt to climate change.

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Integrated Vegetable Cultivation in Odisha: Promoting a Climate Smart Viable Business Model

Pradeep Kumar Mishra[1] *and Kushankur Dey*[2]

1. Background

The Integrated Vegetable Cultivation (IVC) project implemented by Patneswari Agri Producer Company Limited (PAPCL) in Rayagada district of Odisha and initiated in 2016-17 is unique convergence model to overcome the challenges of high upfront investment costs while ensuring appropriate utilization of natural resources (see operational model in Figure 1). The National Bank for Agriculture and Rural Development (NABARD) extended the credit facility under the aegis of Umbrella Program for Natural Resource Management (UPNRM) with loan and grant funds, revolving funds and grant from Sir Dorabji Tata Trust, as well as contributions from PAPCL and project participants. The project offered the resource poor tribal farming households an opportunity to improve their income stream and transition their subsistence livelihoods to sustainable levels. Under the initiative, each participating household brought 50 decimal of their land under integrated vegetable cultivation.

2. Rationale

Vegetable production contributes to India's agriculture and improves the economy's export potential. Earlier it was cultivated as subsistence crop with cereals, pulses and oilseeds and occupied a meagre share of total cropped area. Increasing urbanization, rising income and purchasing power among middle class as well as sizable additions to population have augmented the demand for vegetable. The IVC model aimed at optimal utilization of land and water resources available with the farmers for improving farm income, health and nutrition, and sustainability, while meeting the requirements of climate smart agriculture.

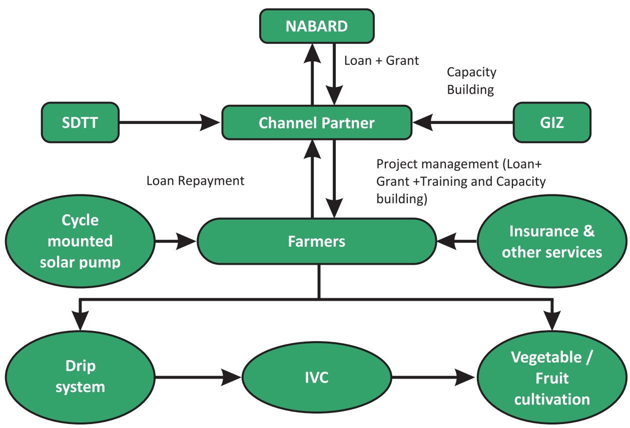

Figure1: Operational model of integrated vegetable cultivation

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The IVC model adopted different horticultural crops to be grown on the borders of the farm land that included seasonal vegetables, perennial vegetables, green leafy vegetables, and fruit bearing trees. Selection of crops ensured an effective utilization of farm land and availability of vegetables for consumption and sale round-the-year. The steady flow of harvest assured a year-round income for farming households. Inclusion of components, such as solar powered irrigation pumps, drip irrigation system, and measures for judicious use of water and other resources made the IVC as an economically viable and sustainable business model for farmers.

However, the model required a significant upfront investment for irrigation facilities, land development, and input costs. Availability of irrigation facility throughout the year was critical for IVC. In most cases, resource poor tribal households in remote and arid part of the country were unable to make such investments.

The IVC model is based on the making available required inputs through existing programmes and schemes of various organizations. Lack of access to finance was a major gap. When the program was being designed, the following challenges were documented to promoting vegetable cultivation:

- Low productivity of agricultural and vegetable crops
- Majority land were upland and did not have access to irrigation
- Lack of water year around
- Lack of access to finance for small and marginal farmers
- Lack of knowledge on package of practices on crop management
- Lack of access to remunerative markets
- Lack of availability of quality inputs

3. 50-Cent Model

The project envisaged transforming the livelihoods of small and marginal farmers though loan-based integrated vegetable cultivation. It aimed at enhancing household income to more than INR 75,000 per year, thus substantially enhancing their incomes and providing them with sustainable livelihoods. It was designed in such a manner that the farmer should not be burdened with loans, nor be flooded with grants. Therefore, a grant-cum-loan product was developed for facilitating IVC implementation by the farmers.

At the time of this study, in August 2017, 144 households were covered under the project. Each household identified 50 decimals of their land to be brought under integrated vegetable cultivation. The objective of the project was to develop an integrated high value crop model in 50 decimals (0.50 acre) of land area. Figure 2 presents a typical 50-cent model plot.

3.1 Project Components

An integrated vegetable cultivation model in 50 decimal lands had the following components:

1) Permanent wire-based boundary and live hedge: A low cost wire-based boundary was provided with concrete pillars in the corners of the plot and wooden pillars in between. Live hedges were developed along the boundary through plantation of Duranto and Glyricidia.

2) Border crops like drum sticks and papaya: On the boundary of the 50 decimal land, around 100 drumstick and papaya plants were planted.

3) Seasonal vegetable cultivation in 20 decimal land: In 20 decimal of land seasonal vegetables were grown with irrigation using sprinkler or drip systems. In each season, at least two vegetables were grown in these 20 decimals. Vegetables like brinjal or tomato and beans were preferred during Kharif season. In Rabi season the focus was on growing onion and pea. Vegetables like Okra and Chilli or Capsicum was grown during summer season.

4) Perennial gourd cultivation in 10 decimal land: Perennial gourds like pointed gourd, spine gourd or little gourd was cultivated on trellis in 10 decimal land. This was expected to ensure regular income to the families in most times of the year.

5) Seasonal Gourd in 10 decimal land: Seasonal gourds like ridge gourd, bottle gourd and bitter gourds were cultivated in different season on trellis in 10 decimals of land.

6) Banana in 5 decimals: Banana was cultivated in 5 decimal of land that would generate income annually.

7) Greens in 5 decimals: Green leafy vegetables like spinach etc. were cultivated in 5-decimal land for home consumption.

8) Water source to provide water round the year: Water sources like perennial streams or springs were tapped to avail water for irrigation throughout the year. In the absence of the above, dug wells or bore wells were provided as a source of water for irrigation.

9) Irrigation: The crops were irrigated either through gravity-based pipe flow system or by lifting water through pumps. For lifting water from the streams, wells and bore wells, solar operated portable pumps were used. Water was applied to the crops either through drip irrigation system or gravity irrigation.

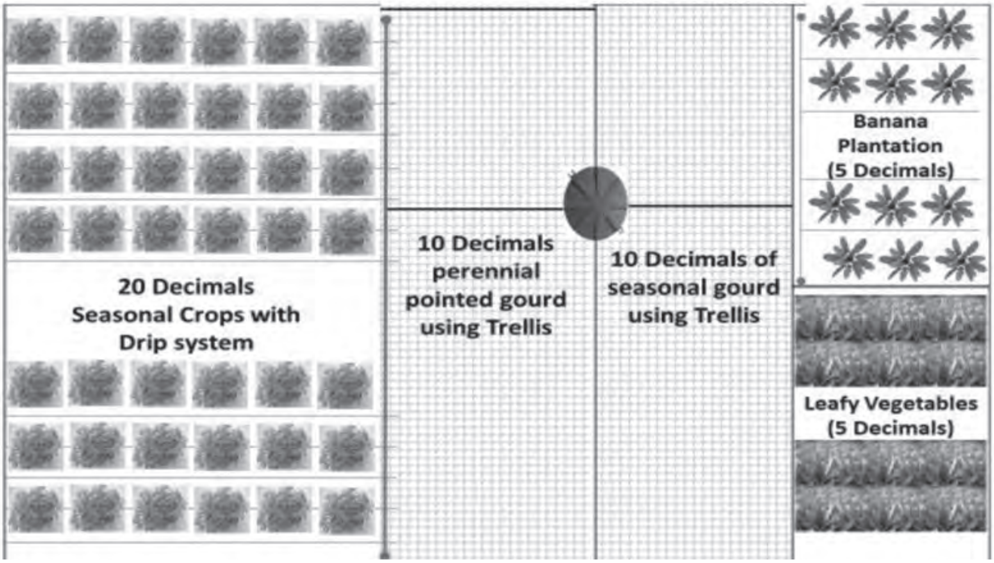


Figure 2: Diagrammatic representation of 50-cent model

Source: PAPCL

The concept of 50-cent model is an innovative model and a break-away from the traditional cultivation practices as reported in Table 1.

Table 1: Comparison between traditional cultivation practices and the 50-cent model

Traditional Cultivation Practices	50 Cent Model
Mono crop cultivation and low cropping intensity	Multiple crops with high cropping intensity
Traditional way of cultivation	Use of technology with proper package of practices
Not as per the demand of market	As per the demand of the market
Seasonal crops	Off season and high value crops
Depends on the rain and moistures only	Assured irrigation throughout the year
Use of traditional seeds	Hybrid and high yield variety seeds with resistant variety
High operational cost	Low operational cost due to use of drip, solar systems, mulching, raised bed plantation
Low productivity and low Income	High productivity and low income

Source: PAPCL 2017

Other than aiming to increase farmer income, the intervention had a goal of attaining water efficient irrigation technologies and enhancing nutritional security of households in the area.

3.2 Outreach

400 families were to be covered under IVC project. Till 2017, the project had an outreach of 144 households, all belonging to the Scheduled Tribe community.

Table 2: Outreach of IVC project (till 2017)

Block	No. of Beneficiaries		
	Male	Female	Total
Muniguda	45	5	53
Bissam Cuttack	82	9	91

Selection of beneficiaries was done on the basis of landholding - the household needed to have atleast 50 cent land available with them; interest in and experience of vegetable cultivation; and their economic status. Preference was given to below poverty line (BPL) households. Availability of irrigation, or potential for irrigation was also taken into consideration, as without irrigation, vegetable cultivation would not have been possible. were selected in a village meeting or *gram sabha*.

3.3 Implementation Process

The PAPCL officials went to notified villages and provided information about the project. In particular, they highlighted that the loan component must be repaid, and during this process, the interested farmers were identified. Application from the concerned farmers was obtained after verifying their proof of identification through Voter ID/Aadhaar card. Once the farmers were identified, the need for inputs and loans were estimated. Efforts were made to provide all support in the form of material instead of cash. Some of the material were provided through convergence with various government agencies such as Department of Horticulture, Government of Odisha. Training programmes were conducted, in which issues such as appropriate quantity of fertilizer, pesticide, etc. and methods of cultivation were discussed.

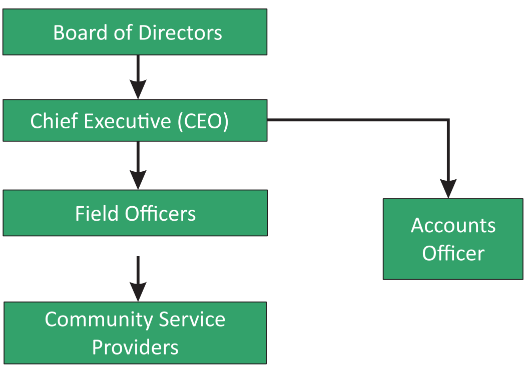


Figure 3: Organization structure of PAPCL

The major activities were undertaken by the field officers and the community service providers of PAPCL (organogram of PAPCL in Figure 3). The Chief Executive Officer (CEO) was responsible for overall planning, review and monitoring. A project management team comprising of five members and based out of project location played an important role in delivering the project.

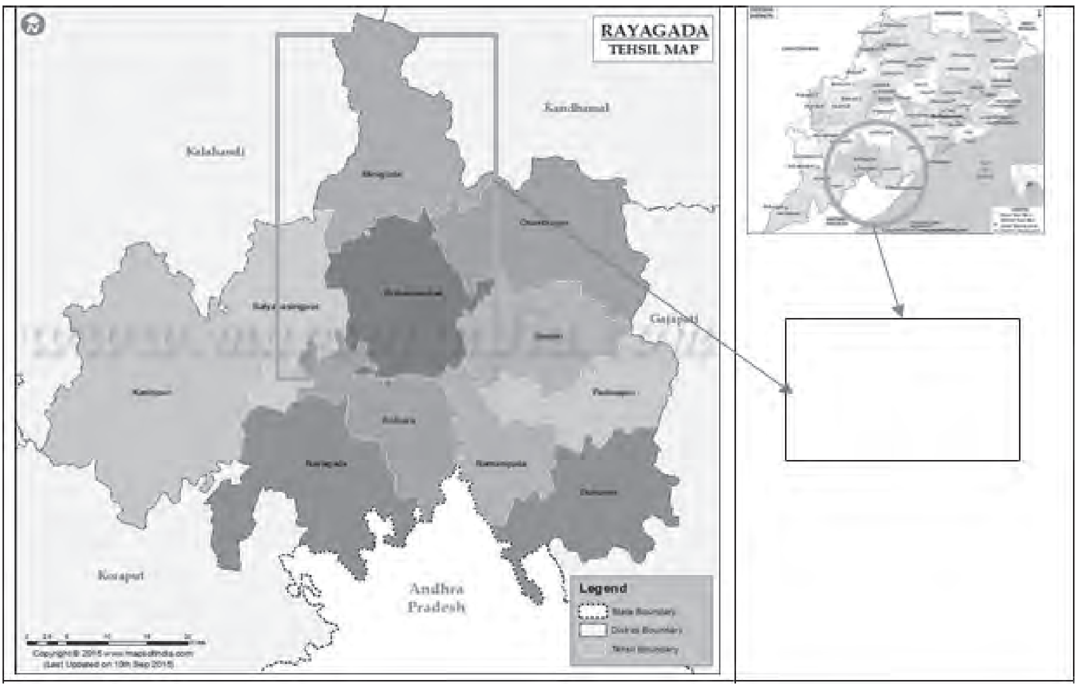
While NABARD lent to PAPCL at 10% per annum, on-lending to farmers was done at 15% per annum. The Producer Company planned to recover loans from the sale proceeds of vegetables and having a share in the produce like bananas.

4. Project Setting

The IVC Project was implemented in Muniguda and Bissamcuttack blocks of Rayagada district. This area is situated in the Southern part of Odisha (see Figure 4) and is characterized by hilly and undulated terrain. The population is predominantly from scheduled tribes. Agriculture is the primary occupation of tribal populace in the area, followed by animal husbandry.

4.1 Socio-economic Profile of Farmers

75 respondents were surveyed from the IVC project area covered under UPNRM. Out of 75 respondents, 58 had taken loan from the project, while 17 were non-loanees. The survey revealed that while loanee farmers had benefited from capacity building workshops and technical inputs other than loans, non-loanee farmers also benefited in terms of training and some technical inputs. The loan component of the project was used for building basic infrastructure and meeting working capital requirements, it was observed that:



Source: Rayagada District Administration weblink

Figure 4: Index map of project area, Rayagada

- About 90% of the loanee farmers were male, while all the non-loanee respondents covered in this study were male.
- Average age of the respondents veered around 40-45 years for both loanee and non-loanee farmers
- 64% of loanee respondents and 74% non-loanee respondents were from the scheduled tribe category; about 12% of loanee and 17% of non-loanee groups were from scheduled caste category and the rest were from other backward castes
- 62% of loanees and 70% of non-loanees had below-poverty-line (BPL) status

Table 3: Descriptive information of respondents

	Beneficiary (loanee)	Non-beneficiary (non-loanee)	Total
No. of respondents	58	17	75
Male	52	17	69
Female	6	0	6
Average age	42	45	43
Social category—SC	7	3	10
Social category—ST	37	10	47
Social category—OBC	14	4	18
Poverty status—APL	22	3	25
Poverty status—BPL	36	14	50

It was also observed that family size of respondents was 5.69 and 5.41 for loanee and non-loanee farmers respectively. Each family had 2.91 and 3.00 literate members on average in loanee group and non-loanee group respectively. The loanee farmers had on average 3.76 earning members while non-loanee respondents had 3.11 earning members in the household.

As given in Table 4, it can be observed that loanee respondents had a higher income than non-loanees attributed to the increased income from IVC project. Loanee respondents had a greater dependence on agriculture and allied activities than non- loanee. 92% of the income of loanee farmers came from agri-and allied activities while the proportion for non-loanee was only 79%.

Table 4: Income and landholding of respondents

	Loanee	Non-loanee
Average land cultivated (in acres)	4.50	3.80
Income from agri-and allied activities (in INR)	98,774	57,920
Total income from all sources (in INR)	107,089	72,878
Proportion of agri-income as that of total Income	92%	79%

It was also observed that:

- 45% of loanee farmers and 29% non-loanee farmers owned livestock (cattle/buffaloes) while the rest did not; these animals were the non-descript local breed
- 72% of the loanee farmers and 59% non-loanee farmers had one or more bullocks
- 38% loanee and24% non-loanee respondents reared goats
- 79% loanee respondents and 88% non-loanee respondents had kutcha houses; none of the houses had a boundary wall
- Borewell and tube wells were the major sources of water with around 85% of loanees as well as non- loanees depending on them
- 24% of loanees and 35% non-loanees owned television. About 15% of loanee and 5% of non-loanee farmers owned bike/scooter, while 84% of loanees and 76% non-loanees had bicycles. There were only two tractors, one with loanee and the other with a non-loanee respondent

4.2 Impacts of the IVC Intervention

IVC intervention had brought in cash crops to farming practices. This has gradually led to the replacement of staples with cash crops. The earlier cropping pattern used to be paddy, ragi, maize, and in a few places, cotton. With the advent of IVC, farmers received support on infrastructure as well as input costs. The non-loanee farmers also received benefits like information and some input costs. In the first season itself, farmers observed that the return from vegetable cultivation was significant.

For example, cultivation of rice on 1 acre of land costs around INR 7000, while cultivation of vegetables in the same area costs INR 16,000 per acre. However, the income obtained from both the crops is significantly different. Rice cultivation provides a Benefit-Cost Ratio (BCR) of 1.96, Ragi 2.31, and vegetable 3.77. In terms of net profit too, vegetable cultivation is way ahead of others – it is about six times to that of rice, and 14 times that of Ragi. Table 5 provides further details.

Table 5: Comparative profitability statement of vegetables vs. staple crops

	Rice	Ragi	Vegetable
Income per acre in (INR)	13,754	5671	60,321
Cost per acre (INR)	7,000	2450	16,000
Net benefit (INR)	6,754	3221	44,321
Benefit Cost Ratio	1.96	2.31	3.77

The profitability of vegetables was found to be higher than that of other crops. In fact, some farmers found that income from vegetable cultivation exceeded income from all other sources. A case in point was that of Mr. Laxman Raju (See Box 1).

Box 1: Vegetable cultivation or migration: Opportunity to Laxman Raju

Laxman Raju, resident of village Sindhipanga in Bishamakataka block of Rayagada district is a school dropout. He lives with his mother, one son and two daughters. There was no source of earning in his native village. Therefore, he used to migrate to Bengaluru. In 2017, however, he decided to stay back in his village and undertake the 50-cent model vegetable cultivation. This decision changed his life. He not only received capacity building training and inputs, he was also provided with technical support for a farming model that diversified the risk of various weather and market related ups and downs. He realized that for the success of vegetable farming, fencing is must. The support for this was provided by the implementing partner. He also received seeds and seedlings of different types of vegetables. Another critical input he received was credit.

Laxman has a sound knowledge about the local market. Though he is not highly qualified, he has good understanding of crop related activities. He understands that market timing plays a major role in pricing of vegetables and accordingly he has phased his crop production cycle. He always tries to space the crops in such a manner that the production takes place in lean period and he gets a higher price.

Prior to this intervention, he raised traditional crops like paddy and ragi which did not meet his financial requirements. He now cultivates crops like *parval* (pointed gourd), cowpea, okra and banana. He earns about INR 70,000 to INR 80,000 annually from this activity, which is far higher than what he would earn if he migrated to Bengaluru. From *parval* alone, he earns INR 30,000 in one season. Seeing his interest and success in vegetable cultivation, The State Government has taken an initiative to finance a tractor. He has been repaying the loan regularly. His success has inspired many others to take up vegetable cultivation.

The benefits accrued to farmers due to vegetable cultivation motivated them to inculcate them in their cropping practices. This has resulted in a change in cropping pattern. Earlier hardly anybody cultivated vegetable. Now more than 90% of the farmers have a component of vegetable in their crop portfolio that can be observed from the Table 6.

Table 6: Changes in cropping pattern among beneficiaries

Cropping pattern	3 years ago	Present situation
Paddy/Ragi/Pulses	33	
Paddy/Ragi	8	
Ragi/Pulses	15	
Others (oilseed/maize/ cotton/Kosla)	19	5
Paddy /vegetable		7
Paddy/vegetable/Ragi		12
Paddy/vegetable/Pulese/Ragi/Cotton		23
Paddy/vegetable/Ragi/pulses		15
paddy/Ragi/oilseed/others		13

Table 7 presents the findings related to profitability of loanee and non-loanee farmers. On an average, net income of loanee farmers from the agricultural activities was INR 60,787, which was about almost twice that of non-loanee. Similarly, from IVC activities, the income to loanees was INR 7306, which is 156% higher than that of loanees. The loanees also observed a markedly higher BCR than that of non-loanee.

Table 7: Profitability of loanee vs. non-loanee farmers (in INR)

	Agri and allied activities		Integrated vegetable cultivation	
	Loanee	Non-loanee	Loanee	Non-loanee
Average income	98,774	57,920	47,895	19,546
Average expenses	37,987	29,023	7,525	4,793
Average profit	60,787	28,897	37,306	14,559
BCR	2.60	2.00	6.36	4.08

It is clear that a loanee farmer earned INR 22,747 more than the non-loanee farmers on an average. Given that the population of loanee farmers was 144 in the IVC intervention, the total extrapolated income came about INR 3.28 million in one year.

The comparison between loanees and non-loanees can be further explored. Figure 5 shows that 47% of the non-loanees earned up to INR 10,000 from IVC, and another 41% earned between INR 10,000 to INR 20,000. Only 11% earned more than INR 50,000. On the other hand, from the loanee group 27% earned higher than that. Only 20% loanees earned less than INR 20,000 from IVC activities.

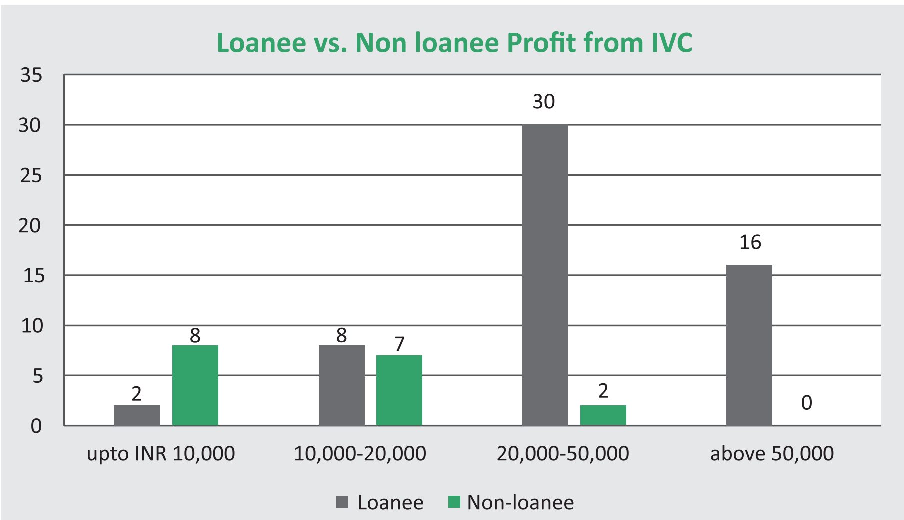


Figure 5: Profit from IVC

The non-loanees received lesser income from IVC activities than the loanee group of respondents.

4.3 Productivity and Quality of Produce

Vegetable cultivation has increased the productivity from the same piece of land. An acre of paddy cultivation provided a revenue of INR 13,754, while vegetable cultivation on the same piece of land yielded a revenue of INR 60,321 per annum. Ragi cultivation on an acre of land, provided a revenue of INR 5671 annually. There was also an observable difference in yield of vegetable of beneficiary in comparison to that of non-beneficiary farmer. While per acre yield of vegetable in beneficiary plots was 15.43 quintals, the yield for non-beneficiaries was 10.70 quintals per acre (See Table 8 for indicative results).

Table 8: Vegetable yield - beneficiary vs. non beneficiary

	Number of farmers	Land (acre)	Vegetable production (quintals)	Yield (quintals/acre)
Beneficiary	58	29.3	452.25	15.43
Non-beneficiary	17	6.85	73.30	10.70

Because of the higher availability of vegetable, its consumption had increased manifold at household level. Table 9 shows that while an average loanee household consumed 1.40 Kg per day, a non-loanee farmer consumed 1.24 Kg per day. However, this difference was not found statistically significant as reported in Table 9. When adjusted with family size, it was found that on average, a family member consumed 247 grams of vegetables (loaneee farmer) while a non-loanee family member consumed 228 grams.

Table 9: Vegetable consumption

Vegetable consumed at home (Kgs per day)	Loanee	Non-loanee
Average consumption per day	1.40	1.235
Average family size	5.69	5.41
Average consumption per family member	0.247	0.228

A few problems were also faced because of the switch to vegetable production. Due to heavy rainfall, vegetable cultivation was at times affected as it happened with tomato crop in Gatiguda in Kharif 2017. Farmers who had used solar borewell for irrigation also faced problems because of mechanical failures. No mechanic or engineer was available for its locally and the farmers had to go till Bhawanipatna or Rayagada for repair of the solar borewell.

4.4 Environmental Impact

IVC project encouraged tribal farmers to apply eco-friendly inputs. As a result, the soil quality has substantially improved due to application of manure in the cultivation plots. At Pinda village of Bisam Cuttack, farmers applied cow urine as pesticide in their 50-cent vegetable field. These vegetables, which had been produced without any chemical inputs such as pesticides and fertilizers attracted consumer demand in the market. The intervention improved soil quality that was validated through soil testing (soil PH, organic carbon content, and the proportion of nitrogen, phosphorous and potash). The soil testing results is given in Exhibit 1. The comparison of soil quality between loanee and non-loanee farmers is given in Table 10.

Table 10: Soil quality comparison of loanee vs. non-loanee farmers

	No. of samples	soil pH	Organic carbon (%)	Available Nitrogen (Kg/ha)	Phosphorus (P2O5, Kg/ ha)	Potash (K2O, Kg/ha)
Non-loanee	11	6.77	0.43	311.91	10.34	206.27
Loanee	16	6.83	0.51	339.69	13.54	221.88
Difference in percent		0.90%	17.94%	8.91%	31.03%	7.56%
t-value		1.544	1.555	1.771	3.026	1.153
significance		13.5%	13.3%	8.9%	0.6%	26%

From Table 10, it is evident that:

- Soil pH of soil samples was almost similar for both loanee and non-loanee farmers
- Organic carbon content in soil samples collected from loanee farmers' land was 17.94% higher than that of non-loanee farmers.
- Available nitrogen content of soil samples collected from loanee farmers' land was 8.91% higher than that of non-loanee farmers.
- Phosphorous (P_2O_5) content of soil samples collected from loanee farmers' land was 31.03% higher than that of non-loanee farmers.
- Potash (K_2O) content of soil samples collected from loanee farmers' land was 7.56% higher than that of non-loanee farmers.

However, it was found that only phosphorous content was significantly different at 5% significant level. Other soil characteristics (pH, Organic carbon, Nitrogen and Potash) were not statistically significant at 5% level. Although the program is not too old and considering that changes in soil quality is a long-term phenomenon, positive changes in soil quality are beginning to be observed.

5. Access to Market

Before the IVC intervention, villagers from Sindhipanga used to buy vegetables from Siripura market. However, now Sidhipanga not only has sufficient vegetable production to meet its own requirement but also villagers from Siripura often come to Sindhipanga for buying vegetables. As is seen in Case Study of Laxman Raju in Box 1, the farmers started phasing their crop production as per the demand in the market. Box 2 captures how Narasingha Jakasika was able to sell the produce locally.

Box 2: Linking Market to Narasingha Jakasika

Narasingha Jakasika, aged 27, from Khuntabadi village of Sivapadar, Munigarh block, Rayagada district belongs to the scheduled tribe community. He is married and has two children. He has two acres of land, of which 50 cent is irrigated, attributed to the IVC project. Both Narasingha and his wife have raised different types of vegetables in different seasons. They work in their land throughout the year. Through their participation in theIVC project, they are able to earn regular income. Narasingha earned about INR 40,000 last year. Narasingha is hopeful that his income will increase by taking some more measures.

Earlier, round-the-year cultivation could not be undertaken because of the lack of irrigation. Now, the IVC project has taken care of this problem. Narasingha has gained knowledge of vegetable cultivation through different training programs imparted by Harsha Trust/PAPCL. Through the project he has also been provided with high quality banana cultivar and other seedlings and seeds. Supply of input is also not a problem now.

The village is 10 K.M away from Muniguda and strategically situated on the side of the highway. This advantage has been exploited by the villagers. One marketing platform has been constructed on the side of the highway under Corporate Social Responsibility scheme of a Corporation. Other farmers of the village also sell their vegetables here. People taking this road regularly have knowledge about this market and purchase from here.

In Khutabadi village of Muniguda Block, a road-side stall has been provided by Harsha Trust/PAPCL. Some farmers like G.Chandankhunti have also been linked with other markets for selling the vegetables. If the market price of their produce goes down in the local market, the farmers take the produces to Ambadola and Lanjigarh market.

However, some farmers are facing a problem of 'right' market access. Kuni Baraika of Gatiguda village (Muniguda block) produced about 20 quintals of brinjal, but could sell it at a low price only.

Box 3: Access to Dukum Market

A market survey of Dukum, Bissam Cuttack block under Rayagada district was conducted in December 2017. The prime objective of the survey was to understand what products are brought into the Dukum Market and along with its source and selling points.

The data collected for the purposed reveals that Dukum is a vegetable driven market where tomato, brinjal, cauliflower and bitter gourd are predominantly supplied by the local producers from villages such as Pinda, Nuasahi etc. The market sourced the vegetables from about 16 vegetable sellers. It was estimated that in a year, the total transaction of vegetables in the market is worth around INR 2.8 million.

It is interesting to note that vegetable like tomato, radish, peas and fruits are brought from outside the area in lean periods, since vegetables are not produced locally as per the market demand. It means that there is a potential of promoting such vegetables in the area for meeting the demand in lean seasons. The market could also potentially cater to external demand for products such as locally processed rice, small millets (madia, kosla, ragi), pulses (Moong, Bidi, Kandul) etc.

The project is at a nascent stage, and only three seasons of integrated vegetable cultivation had passed at the time of this study. As the need for aggregation to fetch better prices came up strongly, PAPCL plans to address it. Procurement would be done in a collective manner, which could save marketing costs and improve bargaining power of producers.

6. Access to Credit

Access to credit is one of the major inputs for augmenting agricultural production. In Muniguda block, credit flow generally came from both formal and informal sources. Koraput Central Cooperative Bank (KCCB) was a source of formal credit in the block. During 2016-17, KCCB had extended loans cumulatively amounting to INR 136.2 million to 3890 farmers. During *Rabi* season, the bank extended credit to 1,963 vegetable growers. KCCB in turn, used to recover the loan through the Large sized Adivasi Multipurpose Cooperative Society (LAMPS). Prior to this development, LAMPS verified the documents of the farmers and recommended for loan to KCCB. The rate of interest charged was only one per cent. In spite of the low rate of interest, the defaulter rate was 10 per cent which was a major concern for KCCB. On the other hand, informal sources in general and Micro Finance Institution in particular, had played a significant role in the credit market.

Though the State Bank of India (SBI) had a role in extending credit facilities, but in practical, accessibility to SBI was very low. The rate of interest to the farmers was only 2% per annum as the remaining 5% was borne by the government (3% by Central Government and 2% by the State Governemnt). The interest rate could be increased from 7% to 10% per annum if repayment wasnot done is due time, and the differential is paid by the loanee.

The main reasons behind preponderance of non-banking and informal sources were the following:

- Door-step credit delivery is provided by the MFIs/informal sources while banks do not yet have such facilities
- Farmers who are engaged in share-cropping (which refers to a tenant farming) also have credit requirement that is not recognized by the banks.
- Training, handholding and technical support are provided by MFIs and their associate organizations. Such facilities are available with government bodies, but it is difficult for farmers to avail such benefits unless some agency takes up the facilitation role, as has been done by PAPCL here
- Complexity in documentation is a hindrance for accessing bank loans. MFIs do not have this problem, as the customer does not have to undertake such documentation (the MFI staff does it)
- Need of frequent visits (three to four visits to customers) by bank officials becomes a constraint because of the limited number bank staff and remoteness of locations. As the MFI offices are in the remote areas, and their field staff make regular visit to customers, making such services accessible

With the Business Correspondent (BC) model taking off for many banks, it is expected that in future banks will be able to deal with the above problems and access remotely located clients.

Annexure 1: Soil quality results of IVC fields, Rayagada

Sr. No	Name of Beneficiary	Code Loanee/ Non-Loanee	Soil pH	Organic Carbon (%)	Available Nitrogen (Kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ ha)
1	Rama Rao Bag	1	6.78	0.35	320	7.4	150
2	Bhika Bag	1	6.7	0.38	335	8.9	185
3	Teli Bag	0	6.7	0.24	260	6.5	160
4	Damarudhar Pujhari	1	6.82	0.53	325	15.2	215
5	Jagannath Pujhari	0	6.86	0.42	300	11.3	200
6	Charana Pujhari	1	6.79	0.78	420	16.2	265
7	Santosh Pujhari	0	6.78	0.43	355	10.5	215
8	Sadhaba Paresika	0	6.71	0.82	435	13.6	315
9	Narasingha Jakesika	1	6.74	0.46	345	11.2	195
10	Madan Mohan Majhi	1	6.81	0.56	335	16.8	210
11	Tankadhara Majhi	0	6.68	0.42	320	9.3	185
12	Arjun Hikaka	1	6.75	0.35	275	10.6	215
13	Birat Hikaka	1	6.75	0.34	330	9.2	235
14	Tankadhara Nag	0	6.71	0.38	290	9.5	165
15	Goura Nag	1	6.8	0.49	360	16.6	245
16	Sitai Kanika	1	6.85	0.56	324	14.30	275
17	Murti Wadeka	0	6.68	0.35	248	9.80	214
18	Shubasis Shramabuka	1	7.05	0.49	345	13.5	235
19	Depai Wadaka	1	6.8	0.63	368	16.2	226
20	Karika Sharmabuka	0	6.78	0.42	284	11.3	200
21	Rama Sharamabuka	1	6.88	0.61	348	13.8	220
22	Drinju Hikaka	0	6.75	0.39	285	12.8	215
23	Laxman Hikaka	1	6.84	0.56	335	16.8	230
24	Brushaba Hial	0	7.01	0.46	342	8.6	205
25	Udhaba Hial	0	6.78	0.45	312	10.5	195
26	Ratnakara Hial	1	6.81	0.55	345	14.8	215
27	Maheswar Raju	1	7.08	0.56	325	15.2	234

Source: Tested by CIFA, Bhubaneswar Odisha and compiled by authors

Sustainable Livelihoods and Adaptation to Climate Change

Bihar Rural Livelihoods Promotion Society

1. Background

1.1 Poverty Context in Bihar

India has 25.7% of its rural population living in poverty and 64% of its rural population depends on agriculture for their livelihood. The socio-economic situation of marginalized groups (such as the poor, women, the landless), characterized by poor access to education, information, productive resources, financial services, human and social capital as well as fewer assets and high debt, greatly enhances the vulnerability of their livelihoods to climate related shocks and stresses. All this is adding up to the growing concern that climate change could slow the progress in poverty reduction. The percentage of population employed in agriculture production system in Bihar is estimated to be 81%, with 90% population living in rural areas, 42% of state population is below poverty line as against the national average of 26%. With 83% of landholding belonging to marginal farmers (0-1 ha), low output and high operating expense forms the backdrop of vulnerability of farmers in Bihar. In 2013, India Meteorological Department (IMD) published a comprehensive monograph on 'State Level Climate Change Trends in India' which is based on long term climatic data (1951-2010) collected from 280 stations for temperature and 1451 stations for rainfall across India. As per the monograph annual mean temperature in Bihar is showing a rise of 0.01-degree Celsius resulting in increase in pest attack, thunderstorm and lightning. The monthly variation in rainfall distribution, shown in the report, is set to have direct impact on crop sowing and harvesting activities.

1.2 Climate Change in India

India has seen a 0.4-degree increase in mean surface air temperature over the past century (1901-2000) and climate change projections up to the year 2010 indicate an overall 2-4-degree rise in temperature. Risk factors in addition to increase in temperature include changes in the monsoon pattern, increased intensity of extreme weather events including flooding and tropical cyclones, extremes of heat, and sea level rise. The variability of monsoon, the seasonality of precipitation, the frequency of extreme precipitation events and short drought periods are all expected to increase. Currently, about 16 percent of the country is drought-prone and about 12 percent is flood affected. Both the frequency and magnitude of these extreme events is increasing, drought incidence has doubled from 6 to 12 between the first and second halves of the last century, and flood-affected areas have more than doubled from 19 million hectares in 1953 to 50 million hectares in 2011–12. A 2–3.5°C increase in temperature and associated increase in precipitation are estimated to lower the agricultural gross domestic product by 9–28 percent. Due to India's vast geographic diversity, the impacts are likely to be varied and heterogeneous. Bihar, in particular has to prepare for both drought and flood simultaneously. Bihar state action plan on climate change notes that 33% of state is chronically drought prone and at the same time 73.67% area of North Bihar is flood prone. The three main agro-climatic zones on the basis of soil characterization, rainfall, temperature, and terrain, North West Alluvial Plains (Zone – I), North East Alluvial Plains (Zone – II), South Bihar Alluvial Plains (Zone – III) have different average precipitation levels and the variations in weather phenomena are wide enough to substantiate the need for relevant interventions in the space of agri-risk management across the three zones.

1.3 Sectoral Context and Institutional Efforts

Agriculture provides employment to 72.3 percent of the rural workforce including 64 percent of poor households, 94.19 million of whom are women cultivators and women farm labour. The dominant agricultural livelihoods of the poor (crop production, livestock, fisheries, etc.) are hugely dependent on natural resources, such as rainfall, fodder, water bodies. Climatic hazards that affect the availability of these natural resources, adversely affect the livelihoods of the poor by impacting production, affecting incomes and preventing building up of assets. Building adaptive capacity in the rural-poor communities requires improving access to effective, locally relevant, no-regret adaptation approaches identified through a participatory planning process involving women and targeted specifically to reach the rural poor population.

India's 12th National Action Plan on Climate Change (NAPCC), an integral part of five-year plan (2012-17), contains assessment of vulnerability of various sectors to climate change and identifies specific adaptation measures to be implemented over the longer term. National Initiative on Climate Resilient Agriculture (NICRA) is another significant initiative to enhance resilience of India's rain-fed agriculture to climate vulnerability. Mahila Kisan Sashaktikaran Pariyojana(MKSP) is another initiative to promote sustainable agriculture through the use of local input and risk mitigation approaches, to ensure food security and increased net household income. Although government programmes like Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), Integrated Watershed Development Program (IWDP), etc., integrate coping capacity of local communities to potential impacts of climate variability and change, they do not have a systematic approach to assessing and addressing climate change risks. Similarly, National Mission of Sustainable Agriculture and National Initiative on Climate Resilient Agriculture are implementing innovative pilots and technological packages on farmers' field but have no specific focus on targeting the rural poor on a large scale and seek to address only 'adaptation gap' issues leaving aside issues related to 'adaptation deficit'.

2. Introduction

Sustainable Livelihoods and Adaptation to Climate Change (SLACC) is a Global Environment Fund supported program, piloted in around 650 villages of Bihar (Khajauli & Rajnagar blocks of Madhubani district and Gurua & Barahchatti blocks of Gaya district) and Madhya Pradesh (Sheopur and Mandla districts) together covering around 12,000 rural households between 2015-2019 to improve the adaptive capacity of rural poor engaged in farm-based livelihoods to cope with climate variability and change. The geographical location for the pilot has been selected based on institutional maturity of Self-Help Group (SHG)/ Village Organisation (VO)/ Cluster Level Federation (CLF) to work on higher order poverty alleviation dynamics and occurrence of extreme weather events of flood and drought. The programme outlines key component in the form of community led risk assessment (risk-response matrix), Participatory Climate Change Adaptation Planning (P-CCAP), climate literacy (daily, short-term and long-term weather forecast), development of implementation framework, capacity building of community, cadre and staff, and building knowledge support system for climate adaptation.

2.1 Project Development Objective

i) At least 50% of the targeted households adopt livelihoods with enhanced climate resilience

ii) At least 50% of the targeted households demonstrate strengthened awareness and ownership of adaptation and climate change risk reduction processes/measures.

2.2 Intermediate Results Indicators

i) At least 8,000 farmers demonstrate climate resilient agriculture practices

ii) At least 30% of the community institutions access technical and/or financial support for climate adaptation plan through convergence with government programs.

iii) At least 6,000 SHGs are trained in adaptation related technologies.

iv) At least 300 staff of state and district offices as well as extension and rural service providers trained on technical adaptation themes.

v) Climate change adaptation guideline developed for National Rural Livelihood Mission (NRLM) implementation framework and disseminated to all State Rural Livelihood Missions (SRLMs)

vi) Establish Climate adaptation units within National Mission Management Unit (NMMU) and SRLMs of participating states.

vii) State level resource agencies and/or technical service providers for providing field level technical

Started with pilot in 100 villages in 2015 in Bihar, SLACC has currently scaled up to around 400 villages in BRLPS pursuing the mandate to establish proof of concept of developing climate resilience among 6000 rural poor in Bihar. BRLPS facilitates SHG formation to bring together coherent group to collectively pursue social and economic aspiration. Around 10 of these SHGs combine to form VO and 20-30 VOs combine to form CLF. Each block is divided in 3 CLFs with representation from each village organization under it. These community-based institutions namely CLF, VO, and SHG are placed at the core of the project (SLACC) to follow bottom up approach in decision making on intervention selection, budgetary provision, book keeping of expenditure, and self-regulatory framework to drive the program ahead. Community Based Organisations (CBOs) are assisted in decision making by project staff placed at block, district and state level with CBO cadres (village resource person acting anchoring livelihood activities in the VO, Skilled Extension Worker anchoring livelihood activities in coordination with office bearers of CLF and project staff, book keepers anchoring book keeping at village level, Master book keeper anchoring book keeping at CLF level) acting as the bridge between promoting agency BRLPS (Jeevika) and the CBOs. CBOs have been provided with requisite grant and loan fund to steer interventions with the support of BRLPS and partner organizations. Decision (financial and non-financial) at CBO level is facilitated in regular meetings in the presence of office bearers of the constituent CBO. To assist CBOs in decision making and streamlining interventions, dedicated team of development professionals and agriculture graduates from premier institutes like IRMA, Symbiosis, IIFM, and BHU have been placed in SLACC blocks to anchor the program, supported actively by following partners: -

1. PRAN (Preservation and Proliferation of rural resource and nature)- Lead Technical Partner
2. Crop In Technology Solutions - Agro - Weather Advisory Service Provider
3. Skymet Weather Services Pvt. Ltd.-Weather forecast provider
4. IFFCO Kisan Sanchar Limited (IKSL) - Crop, government convergence programs, health & hygiene advisory provider
5. TARU Leading Edge Pvt. Ltd. - Monitoring & Evalution Agency

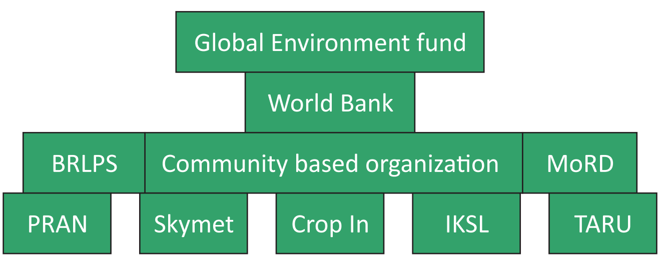


Figure 1: Institutional arrangement

3. Approach

3.1 Framework

Framework for program implementation is spread into four major quadrants for planning, implementation, and mainstreaming community based climate change adaptation process as detailed below:-

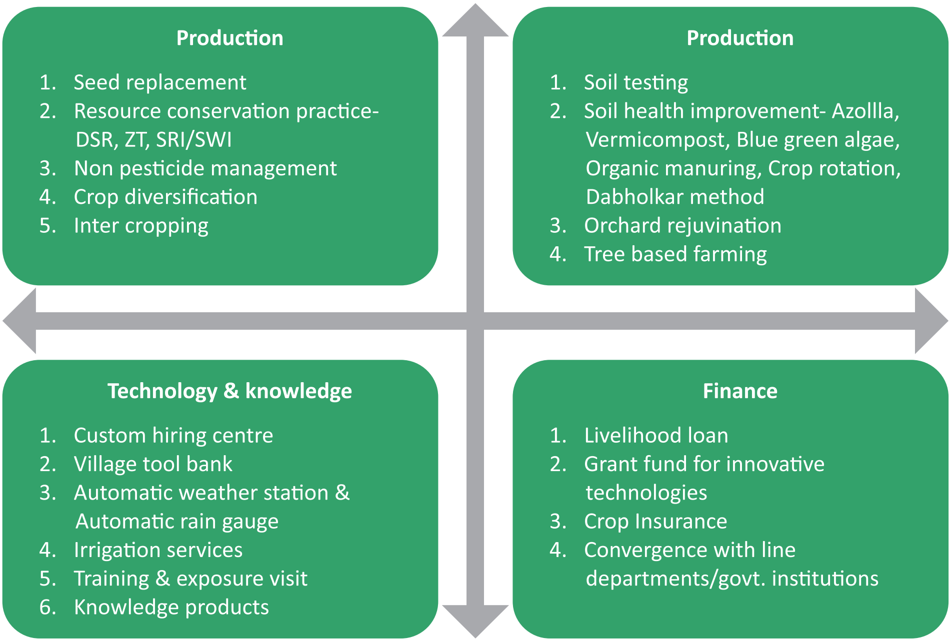


Figure 2: Programme framework

3.2 Vulnerability Assessment Tool

To ensure bottom up approach in the journey of building resilient among community against climate change and variability, participatory planning exercise to devise climate change adaptation planning has been adopted in following ways: -

1. Transit walk with community to identify resources (water, land, animal and forest) in the village.
2. Preparation of annual livelihood calendar in the village
3. Preparation of calendar of weather risk in the village
4. Ranking of livelihood options based on income and expenditure
5. Ranking of livelihood options based on weather risk
6. Comparative of all above data into a consolidated customized report on livelihood options, corresponding weather risks, and the adaptation/mitigation strategy to manage/mitigate the risks.

Community based participatory exercise helped build awareness around difference between climate and weather, climate variability and change, identification of major weather-based risks in the region, preparedness for the risk and design interventions accordingly.

3.3 Risk Response Matrix

In addition to the conventional poverty alleviation approach, SLACC employs risk assessment and response mechanism to build resilience among rural poor to cope with weather risks and shocks. Risk-response matrix adopted in SLACC is briefed below: -

Table 1: Risk response matrix

Sr. No.	Risk	Crop	Vulnerability period	Adaptation measure
1	Insufficient rain	Wheat, Paddy	Sowing period	Zero tillage (Wheat)- Leverages soil moisture Direct seeded rice (Paddy)- Practiced for rain-fed and deep-water ecosystem
2	Flash floods	Paddy	Kharif	Staggered nursery
3	Delay in crop cycle	All	Annual crop calendar	Farm mechanization (Custom hiring centre @ cluster level and Village tool Bank @ village level)
4	Flood	Paddy	Kharif	Water submergence resistant variety (E.g. Swarna-sub 1)
5	Drought	Paddy	Kharif	Less water intensive sturdy crops like millets (E.g. finger-millet, Sesame)
6	Local pest infestation	All	Annual crop calendar	Local pest resistant variety (e.g. SML-668, Vishal)
7	Terminal heat stress	Wheat	Rabi	Heat resistant variety (e.g. HD 2967) Direct sowing using Zero tillage machine so that milking stage is complete before exposure of westerly wind
8	Long dry spell	Paddy	Kharif	Dedicated irrigation system for the village organization
9	Crop loss due to stagnant water	Paddy	Kharif	Contingency planning- Cultivation of water chestnut in stagnant water
10	Loss of yield due to frost	Potato	Dec	Intercropping of Potato with Rajma/Bakla - Rajma/Bakla acts as cover crop for Potato and minimizes the impact of frost. - Increases cropping intensity.

4. Results of the Intervention

Key interventions (quadrant wise) under SLACC are detailed as under:

4.1 Production

Seed replacement - Local seeds have low coping mechanism towards changed weather conditions like increase in temperature, humidity, heat stress, pest attack etc. In consultation with research institutes and Agriculture Universities, seed replacement has been adopted to introduce varieties that can withstand weather extremities like water logging in fields (Paddy- Swarna-sub1), scanty rainfall (Ragi- RAU 3/RAU8), local pest attack (Yellow mosaic pest resistant variety in Mung- SML 668), heat resistance (Wheat- HD 2733, HD 2967) etc. Seed treatment using Rhizobium, Phytogypsum and Trichoderma has been mainstreamed into cultivation practices.

Table 2: Detail of seed replacement undertaken in SLACC

Sr. No.	Crop	New variety	Traditional variety
1	Wheat	HD 2733	UP 262
		HD2967	Lok one
2	Potato	K Pukhraj (Madhubani)	Nepali aalu Lal gulab
		K Sinduri (Madhubani)	
		K Ashoka (Gaya)	
		K Jyoti (Gaya)	
3	Rajma	Utkarsh	
4	Bakla	S Gaurav/Suraksha	Laharia
5	Fenugreek	HM444 (Green methi)	
6	Coriander	Pant Haritama	

Table 3: Analysis of demo versus control plot for climate resilient varieties vis-a-vis traditional variety

Sr. No.	Intervention	Crop	Variety	Demo plot results (Yield in Qt/katha)	Control plot results (Yield in Qt/katha)	Impact parameter	Remark
1	Seed replacement- Stress tolerant variety	Potato	Pukhraj (white)	7		Yield	Market rate- Rs 5-6/kg
			Sinduri (Red)	5.9			Market rate- Rs 6-7/kg
			Traditional lal gulab		3.5		Market rate- Rs 6-7/kg
		Green gram	SML 668 (medium size)	0.22		Pest infestation- 10%	
			Traditional variety (small size)		0.15	Pest infestation- 25%	
			Vishal	0.22			
			PDM 139	0.23			
		Ragi	RAU 8	0.27		Yield	
			Traditional		0.15		
		Paddy	Sahbhagi	0.75		Crop security	
			Swarna sub 1	0.88		Crop security	
			Rajshree	0.78		Crop security	
			COR 51	0.7		Crop security	
			Kasturi	0.6			High market price
			Traditional		0.7		
		Urad	PANT U31	0.23		Yield	
			Traditional variety		Traditionally Urad is not taken in Zaid		
2	Technology- Zero tillage	Wheat	PB 343	0.9	0.47	Resource and yield	
3	Technology- SWI		HD 2967	0.8	0.75	Resource and yield	
4	Technology- SRI	Paddy		0.98		Resource and yield	
5	Technology-Paddy transplanter			0.75		Resource and yield	
6	Technology- DSR			0.68		Crop security	
7	Traditional paddy				0.68		

Resource conservation practices like DSR, ZT, SRI- Direct seeded rice has been adopted to leverage on residual soil moisture to sow the crop and shrink the sowing period to avoid dry spells which lead to early harvest and an additional window for the farmer to take up short vegetable crop like tomato, cucumber etc. at a timing when market offers better rates for the produce. System of Rice Intensification has been adopted to intensify crop in per unit area and obtain better produce with optimal water requirement (SRI). Crop in milking stage during the month of February can't withstand severe exposure to western winds and dries up resulting in large scale crop loss. Zero tillage as a technology has been adopted for direct sowing and thereby saving approx. 15 days. This lead of 15 days leads to completion of milking stage by the time crop gets exposure to western wind, thus saving the crop. Apart from this, zero tillage is a conservative method that retains soil moisture, maintains organic carbon content and saves input cost on seed/fertilizer/pesticides etc., thereby increasing net profitability. Crop cutting experiment (yield assessment technique) recorded following observation:

Table 4: Observations of crop-cutting experiment

Sr. No.	Variety	Yield (Quintal/Kattha)
1	PB 343 variety using normal cultivation practices	0.47
2	PB 343 variety using Zero tillage method	0.90

Intercropping to leverage as self-defense from weather borne risks: -

i. Potato (K Pukhraj/Sinduri/Jyoti/Ashoka) has been intercropped with Balka (Swarnagaurav) and Rajma (Utkarsh). Bakla/Rajma plants act as cover crop for Potato and save it from frost. Crop cutting experiment recorded that local variety (Lal Gulab) gave yield of 3.5 Quintal/Kattha, while K Sinduri variety gave yield of 6 Quintal/Kattha at same market price.

Table 5: Climate resilience through intercropping

Sr. No.	Crops	Climate resilience
A	Potato + Rajma/ Bakla	Cover crop (Rajma/Bakla) prevents damage by frost.
B	Paddy + Arhar	Arhar breaks wind and prevents lodging

ii. Spices crops namely Fenugreek (HM444), Coriander (Pant Haritama), Ajwain (Rajendra Mani), Fennel (Rajendra Saurav), Garlic (Jamuna Safed 3) have been introduced as cash crops and the community is upbeat about productivity and net profit from these crops.

Crop Diversification- Crop portfolio has been diversified from traditional paddy-wheat basket to expand into millets, mushroom and orchards. Millets are sturdy crops that can survive even scanty rainfall so RAU 8 variety has been introduced which requires very less water for its survival. The crop is also a rich source of fodder for livestock. Mushroom production has been adopted as alternate livelihood source with no farm-based risks like rainfall, temperature, pest attack etc. Production system in mushroom is household based, has low input cost and is maintenance intensive and the return is significantly high. Community is upbeat with this alternate source of livelihood. Passive management of large-scale mango orchard available in Madhubani district is resulting in poor returns for the farmers. Working on risk diversification principle, just like in mushroom case, intervention has been designed around its rejuvenation to evolve as alternate source of livelihood with risks different form farm-based livelihood.

Table 6: Crop diversification for climate resilience

Crop	Climate resilience
Ragi/ Madua	Adapts to scanty rainfall, low fertile soil, high temp.
	Nutrition rich
	Fodder rich crop (30-35 Qt/H fodder)

Non-pesticide management practices- In order to improve organic carbon in soil, non-pesticide management practices have been adopted by training the community on non-pesticide based cultivation practices. Demonstration of Azolla, organic fertilizers, organic pesticides, integrated pest management, Pheromone trap etc has been conducted in detail. The components taught under the training are briefed as below:-

Table 7: Organic farming training

Sr. No.	Organic ingredient	Purpose
1	Srijeevamrit	Substitute of Urea
2	Pranamrit, Barkamrit	Substitute of DAP
3	Neemastra	Prevents from White fly
4	Bramhastra, Angeastra	Prevents from caterpillar
5	Lohastra	Prevents from Aphids
6	Mathhastra	Fungicide
7	Sriamrit	Growth regulator
8	Sribeejamrit	Seed treatment
9	Sarvkitnashi	Prevents from fruit & shoot borer

4.2 Ecology

Soil testing and soil health improvement practices- Soil health over years has degraded owing to variety of farm based practices. Farmer being unaware of soil health applies nutrients on its assumptions which are largely incorrect. Soil testing lab has been established in all four blocks to test soil on pH, Electrical Conductivity (EC), Organic carbon, Nitrogen, Phosphorous, Potassium, Sulphur, and micro nutrients like Zinc, Iron, Manganese, Boron, Copper and additional 3 parameters like Lime, Gypsum, and Calcium

Carbonate. This will provide farmers opportunity with informed choice for improving soil health, thereby enhancing overall productivity. Azolla cultivation has also been adopted to improve fodder nutrition for livestock and nutrient content in soil. Vermi-compost has been built to make available compost for improving soil health.

Tree based cropping- Tree based cropping has been implemented for cash crops like papaya and drumstick. This evolves as additional income source contributing in cash flow for the farmers thus building their resilience. Tree plantation of mango, drumstick and papaya has been done on large scale in convergence with horticulture department to diversify farm-based production risk.

4.3 Technology and Knowledge Management

Automatic weather station and automatic rain gauge- Lack of capacity to counter dynamic weather conditions makes farmers vulnerable towards weather borne risks. Technology has been roped in to equip each extension resource with smart phone and crop- application to record entire crop cycle, generate alerts and facilitate advisory from specialist for the alert generated. Precise weather information on rainfall, temperature, humidity, solar radiation and wind speed & direction at village-level has been made available through installation of Automatic Weather Station and Automatic Rain Gauge.

Agro-weather crop advisory- Agro-weather crop advisory services is the unique feature of SLACC under which a pool of 110 cadres are provided with smart phone and trained on Smartfarm app to carry out geo tag, add plot, audit area, record crop stages, generate alert, facilitate advisory and record harvest. 20 automatic weather stations and 80 automatic rain gauges are installed in 100 SLACC villages in Bihar to capture hyper-local data on min-max temperature, humidity, rainfall, wind speed, wind direction in three categories daily weather, short term forecast; and long-term forecast and the generated data is fed into a central portal where Agro-weather crop advisory is developed and disseminated to farmers on their mobile. Advisories disseminated to farmers fall in three broad categories of (i) package of practice (PoP), (ii) short term weather forecast and (iii) curative advisory in response to user raised alerts. While PoP advisory and weather forecast is streamlined based on input from subject matter specialist and system configuration, curative advisories are sent in response to alerts raised by cadres. This has enabled farmer to streamline improved package of practices, re-align cultivation practices like sowing, irrigation, fertilizer/pesticide spray, harvest etc. based on short term weather forecast and avoid crop loss due to pest and disease attacks. Agro-weather forecast services decrease the temporal and spatial unpredictability in weather phenomena. Mobile based daily advisory to farmers has been made available based on planning for their seasonal requirements like crop selection, seed variety, treatment practices, crop package of practices, pest control etc.

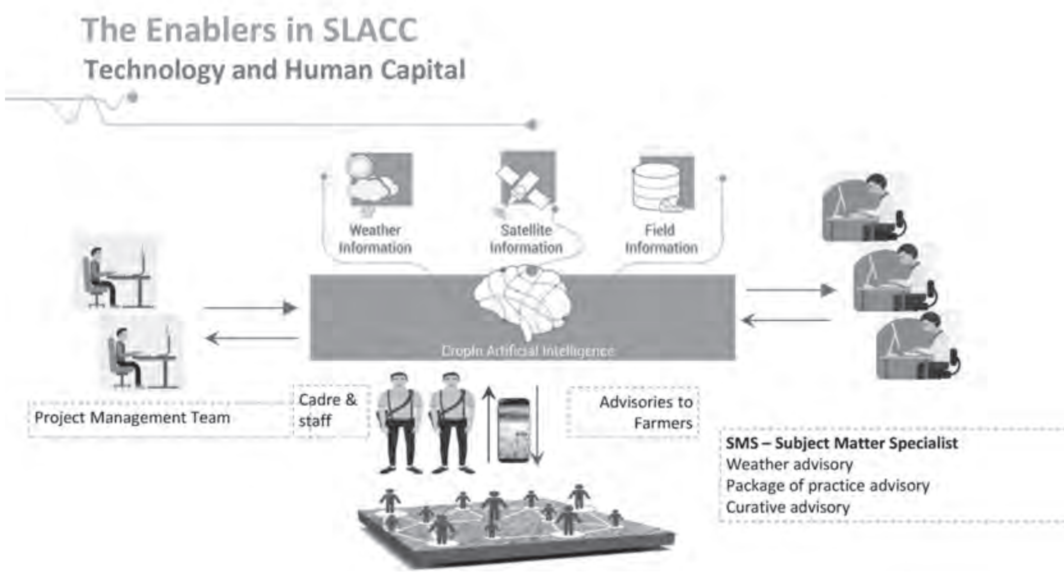


Figure 3: Schematic representation of technology and human resource in SLACC

Training and capacity building- Exposure visits to farms of climate smart farmers, agriculture universities, Kisan fair, machinery exhibitions have been arranged for farmers, extension workers and staff, to build awareness on climate change adaptation work undertaken by other institutions. Trainings on package of practices has been periodically arranged to build capacity towards climate resilience activities planned in the project. Consistent capacity building of farmers has built an increased level of understanding on climate change and adaptation practices. Various knowledge tools like seasonal package of practices, project orientation tool etc. have been developed for the community to adopt climate resilient practices as standard cultivation practices on a large scale.

Irrigation services- Lack of timely irrigation in crucial stage of crop growth leads to crop failure. So installation of community irrigation system is done to ensure timely and sufficient irrigation requirement for the crop. Technologies like drip, submersible irrigation, and solar irrigation have been demonstrated at large scale in SLACC.

4.4 Finance

Dedicated loan component for enabling farmers to adopt climate smart technology, purchase stress tolerant seed variety, purchase energy efficient irrigation systems, diversify income portfolio by investing in livestock, purchasing insurance, purchasing farm equipment to ease farming process etc. has been designed in the project to enable smooth transition towards adoption of resilient practices.

Table 8: Scale of operation

Sr. No.	Intervention	Outreach
1	Seed replacement	10,000
2	Mushroom production	5,000
3	Soil testing	4,000
4	Irrigation services (30 units established; 70 in process)	2,000
5	Training and capacity building of cadre and staff	12,000
6	Exposure visit of farmers, cadres and staff	1,500
7	Automatic weather station and automatic rain gauge	100
8	Agro-weather advisory services	4,000
9	Farm mechanization	4,000

Table 9: Convergence done under the programme

Institutions	Purpose
Dr. Rajendra Prasad Central Agricultural University (DRPCAU), Pusa; Indian Council of Agricultural Research (ICAR) Patna; Central Potato Research Station (CPRS) Patna; Indian Institute of Vegetable Research(IIVR), Varanasi, Jain Irrigation, Sabour Agriculture University, District Agriculture Department Madhubani & Gaya, Horticulture department Madhubani & Gaya, Krishi Vikas Kendra (KVK) Birouli, Makhana research station Darbhanga, TERI, International Water Management Institute (IWMI), Aga Khan Rural Support Programme (AKRSP)	Seed, custom hiring centre, training & exposure visit, plant protection tools, Mushroom spawns, Treee plantation under Van Poshak scheme, Vermicompost, Azolla, Papaya/ Drumstick, Solar stove, Soil testing, Solar Irrigation schemes with BREDA A total of INR 18.9 crores has been leveraged under convergence with various departments/institutions

5. Impacts

Impact of the project has been documented, highlights of which are provided below

5.1 Monitoring and Evaluation (M&E) Findings

Third party mid-term performance evaluation (survey sample size- 1400 farmers) of the project by TARU Leading edge has yielded following insights into the effectiveness of the project:

a. Very high level of awareness of interventions- approx. 90%

b. Very high awareness of adverse weather events and correlation of weather borne risk with crop loss; knowledge of link between interventions and weather is less clear

c. Very high inclination to continue (almost 100%) and self-reported benefits in dealing with adverse weather conditions (70%-90%).

5.2 State MIS has Yielded following Additional Insights into Impacts

a. Almost 100% of targeted farmers have demonstrated climate resilient agriculture practices.

b. Almost 100% of CBOs have accessed technical and/or financial support for climate adaptation plan through convergence with govt. programs

c. Almost 200% of target officials have been trained on technical adaptation techniques.

d. Almost 90% of targeted farmers have accessed climate resilient technology to adapt to weather risks. 100 Village Tool Banks and 11 Custom Hiring Centres have altogether generated approximately INR 3.5 lakh rupees as user fee from member farmers.

e. Almost 30% of targeted farmers have safeguarded productivity against crop loss due to dry spells. CBOs have generated almost 1 lakh rupees in lieu of service charge for providing critical irrigation service.

5.3 Digital Farm Management

Mapping using geo-tagging of all natural resources, target farms has been done for entire project area for virtual monitoring and presentation of interventions adopted on the farms to safeguard productivity against weather induced loss.

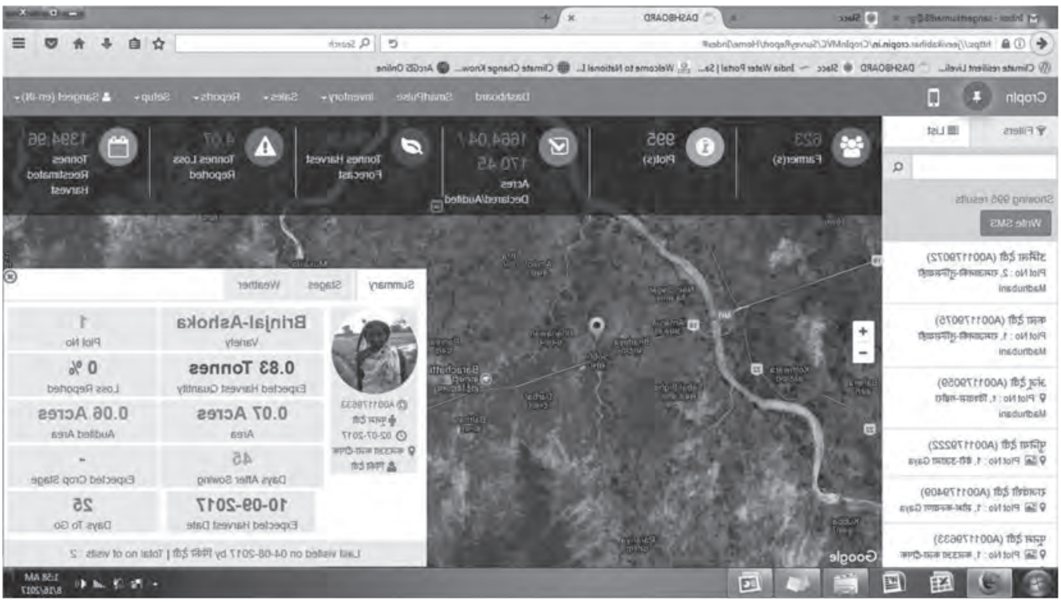


Figure 4: Geo-tagging of natural resources and farms

5.4 Service Models (Entrepreneurial/Enterprise Mode)

Custom hiring centre & Village tool bank- Farm mechanization has been stressed to improve farm productivity by timely sowing, harvesting, efficient fertilizer use, efficient weeding and resource conservation techniques. Due to change in weather parameters, risk free cultivation windows are usually very short to capitalize. Farm machineries in those scenario turns useful to leverage the small window, remove drudgery, respond to labor shortage and leverage efficiency of scale. Bigger equipments like Paddy transplanter, Zero tillage, Thresher, Reaper binder etc. have been purchased and placed at cluster level. Custom hiring centres refers to services points at CLF level where farmers can lend bigger machineries which they cannot afford to purchase at individual level. Apart from bigger farm machineries, smaller equipments that are required in villages like vegetable transplanter, digital moisture meter, power weeder etc. are placed in village tool bank in each SLACC villages. These custom hiring centres and village tool bank are run as enterprise by the CBOs. Apart from enterprise level service model, individual entrepreneurs have also evolved out the pool of SLACC cadres after understanding the gap in preparedness and response mechanism to adapt to weather vagaries. Entrepreneurs have established solar irrigation facility in convergence with BREDA and are selling water for irrigation purpose to fellow farmers. Similarly, farmers have come together to form producer group to market the mushroom that they collectively grow. These farmers are now availing training on mushroom processing to establish mushroom processing units. Following entrepreneurship route, progressive cadres have adopted mushroom, nursery and vermicompost at commercial scale to take lead as agents of change.

6. Lessons Learnt

SLACC started with 100 villages in Bihar in 2015 and within two years based on the learnings from the program, it has been scaled up to around 400 villages. The learnings are summarized as below:

1. Project like SLACC are hope of building bridge between scientific knowledge accumulated at University/research station/labs to farmers' field.
2. Convergence with existing government programs is a much-needed step to avoid duplicacy of efforts and improve efficiency.
3. Customized advisory on soil moisture, weather forecast, latest knowledge, sowing window, pest management, weather insurance, farm mechanization, canal irrigation rejuvenation are new age need of farmers that need to be addressed on priority basis.
4. Weather based advisory has done well in the project but collection of evidence is needed.

7. Challenges and Way Forward

7.1 Challenges

a. Ownership of community asset by CBOs usually takes longer time and more so if the concepts are new. Irrigation service centre, CHC, VTB etc. needs more ownership at community level to ensure sustainability.

b. With consecutive weather adversaries in subsequent seasons in Bihar, farmers sometime look to quick solution instead to investing time and effort in long term solutions. Farmer mobilization for sustainable solution is a challenge.

c. Transition from age old practices that are redundant right now is also a challenge given the fact that farmers to accustomed doing that. For example, production of paddy despite fast depletion of ground water and frequent occurrence of dry spells.

7.2 The Road Ahead

The project envisages the following future initiatives:

a) Investing in rain water harvesting in Gaya, which is a rain shadow region with fast depletion of ground water.

b) Intensifying irrigation service points in Madhubani to reduce surface flooding by curtailing rejected recharge. The project has partnered with IWMI-AKRSP (I) to establish large scale irrigation sub-project in Madhubani.

c) Invest on a pilot basis in weather index based insurance.

d) Establishing NPM shop at CLF level and handhold the CBOs to operate it on enterprise mode.

e) Making MIS application operational for better monitoring and implementation.

With above mentioned steps, the journey towards climate resilience has just begun. This journey towards climate resilience is not just about adoption of new practices; rather it is about unlearning redundant practices and evolving scientific temper at community level to adopt practices that are often contrary to popular myths. This journey is a social movement towards better future for not only the producer but also the consumer and all other stakeholders.

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Building climate resilience through System of Crop Intensification – Contrasting and similar experiences from the Bundelkhand and Himalayan Regions of India

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People's Science Institute and Dehradun

1. Background

The Bundelkhand and Himalayan regions of India represent two stark contrasts in agro-ecological conditions and effects of climate change, but they bear similar characteristics of vulnerability in terms of fragility, marginality and accessibility. According to the classification of agro-climatic zones, most of Uttarakhand and Bundelkhand fall under the Western Himalayan Region and the Central plateau and hills agro-climatic zones respectively. The Himalayas, being the youngest mountain ranges in the world, are also among the most unstable, rendering Uttarakhand vulnerable to the slightest of weather extremities and making it one of the most climatically sensitive, fragile and vulnerable regions of the country that is frequently hit by floods, cloud bursts and landslides. The state is perhaps the most vulnerable to natural disasters and is classified in Zones IV and V of the earthquake intensity map of India. These disasters are as a result of anthropogenic, climatic and geological reasons. The last three decade have witnessed catastrophic disasters especially the 2013 Kedarnath Floods, the aftermath of which caused a loss of life and livelihoods to thousands of people in districts of Rudraprayag, Bageshwar, and Chamoli among others. In the recent times, years 2016 and 2018 were excessive and erratic rainfall years, during both the *Kharif* and *Rabi* seasons[1].

Bundelkhand covers an area of 7.08 million hectares (Mha) in seven districts of Uttar Pradesh and six districts of Madhya Pradesh. The region generally slopes from south to north and is characterized by hard rocks and undulating terrain. The Bundelkhand region has faced conditions like droughts repeatedly in the last decade and was declared "Drought Affected Special Area" by the Government of India. Despite these climatic conditions, agriculture is the predominant occupation in Bundelkhand with over 80% of the population dependent on farming, livestock and usufructs from forests in addition to income from seasonal migration after *Rabi* sowing. Bundelkhand region has faced an unending spell of natural disasters- continuous droughts between 2003 and 2010, floods in 2011, late and deficient monsoon rains in 2012 and 2013; droughts again in 2014 and 2015, and erratic high intensity rains in 2016, 2017 leading to meteorological, hydrological and agricultural droughts almost every year affecting the already low productivity of the region significantly. Uttarakhand has a total population of approximately 1 million[2]. More

[1] Irrigation Department, Uttarakhand

[2] Census of India, 2011

than 70% of the population of Uttarakhand is rural of which 90% is dependent on rain-fed agriculture. Almost 90% of the farmers have an average land holding of 0.6 ha. The districts of Rudraprayag and Bageshwar, have a rural population of almost 90% each with the Scheduled Caste population being 20% and 26%, respectively. Similarly, for Bundelkhand, the total population of the region is 18.32 million out of which over 79% is rural. The population density of the region is only 260 persons/sq.km, against the national average of 382 persons/sq.km. In Panna district of Madhya Pradesh, which falls in Bundelkhand region, almost 87% of the population is rural, with a Scheduled Caste and Scheduled Tribe population of 20% and 16% respectively[3]. Caste dynamics are very strong in the Bundelkhand region. SC/ST communities are mostly found on the fringe of development, and are landless, sharecroppers or peasant cultivators.

2. The Problem

The above mentioned agro-climatic factors for Uttarakhand as well as Bundelkhand affect the agricultural communities most, as subsistence agriculture is the mainstay of the people. They have an average landholding of less than 1 acre, most of which is under dry land or rain-fed farming. Due to change in the hydrological cycle, soil moisture has reduced and crop productivity has decreased resulting in increased workload of women, and enhanced food and livelihood insecurity. With land under cultivation on a decreasing trend due to various factors, human animal conflict and lack of income generating activities, high rates of migration have also been experienced in many villages. In these remote villages, there is a lack of exposure to and knowledge of advancement in technology about new improved organic seed varieties, climate resilient sustainable cropping systems, and soil health enhancing practices, moisture and water conservation measures, storage facilities and market linkages. In a study conducted by PSI on understanding the food gaps at the household level in Uttarakhand, it was found out that only 30% of the requirement of the pulses consumption per gram per day was available through farm production and the remaining 70% was purchased from the market or not available at all. This was especially so in the remote and SC dominated villages. Similarly, the basic minimum quantity of food at household level was not available to most of the people in Bundelkhand. There is a significant gap in the total food production and the needs of the people, resulting in food insecure households and undernourished people.

People's Science Institute is a non-profit public interest research and development support organisation based in Dehradun that has been working in areas of livelihood security through agricultural innovation, spring-shed development, fluorosis mitigation, disaster resilience and preparedness among many other areas. It has relentlessly tried to understand the impacts of disaster on traditional livelihoods while incorporating the collective action framework for mitigating these impacts in the disaster and poverty prone regions of Indian Himalayas and Bundelkhand region for more than two decades.

[3] Census of India, 2011

While working with the farmers in Uttarakhand and Bundelkhand and after much introspection, PSI realized that most farming interventions in the past have been developed through on-station trials, these techniques are mostly promoted through top-down approaches that has mostly benefitted well to do farmers leaving behind the small and marginal farmers. Further, these techniques require a good amount of inputs such as chemical fertilizers, pesticides and assured irrigation. This means higher yield is directly proportional to higher inputs.

3. Innovation Adopted

Rice and wheat are the most widely cultivated Kharif and Rabi crops respectively, in both the regions. But their cultivation is often unremunerated and unsustainable. Rice and wheat yields are very low. Poor, small and marginal rice farmers (about 90% of the total farmers) are often unable to meet their annual grain needs.

Between 2006 and 2010, PSI undertook on farm trials on System of Rice Intensification (SRI) and its application on other crops with about 30,000 farmers of Himalayan and Bundelkhand regions. The principles of SRI can be applied for a variety of crops including pulses, millets, and oilseeds. The initial farm trials demonstrated that SRI could be a cost effective method of enhancing grain yields and straw volumes. The much higher SRI crop's stalk volume provided more fodder for cattle leading to increased milk production and increased farm yard manure for fertilizing fields. Inspired by this success of SRI demonstrations, PSI decided to apply SRI principles to wheat and termed it as the System of Wheat Intensification (SWI) and later on other crops renaming it as System of Crop Intensification (SCI). Based on the experiences and success of these trials, in the year 2014, PSI introduced SCI in some of the most vulnerable villages of Bundelkhand and Uttarakhand as an approach to address issues of climate change, lack of food and livelihood insecurity as well as ecological sustainability.

SRI methodology is based on four main principles that interact with each other - early, quick and healthy plant establishment; reduced plant density; improved soil conditions through enrichment with organic matter and reduced and controlled water application. Based on these principles, farmers can adapt recommended SRI practices to respond to their agro-ecological and socioeconomic conditions. Adaptations are often undertaken to accommodate changing weather patterns, soil conditions, labour availability, water control, access to organic inputs, and the decision whether to practice fully organic agriculture or not.

1. Seedlings raised from healthy seeds are transplanted when they have just two leaves (8-12 days old). This leads to vigorous tillering and root growth.
2. Wide spacing: The young seedlings are carefully transplanted in a square pattern, with one or at most two plants per hill and a recommended spacing of 25cm x 25cm between adjacent plants. This increases the nutrition, air and light available per plant.

3. Reduced water use: Besides water, roots require oxygen for good health. Therefore less water is used, just enough to keep the soils moist, well-drained and aerated. This improves the growth of roots and beneficial soil microbes.

4. Weeding and soil aeration: Regular weeding in the first month after transplanting controls weed growth, aerates the soil and maximizes nutrients supplies. Line planting facilitates the use of mechanical weeders which incorporate weeds into the soil and aerate it.

5. Organic cultivation: Improved organic composts, such as NADEP or vermi-compost, are preferred along with special preparations like *panchgavya* or *amritghol* to enhance soil fertility. Chemical fertilizers may be used only if needed to balance organic fertilizers.

The System of Crop intensification (SCI) is an agro ecological innovation for improving agricultural production, food security and resilience to climate change. Application of principles and practices of System of Rice intensification (SRI) for a range of other crops is being referred to as SCI. It aims to achieve higher output with less use of or less expenditure on land, labour, capital, and water – all by making modifications in crop management practices (FAO, 2014).

4. Process Innovation

The methodology that PSI adopted to implement this agricultural behavioural practice change with the farmers in both Uttarakhand and Bundelkhand was a holistic one. PSI identified interested local youth or progressive farmers as Village Level Resource Persons (VLRPs) who were trained in the process of SCI. These VLRPs provided timely support to local farmers in terms of capacity building, adaptability in local contexts, exposure visits to different areas for an exchange of knowledge and demonstration. Post-harvest facilitation of PSI ensured that local contexts and traditional knowledge systems are adhered to.

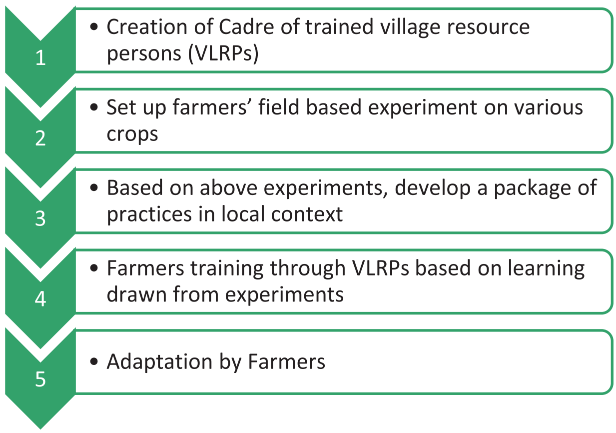

Figure 1: PSI methodology to promote SCI

In the year 2014, post Uttarakhand floods of 2013, after provision of immediate relief in the form of food and temporary shelter, PSI planned some entry point activities focussed on agriculture to promote SWI with the farming communities of 10 flood affected villages of Rudraprayag (Madhu Ganga cluster) and Bageshwar (Revati Cluster) districts. Awareness was spread through demonstration effect by selecting and training approximately 60 farmers from each of the clusters of Rudraprayag and Bageshwar districts. The first experiments in those clusters were undertaken with wheat in the Rabi season of 2014-2015.

Madhu Ganga cluster of Rudraprayag district is completely dependent on rains whereas Revati cluster of Bageshwar still has some land under irrigation where PSI is also involved in implementing irrigation facilities for farmers where they grow paddy by transplanting as opposed to direct sowing. In villages of Panna district of Bundelkhand, paddy is mostly grown by transplanting method. Here also PSI promoted irrigation through construction of earthen check dams and digging of farm ponds.

Box 1: Vimla Devi, Bageshwar

In the year 2017, Vimla Devi undertook the cultivation of Wheat through the SWI methods in an area of 0.8 ha. This was undertaken on an otherwise barren land that belonged to her family. Vimla Devi says, "When I decided to apply SCI methods on my farm, many villagers made fun of me that I was trying to revive a piece of land that was barren. I also thought it is ok if one piece of land is wasted for one season and forgot about it. But when I visited the same piece of land after some time, I was shocked to see a lush healthy green patch of land as opposed to a barren land. The soil quality had improved. Seeing the results, I decided to undertake vegetables and spices cultivation using SCI techniques. Applications of all principles of SCI is difficult in a mountain terrain but what is important is understanding the underlying science behind it. Then one can alter the practices as per the context. I am very happy that I undertook the decision to adopt SCI and I am able to feed my family and feel empowered as a woman farmer". Today Vimla Devi is encouraging more women farmers through women's groups to adopt SCI for not only food security but livelihood as well.

5. Outcomes

5.1 SCI for Climate Resilience

The years of 2014 and 2015 were rain deficit years where the variability in rain and its timing affected many crops across the state of Uttarakhand. For the Rabi season of 2014 where wheat was cultivated, as much as 90% increase in productivity per ha on an average was observed by the 138 farmers of Madhu Ganga and Revati clusters, in SWI crop as compared to conventional wheat crop.

In 2015 for Kharif crops like paddy and kidney beans, the productivity of SCI was 20 to 30 percent more than the conventional crops in both the clusters despite low rainfall.

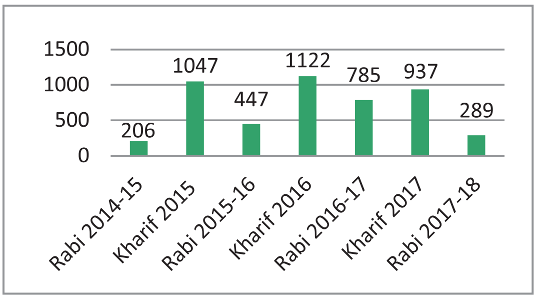

Figure 2: Number of farmers in Uttarakhand

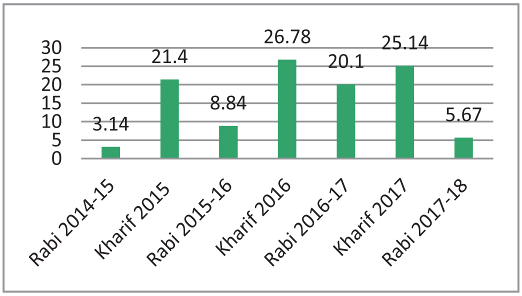

Figure 3: Area under SCI (ha) in Uttarakhand

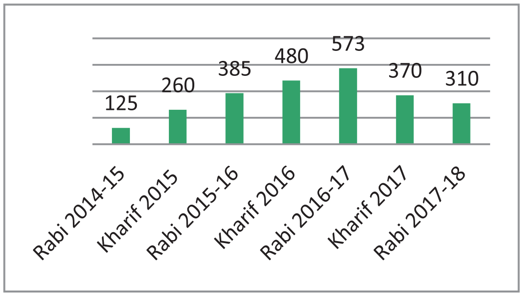

Figure 4: Number of farmers in Bundelkhand

It is worthy to note that the decline in SCI productivity was much less than that observed through the conventional methods of cultivation which proved that SCI crops still stand an increase in production compared to conventional methods under stress conditions.

The districts of Rudraprayag and Bageshwar faced excess rainfall in the year 2016. Despite this, the Kharif crops witnessed an increase in productivity. For paddy, 130 farmers who tried out SRI, were successful in achieving almost 40% increase in productivity as compared to the conventional farming method. Kidney beans grown with SCI practices in a total area of 14.6 ha by 569 farmers witnessed an average increased productivity of 66%. Similarly, for Rabi wheat, 580 farmers who adopted SCI in 14.2 ha got an average productivity increase of about 40%, despite low winter rains.

In 2017, Madhu Ganga cluster of Rudraprayag experienced average rainfall whereas Revati cluster of Bageshwar district had a deficit monsoon. The average grain productivity in paddy and kidney beans through SCI was 24% and 44% respectively in Madhu Ganga cluster, whereas the productivity gains were 17% and 40% respectively in Revati cluster despite low rains. Productivity gain in SWI crop ranged from 25% to 43%.

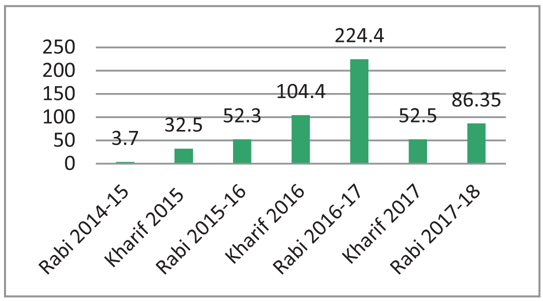

Figure 5: Area under SCI (ha) in Bundelkhand

By 2018, more farmers were confident of SCI practices. In Kharif, as much as 607 farmers adopted SCI in 6.3 ha of paddy land getting an average productivity gain of 47 per cent while 839 farmers adopted SCI in 16.3 ha of kidney beans getting an average productivity gain of about 40 per cent. The SCI crop in Revati cluster which experienced heavy rains and subsequent hailstorms just before the harvesting season, did much better than the conventional crops.

Panna district received only 60% and 65% of its average rainfall in both 2014 and 2015 respectively. Farmers themselves recall that dry spells were on an increase in both these years varying from 15-20 days in 2014 and more than 30 days in 2015. When crop cutting was undertaken in 2014 in 6 plots, there was an increase of 38% in the yields of paddy when it was compared to conventional crop plots. The average paddy grain in SRI plots was 2.53 tons/ha as compared to 1.83 tons/ha in the conventional plots.

With such high rates of fluctuations in rainfall for a rain fed agricultural region, it was difficult to convince farmers to adopt SCI. But continuous efforts to engage farmers in different ways like exposure visits to demonstration plots where they could see for themselves the benefits of SCI despite varying climatic conditions were testimony enough for them to further adopt the application of SCI.

5.2 Food and Livelihood Security

In the year 2017, PSI initiated the application of SCI for pulses (other than Kidney Bean which is a cash crop) in the Madhu Ganga cluster of Rudraprayag district of Uttarakhand. In the earlier years, less than 10 per cent of the farming communities were growing pulses in Rabi season. Considering the nutritional significance of pulse and potential of SCI, 256 farmers were mobilized in the Rabi season of 2017 to try out SCI in Lentil (Masoor) in 3.95 ha. In a sample survey covering 100 farmers, it was found that more than 90 per farmers applied SCI in lentil, recording 79 per cent increase in production. Despite untimely rains, the average SCI productivity was 0.42 T /ha as compared to conventional yield of 0.24 T/ha. Even under conditions of limited land under cultivation for lentil crop (average 0.02 ha per farmer), the production that was achieved was high thus reducing the dependence on the market for a traditional pulse that was long forgotten by the local communities. In the Kharif of 2018, more farmers have taken up SCI in traditional pulses like *Gahat, Tur,* Soyabean and *Urad.*

In the region of Bundelkhand it was observed that there was a 30 per cent increment in grain production of paddy and wheat especially, which provided food security for additional 20 days for farmers with an average of 0.02 ha land. This reduced expenditure and dependency on the market to meet household food demands. Reduced production costs and increased production provided food security for an additional 3-6 months annually for small and marginal farmers.

In terms of livelihood security, in Bundelkhand, it has been observed through continuous monitoring and evaluation, that farmers who have adopted cultivation with the help of SCI have either been able to increase their income or reduce their expenditure in terms reduced input costs and dependency on the market owing to increasing yields for various crops. Table 1 provides evidence that in the wheat crop alone a farmer was able to save almost 30% of his/her input costs in terms of seeds, chemical fertilisers, pesticides. The net profit earned is almost 100% more in the case of wheat, forming the basis for higher returns. Similarly in Uttarakhand, with the cultivation of the Kharif crop of kidney beans, a 52 per cent increment in grain production provided additional income of INR 7000 for farmers with average 0.02 ha in the region. There are many stories from the programme area, where farmers have not only achieved food security, but also got their ornaments back from the local money lenders, with whom they had to mortgage them in 2009. Many farmers have come back from the cities they had migrated to, thanks to the SCI method; resulting into a kind of reverse migration.

Table 1: Cost benefit analysis – conventional vs. SWI method

S. No.	Material / Activity			Traditional methods		SWI methods	
		Unit	Price per unit	No. units	Total	No. units	Total
1	Material cost						
1.1	Seed	kg	25	60	1,500	5	125
1.2	Priming of seeds and seed treatment Materials (jaggery, cow urine, warm water, compost)	(lump sum + including man days)	175	-		1	175
1.3	DAP	kg	24	50	1,200		
1.4	Urea	kg	8	50	400		
1.5	Herbiside	litr	1,200	1	600		
1.6	Panchagabhya	kg	20			20	400
1.7	Mataka Khad	kg	40			0	10
1.8	Weeder (one weeder in 10 farmers)	Unit	1,300			0	130
2	Total Labour unskilled	man-days	150	12	1,800	33	4,950
3	Total Labour skilled (farm preparation, Tractor, Thrashing)	man-days	200	10	2,000	10	2,000
	Total Costs				7,500		7,790
	Gross Revenue (grain sales)	ton	14,000	0.88	12,600	1.32	18,480
	SWI methods				**5,100**		**10,690**
	Production cost per kg				**8.3**		**5.9**

Source: SWI promotion in Panna cluster (Shahnagar block) by PSI through the project "Natural resource management through community mobilization in Bundelkhand" funded by SDTT, 2014-15

Farmer Speaks, Bundelkhand

Balkishan Kewat, a 55 year old farmer in the village has 2 acres (about 0.8 ha) of land started growing paddy on half of his land in 2010. This started as an experiment following the success of his brother Pritam Kewat who had grown paddy using the SRI method. Pritam got a yield of 3 tonnes per acre using only 3 kg seed. Next year, Balkishan cultivated paddy with SRI methods in 2 acres of land. Using the SRI methods, he got more rice and husk than he used to get from the conventional method. By selling the surplus production, he not only fed his family of 11 but also bought silver ornaments for his wife and daughter. Encouraged with the benefits of the SRI technique in paddy cultivation, Kewat is all set to use this technique for other crops, namely wheat and black gram.

5.3 Ecological Sustainability

The principles of SCI which are an extension of SRI itself draw on 2 key principles – increasing the microbial activity in the soil and keeping it from becoming anoxic. These two principles are being promoted through practices of application of organic manure and efficient water use, respectively. PSI promotes the use of *Matka khad* which is a preparation of cow dung (5 kg), cow urine (5 litre) and jaggery (250 gms) added to 10 litres of water, sufficient for half acre of land. This preparation is kept for three days for composting and should be used within 4-5 days along with the application of irrigation water or rainfall as applicable. One litre of *Matka khad* is to be mixed with 10 litres of water before applying to the field. This kind of application has increased the productivity of the soil as well and in some cases helped turned barren land into fertile fields in combination with SCI methods. SCI has also ensured reduced water use by application of water only for retaining moisture. Combined with this weeding to control weeds has also increased soil aeration and maximized nutrient supplies.

As SCI requires little input cost (with no use of chemicals) and provides very high returns, it requires very less external input. When farmers get benefits from the innovative agronomic methods, they continue with it. Experience has been that other farmers upon seeing the obvious benefits follow the suit. It becomes a bottom-led extension approach requiring no external support, which has been showcased all over the world.

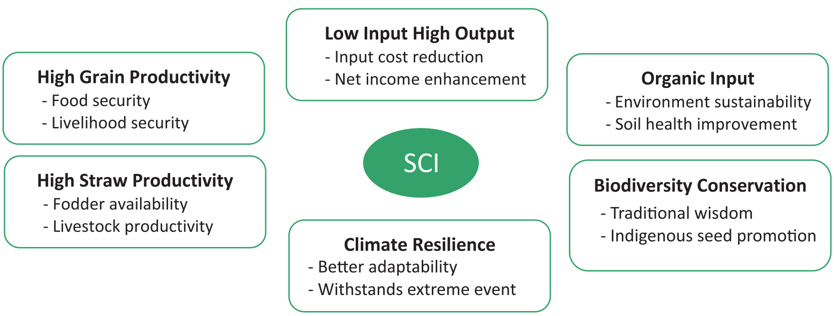

Figure 6: Benefits of SCI

6. Challenges and Way Forward

One of the biggest challenges that SCI faces in promoting the SCI approach is that it is seen as labour intensive because of the number of steps involved. Farmers, especially women farmers who constitute 60-70 % of agricultural labour are hesitant to adopt this technique as they are burdened with other domestic responsibilities. At the macro level, the challenge is to get a large scale context specific response from policy makers to make SCI a bottom up approach as opposed to agricultural policies that are first developed and then 'adapted' to suit farmer needs. This approach discourages farmers to adopt the practice, as new technology is something they are averse to without demonstration in the local context.

To scale up SCI, central and state governments need to make it an integral part of the agricultural extension systems and other existing programs like MGNREGS and watershed development. In addition, it warrants sustained research, strategic action and policy advocacy by research institutions and civil society organizations as complementary initiatives to enable communities to maximize SRI's enormous potential. Since SCI does not depend heavily on external inputs, strategic action should focus on capacity building by demonstration to explain its logic. Training of extension/development staff and farmers in SCI should be undertaken. Community-based organizations should help scale up innovations. The strategy must equip farmers with requisite knowledge and develop appropriate tools (weeders, markers, transplanters, etc.) and low-cost sustainable farming inputs like good quality seeds and organic fertilizers. Various institutions like Krishi Vikas Kendras (KVKs), agriculture universities, research institutions and schemes such as ATMA and MGNREGS should work through local Panchayats and NGOs to train Community Resource Persons (CRPs). Leveraging Corporate Social Responsibility (CSR) support can add more resources. Members of Parliament can initiate the strategic action through their leadership, commitment, energy and Sansad Adarsh Gram Yojna (SAGY) resources.

Climate Smart Agriculture Initiative through Integrated Watershed Management: A Case from Village Haripur-Narsinghdanda of Champawat District in Uttarakhand

Kapil Lall[1], M. S. Kunwar[2] and Hirdesh Chunera[3]

According to the Special Report (SR15) of the Intergovernmental Panel on Climate Change (IPCC), the impact of 1.5^0 C[4] increase in global temperature will disproportionately affect vulnerable households through food insecurity, increased food prices, income losses, less livelihood opportunities, adverse health impacts, and population displacement.

It is evident that the communities whose livelihoods are closely related to natural resources are facing more uncertainty due to the changing climate. During the last decade, Uttarakhand has experienced frequent occurrence of extreme events such as flash floods and cloud bursts resulting in devastating effects on the communities. Furthermore, the changing climate has resulted in changing cropping patterns in the region. Cultivation of traditional crops such as local millets, buckwheat, soybean and barley are in the decline in the region. The output from agriculture is much less considering the soil and environmental conditions. On the marketing front of farm produce too, the efforts need to be stepped up. Markets are dominated by a few private players and the regulated markets are not so active. Almost the entire horticultural produce of the area is either consumed locally or is collected by some contractors.

The present case study provides a view of farmers' innovative efforts in the Haripur-Narsinghdanda Gram Panchayat of Champawat district in the state of Uttarakhand, and represents the Climate Smart Agriculture approach adopted by the village community through participatory watershed management activities. It represents a successful case towards strengthening resilience and adaptive capacity to climate related hazards and natural disasters. For better representation of the case, an effort has been made to bring out the initiatives taken by the local community to enhance their livelihood through sustainable agriculture development integrating with climate change adaptation. The efforts of farmers have not only addressed the impacts of climate change to large extent but has also strengthened the food security and livelihood opportunities in the village.

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4 Special Report (SR15) of the Intergovernmental Panel on Climate Change (IPCC) October 2018

1. Geographic and Demographic Profile

A part of the Western Himalayan Region, Haripur-Narsinghdanda is a small Gram Panchayat (GP) located at an altitude of 1750 mts in the Dhamisaun micro-watershed of Champawat District in Uttarakhand. Climate here is temperate to subtropical; the average temperature remains 5°-30°C. During monsoon season, the area receives 75% of rain, with an annual rainfall of 1200 mm. The area of GP Haripur-Narsinghdanda is 175.075 Ha which is spread over 11 hamlets having a population of 833 (Male: 442, Female: 391)[5]. The economy is highly dependent on climate sensitive sectors like agriculture, horticulture and livestock, with other economic activities being limited. Rain-fed agriculture is practiced in nearly 60.83 percent (i.e. 106.492 Ha)[6] of the total agricultural area of the GP, predominantly by marginal farmers, who are directly impacted by the changing climatic conditions. The Himalayan region has been identified as being not only highly vulnerable to the impacts of climate change, but also having a low capacity to adapt to the constraints. The instability of climate has further accelerated the process of marginalization of the village communities.

2. Rationale for the Initiative

Hill and mountain habitats have five overarching specificities. They are: (i) inaccessibility; a product of altitude and terrain coupled with inadequate access infrastructure that hinder mobility, imposes isolation and "closeness"; (ii) fragility; a product of altitude, steep slopes, and other associated biophysical conditions that prevents higher intensity of land use, and limits both the physical and economic scope of input use; (iii) marginality, that results in limited and low payoff options and high cost of upgrading resources; (iv) diversity resulting from a high degree of spatial, temporal, physical and biological variability over short distances that at one level makes it difficult to achieve economies of scale but at the same time offers potential for higher productivity and specialization; and (v) niche which implies potential for products and services having a comparative advantage over the plains. It is evident that the communities whose livelihoods are closely linked to natural resources are facing greater uncertainty than ever before. Rain fed agriculture being primary occupation of the communities, exposes them to greater risks and makes them more vulnerable to climate change effects.

3. Socio-Economic Conditions and Needs of the Impact Group

The economy of the hilly regions of Uttarakhand is predominantly rural and highly dependent on climate sensitive sectors like agri-horticulture and livestock; other economic activities are limited. Agriculture is mostly practiced on sloping lands and in small patches of terraced lands and relies entirely on seasonal rainfall. To feed their livestock, farmers rely heavily on natural fodder resources including forest areas, thus adding to the continuous degradation of natural resources for fulfilling the various needs of village population.

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[5] Census 2011

[6] Participatory Rural Appraisal Exercise conducted under Component 2 - Project Society Watershed Management Directorate (PSWMD) of Integrated Livelihood Support Project

Farmers from the village have migrated to urban areas or to the plains, which is a result of fragmentation of landholding and environmental degradation leading to water and fodder scarcity, impacting viability of agriculture and livestock related livelihood options that remain the mainstay of the hill economy. This already stressed situation has been further aggravated in recent times by the effects of climate change. Increasing variation in precipitation (both rainfall and snow), and temperature has altered the soil moisture availability, plant phenology and viable altitudinal range, and pest susceptibility. The families of farmers cultivate crops in limited area for just fulfilling their household needs, resulting in increase in area under fallow land in the region. Due to subsistence livelihood prevailing in the region, migration and remittance economy operates in the region. Therefore, there is a need to develop and improve agricultural standards of the region, to enhance the livelihoods of the village community.

4. Prevailing Issues

Champawat District is highly vulnerable to climate mediated risks. Due to anthropogenic increase in greenhouse gas emissions, the atmospheric temperature of the area is rising, resulting in recent natural extreme weather events like upward movement of snowline, depleting natural resources, erratic rainfall, irregular winter rains, advancing cropping seasons, fluctuations in the flowering behavior of plants, shifting of apple cultivation zones, and other crops, reduction in snow in winter & depletion off perennial streams. The problems experienced due to specific reasons are mentioned as under-:

4.1 Rising Temperature

The region has experienced an increase in maximum temperature up to 1 degree centigrade. The impact of rising temperature has led to shifting of apple orchards towards higher altitudes. Increased vulnerability of agri-horti sectors and absence of any other livelihood options has resulted in migration of productive labor. Some of the other patterns observed due to rise in temperature are: change in cropping patterns, greater losses in winter crops as compared to rainy season crops, increase in pests and diseases, infestation in crops, decline in the production of wheat and potato and consequent adverse impact on food security, reduction in traditional crop diversity (For example, finger millets, barnyard millet etc.), degradation of soil and declining soil moisture due to increased heat stress and early snow melting, and decline in availability of fodder and its adverse impact on animal husbandry among others

4.2 Changed Precipitation Conditions

There has been a decrease in water availability in the streams and rivers in summer due to decreased snow fall. Increased run-off, less infiltration and loss of surface soil on steeper mountain slopes accelerate the rates of siltation and flash floods. Increased run-off coupled with removal of forest cover, have already started showing signs of depleted hill aquifer regime. Overall trend shows decrease in water availability in the area. Streams and natural springs that used to act as the lifeline of the mountain communities by providing much needed water for drinking and agriculture during dry spells, are drying up.

4.3 Extreme Weather Events

Intense rainfall coupled with deforestation, sloping terrain and loose soil have led to soil erosion and loss of fertile soil, thereby making agriculture impossible. The process of land degradation and loosening of soil has further catalyzed:

Sudden events leading to total loss of crops and property

There has been increased instances of landslides compared to the past. Sudden weather events like hail storm in 2009 have heavily impacted crops and increase in losses. Cloud burst in June 2013, resulted in major natural devastation.

Land and soil degradation due to intense rains

The increasing pressure on forests have increased the man-animal conflicts, resulting in decline of biodiversity. There area is witnessing proliferation of invasive species (Lantana), increased requirement for feed supplements for livestock fodder scarcity and resultant drudgery for women.

5. Project Approach and Activities Undertaken

Participatory Watershed Development is a component of the Integrated Livelihood Support Project (ILSP) funded by International Fund for Agriculture Development (IFAD) and being implemented by Watershed Management Directorate, Dehradun in Haripur-Narsinghdanda Gram Panchayat. This is being done by the local Gram Panchayat institution, Village Water and Watershed Management Committee (VWWMC) headed by the Gram Pradhan in the form of Participatory Watershed Management, Food Security & Scaling Up, Access to Market and Monitoring & Evaluation and Knowledge Management.

The main objective of the project which was launched in the year 2012 was to reduce poverty through developing livelihood of the village community in the Micro Watershed (MWS) area. Under the project, the community decides, plans and implements all the activities to be carried out in the Gram Panchayat area. At the Gram Panchayat level, Gram Panchayat Watershed Development Plan (GPWDP) is prepared which enlists the different activities decided by the community and the budget allocated for each activity. Along with watershed activities, climate smart agriculture has been given importance to provide livelihood options at producer group level in conjunction with climate resilience.

The steps taken to implement the project are mentioned as under:

5.1 Problem Identification

After the inception of project, a series of Participatory Rural Appraisal (PRA) exercise was carried out in the Gram Panchayat to provide an open platform to the participating community in identifying the problems/issues and possibilities in Natural Resource management (NRM), agriculture, horticulture, and other village based interventions with the help of community. Participatory Rural Appraisal (PRA) exercise was carried out for validating the information gathered through secondary sources. These include Historical Transect/ Time Line, Resource Mapping, Social Mapping, Seasonal Diagram+ Daily Activity Schedule, Venn diagram/ Chappati diagram, Livelihood Analysis, Focus Group Discussions, Tree Matrix, Wealth Ranking and Transect Walk to identify the existing resources, issues of the Gram Panchayat. The information derived from this activity helped in preparation of Gram Panchayat Watershed Development Plans (GPWDP). During the PRA exercise it was found that while the agricultural land was depleting and the farmers grew only staples for self-consumption, majority of the farmers did not reach food self-sufficiency. Further, farmers also claimed that the perennial water sources were depleting and water for irrigation was not available, leaving agriculture completely rain-fed.

5.2 Preparation of GPWDP Plans

GPWDP was prepared with the help of village community highlighting the activities to be performed under the project. A budget of INR 54 Lakhs was allocated for the area to implement watershed activities as mentioned below:

i. Natural Resource Management: Under this sub activity Assisted Natural Regeneration of Oak (ANR Oak) was carried out in 10 ha. and plantation of trees in another 10 ha. area in the Gram Panchayat.

   In the inter Gram Panchayat space, in a total of 205.87 Cu M area, crate wire check-dams were built and 312.73 Cu M area of dry stone checkdams were constructed. In an area of 314.32 Cu M, retaining wall were constructed as part of soil and moisture conservation activities. In addition, for the catchment area, treatment recharge pits, dug out ponds and contour trenches were made.

ii. Water harvesting and Minor Irrigation: A total of 2 irrigation tanks and 29 rooftop rain water harvesting tanks were constructed.

iii. Agri-Horticulture: Orchard development was done in 0.87 ha along with 3 ha of homestead plantation. In addition to these, 6 poly houses were also constructed.

iv. Livestock: Napier crop border plantation was done in 6.5 ha and stall feeding is being promoted in the area.

v. Rural Access: Last mile connectivity was established through construction of small bridge and 0.52 kms rural road.

vi. Access to market: In-order to support market linkage activities for agri-horticultural produce a self-reliant Cooperative Society was registered in the year 2017 under the name of 'Bishjula Ajeevika Swayatt Sehkarita, Khalkadiya,' which has been equipped with all the necessary equipments and a large collection centre for processing, grading, sorting and packaging. To provide efficient backward linkage, this collection centre was linked with three small collection centres located at village level (Haripur-Narisnghdanda, Ladabora & Badpass). Farmers from the different producer groups of the area are board members of the cooperative society holding responsibility for the management as well as business activities carried out by the cooperative society.

vii. Agronomic measures to adapt to climate change: Furthermore, on the basis of adverse climatic events for agriculture cultivation like early season drought, mid-season drought, terminal drought (early withdrawal of monsoon), continuous high rainfall in a short span leading to water logging, outbreak of pests and diseases due to unseasonal rains, extreme events like heat wave, cold wave, frost etc., contingency measures are being taken which include change in crop, cropping system including crop diversification and agronomic measures as per adverse climatic conditions. Some of the agronomic measures which are taken as per the climatic conditions in the region are:

- **Early Season Drought:** Incase the delay is by 2-4 weeks the cropping pattern was changed from Potato-Wheat-Potato to delayed sowing of kidney beans/ french beans. In case of delay of 6 weeks, kidney beans is replaced by vegetable pea and if the delay is 8 weeks then sowing of radish, vegetable rai, and organic practices to control late blight of potato is followed.
- **Mid-Season Drought:** In case of long dry spell of consecutive 2 w eeks rainless (>2.5 mm) period at vegetative stage, gap filling in kidney beans and inter culture operations are carried out. At the flowering stage, organic management of cut worm is practiced.
- **Terminal drought:** In case of early withdrawal of monsoons, harvesting at physiological maturity stage of kidney beans is carried out. For the Rabi season, mostly early maturing crop varieties like *Toria* etc. are preferred.

The above activities form a package for resilience against climate change

6. Impact of the Initiative

As part of the project, intermediate Impact Assessment was carried out in February 2018 by an external agency. The Impact Assessment Report highlighted the following positive impacts of the initiative:

6.1 Micro Watershed (MWS) Profile

Soil fertility is reported to have improved. The factors resulting this change are the use of organic composting, repairing terrace farming, mulching, use of organic fertilizers, and adoption of other soil and moisture conservation practices such as minor irrigation

6.2 Revenue Village Level Profile

- Majority of the farmers in the study area grow two crops per year after project interventions
- Marginal farmers, having an agricultural area of less than 0.5 ha, account for 75 percent of the total farming HHs. Small farmers comprise 23.7 percent of the total farming households
- Among the modes of irrigation, there is a rise in the area irrigated using percolation dams, and irrigation tanks

- Producer Groups as a source of credit has received positive response in the project area
- The reported agricultural income indicates considerable improvement in income from fruit cultivation
- The average number of milking cows and buffaloes per household has increased over time
- The most popular livestock services utilized by majority of the households has been artificial insemination and livestock vaccination for both baseline and Impact Assessment survey

6.3 Household Assets

- About 95 percent of the sample households in this survey have access to a toilet within the house or shared/community toilet; while the corresponding figure for baseline survey was about 84 percent
- Average distance travelled to access drinking water has marginally reduced for all the three seasons as compared to the data collected during baseline survey
- Ownership of household assets has improved from the Baseline survey till Impact Assessment survey

6.4 Access to Financial Services

- Almost all the households in the study area have bank accounts
- During baseline survey, only one-fourth of the households in the project area were reported to be involved in regular savings whereas, during Impact Assessment survey, 68 percent of the sample households in the project area are practicing regular savings
- The trend of availing a credit from local moneylenders has waned in the project area, still a considerable percentage of households tend to depend on local moneylenders for emergency loans

6.5 Producer Groups (PGs)

- During the survey, it was noted that all the sample households are part of producer groups; of these, 26.4 percent hold leadership positions
- The percentage of households that attended training pertaining to micro-finance and linkages with external funding sources has increased
- 10 percent of the sample households who are part of producer groups are part of livelihood collectives formed under the project ILSP. Of these, 90 percent have reported using services provided under livelihood collectives. Largely, these services range from providing farmers with agricultural input supplies, awareness generation, and preliminary processing of agricultural produce

6.6 Migration

- The proportion of migration has increased from 22 percent (baseline survey) to about 32 percent. Prevalent cases of migration are temporary and seasonal in nature
- 40 percent of the sample households cite reasons such as better opportunities in terms of education, health, and employment , for migration

6.7 Gender and Empowerment

- Comparing the average number of hours spent by men and women in the study area, the women spend a considerable portion of time in agriculture related activities
- Most of the decisions on key matters in the household are largely taken by the family. Womens' participation has marginally improved in the decision-making process of the family

6.8 Vulnerability

- Majority of the sample households have faced extreme events such as the prevalence of droughts, hailstorms, torrential downpour and pest infestation etc.
- The analysis shows that droughts and torrential rains occur more frequently than other types of extreme events, and their severity and negative impact on households are also more. Floods and flash floods are not as severe as droughts and torrential rains, though they impact about one-fourth to one-third of the population. Forest fires occur every year as mentioned by 63 percent of respondents. Pest infestation impact 75 percent of the households every year.

7. Scale and Sustainability of Programme

For the sustainability of the project interventions, three pronged efforts were made:

1) Economic sustainability of important project activities for vegetable cultivation under poly house structures and fruit tree plantations;
2) Ecological sustainability, to ensure focus on regeneration of natural resources such as ground water, degraded pastoral lands; and
3) Institutional sustainability, to build capacities of producer groups, vulnerable producer groups, a livelihood collective, Self Reliant Cooperative Society was registered in the year 2017 under the name of Bishjula Ajeevika Swayatt Sehkarita, Khalkadiya.

All the activities under the project are based on community participation and engagement, which has ensured the involvement of all the participants in the process from planning, implementation through to evaluation. Early stage involvement of the participants in the project has helped in formulation of strategy and execution of activities of Gram Panchayat. In the process of formulation and execution, the participation of women, youth and landless poor families was ensured in order to have inclusive implementation and benefit sharing at different stages.

As a part of the project intervention, formation and strengthening of user groups, producer groups, vulnerable producer groups were proposed. The livelihood collective has been strengthened to handle the marketing of agri produce including vegetables (tomatoes, capsicum) and other products. A team of resource persons in the village have been identified and trained for various technologies proposed under the project. The local resource person is representing community interests and is the interface between the community and local technical experts as well as the Government. linkages. The project has also helped in improving the capacity of the local community in order to develop and support future adaptation actions.

Physical and community assets built under the project are managed by the Community Users Group and a guideline for using the community assets have been developed and signed by the users. Technical support has been provided by experts from the project. The ownership and maintenance of the structures rests on Gram Panchayat and Water User Groups. The village committee decides upon the operational issues related to activity. There is a mandatory agreement between the user group and Panchayat for the management and maintenance of the assets to be created. This is particularly so for watershed maintenance funds.

Income diversification through adoption of technology based activities is expected to be sustainable because of well-established marketing linkages that will provide better returns from the produce. This initiative is supported under the project, through intensive planning in harvest season, set up of collection centers and direct linkages with the markets. All these are executed by the livelihood collectives established in region for different produce proposed under the project. The livelihood collective has been provided with three staff who are selected from amongst the educated youth of the village itself.

Livestock is a secondary source of income for the community. This source of livelihood is important for income diversification and minimising the risk of vulnerable communities. The local communities are supported by providing animal health care services in the villages under the project. Besides, cultivation of fodder trees in Gram Panchayat has increased the green fodder stock in the village, which is beneficial to enhance the digestion process of livestock and decrease GHG emission level caused by livestock. For making this activity sustainable, these farmers are being linked with network of collection centre of Anchal Dairy in the nearby villages. This linkage has provided long term assurance of returns from their milk produce along with other privileges such as patronage bonus, loan facility and input support facility from the Dairy.

Knowledge generation from field evidence and dissemination of these field based best practices to larger audience for policy inputs and replication through various Government as well as Non-Governmental Organizations is carried out under the project.

8. Scope for Further Replication

Public representatives, community leaders and officials from the Government are being involved in visits to field sites to sensitize them on the field level issues and to influence policy, planning and resource allocation decisions. The best practices and case studies on climate smart interventions are being disseminated through local and national media to create required acceptability by mainstream funding agencies. This is facilitating further replication of proven and successful interventions for the benefit of hill communities in rest of the Northern Western Himalayas.

9. Conclusion

The successful implementation of these activities in the Haripur-Narsinghdanda Gram Panchayat is a step towards strengthening resilience and adaptive capacity to climate related hazards and natural disasters. Project inputs, as a whole has brought farm diversification, reduction in vulnerability, and promoted environmentally sound and sustainable livelihood. The interventions have addressed the issues of drudgery of women by improved access to water, making available fodder and alternative sources of water. The village communities are now able to irrigate their land even during unfavorable climatic conditions. Due to this, it is hoped that in the coming future, the migration of youth from the village in search of employment will decrease because of greater access to employment opportunities within the village.

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Fighting Drought and Improving Food Security in Maharashtra: A Women-Led Climate Resilient Farming Initiative

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Swayam Shikshan Prayog (SSP)

1. Introduction

Swayam Shikshan Prayog (SSP) promotes sustainable community development through empowerment of women at the grassroots. SSP widely advocates for the recognition of grassroots women in their new roles of farmers, entrepreneurs, community leaders and change makers. At the core of SSP's approach is building robust partnership eco-systems that enable grassroots women's networks to access skills training, financial and digital literacy, technology and marketing platforms. The organization started its work in rural reconstruction with women in the forefront, following the Latur earthquake in 1993. Ever since, SSP's concerted efforts have been the socio-economic empowerment of women in some of the drought affected districts of the Marathwada region of Maharashtra, India. SSP operates in Latur, Osmanabad, Solapur, Nanded, Washim and Beed districts of Maharashtra most of which have earned the dubious distinction due to rising farmer suicides and recurring droughts owing to climate change implications on agriculture economy.

Marathwada, our project area, is the worst drought-hit region. According to a recent publication by the Hindustan Times , the State Government of Maharashtra has declared drought for 26 districts out of the 36 districts in the State. One of the driest regions in India, Marathwada falls under three major agro-climatic zones that range from scarce to moderate to assured rainfall and experiences 44% lesser rainfall than the national average and 20% coverage in irrigation. The region has been reeling under severe drought resulting in crop failure, depletion in ground water level, increased climate risks, food insecurity and uncertain cash flow in the absence of diversified livelihoods. These, in turn, have made farming economically unviable especially for small and marginal farmers. Despite such agrarian crisis, farmers have continued to grow water intensive single cash crops with expensive chemical inputs.

Among the small and marginal farmers, women are the worst affected by climate change repercussions. Women are extensively involved in farming but are barely recognized as farmers. They do not have ownership over land which limits their access to productive resources like finance, market, water and government extension services. The policy makers and government have continued to perceiving them as labourers. The double burden of risks due to climate change resulting in food and income insecurity and their limited

[1] https://www.hindustantimes.com/mumbai-news/maharashtra-declares-drought-26-districts-hit/story-ETaPfo9owb7yVW8EQ1lQGL.html

decision making related to the crops grown, has also led to negative impact on women's health. Addressing these complex issues of climate change, gender roles and its impact on health and nutrition, SSP redefined resilience for small and marginal farming households.

Evolving over the years (2014 onward), the "Women-led Climate Resilient Farming Model" (WCRF) repositions women as farmers and as bearers of knowledge, enabling them to take informed decisions related to what to grow, what to consume and how much to sell. It aims to empower women as change makers in agriculture with a view to promote resilient livelihoods for small and marginal farming households. In the process, the model ensures farming becomes an economically viable venture for these small and marginal holders. This is through integrated farming techniques, increasing livestock and farm-allied businesses, increasing consumption and marketing of nutritious farm grown food crops.

SSP teams sensitize women and their families in the villages of Maharashtra, drought prone Marathwada region. At the frontline, teams identify and train *Samvad Sahayaks* or Community Resource Persons (CRPs) who mobilize farmers, identify potential women farmer and families and provide continuous handholding support to empower women farmers throughout the project period. For intensive trainings on WCRF model, women farmers from small and marginal farming households are selected by CRPs and SSP teams, with adequate family support and readiness to shift to sustainable farming.

As women gain recognition as farmers, SSP encourages participation of women in local development by developing successful farmers as leaders/champions through leadership workshops. These champions become the "evangelists for the model" beyond the project, and in turn develop new leaders and lead grassroots advocacy efforts at the district and state level govt. Overall the project intervention builds upon SSP's experience in implementation of the WCRF model and its advocacy at the district and state level by leveraging resources that include entitlements for women farmers. SSP's role is to create an enabling eco-system that establishes linkages between key components by:

- Creating awareness on role of women in food security and agriculture
- Partnership eco-system with agriculture scientists, universities, government and institutes
- Creating a network of agriculture promoters and community leaders
- Pathways for the poor farmers, from farm to market and to the table

District teams of professionals supervise and monitor the implementation to ensure quality through regular program audits and measurement of performance indicators. The initiative is now being implemented at scale across 650 villages with support from the Govt. of Maharashtra (MSRLM), CSR and other funding agencies.

This case study presents an overview of the challenges faced by the Marathwada region due to climate change, and the Women-led Climate Resilient Farming (WCRF) approach with defined processes and outcomes, for small and marginal farming households.

2. Rationale

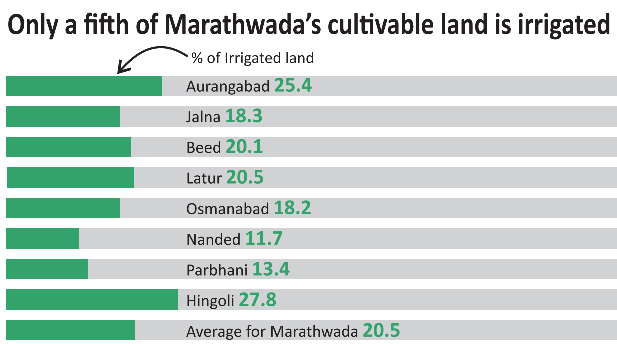
Marathwada is the region comprising the eight districts of Jalna, Aurangabad, Parbhani, Hingoli, Nanded, Latur, Osmanabad and Beed. It accounts for 16.84 per cent of the state's population and is home to nearly 30 per cent of the state's Below Poverty Line families. Falling under the rain shadow area, this region receives less rainfall compared to other districts in the state. The map below shows the state of Maharashtra and the blue coloured regions under Aurangabad division are together referred to as the Marathwada region.

Source: (https://www.maharashtra.gov.in)

Figure 1: Map of Maharashtra

2.1 Issues in Marathwada

Drought: According to a study by the Indian Institute of Tropical Meteorology and the Indian Institute of Science, between 1870 and 2015 the region faced 22 droughts, of which there were five instances of two consecutive droughts, the most recent of which were in 2014-15 and 2015-16. Marathwada had a rain deficit of 40% in both 2014 and 2015. Figure 2 shows the percentage of irrigated land in Marathwada constitutes only a fifth of the total land.



Source: Maharashtra agriculture department

Figure 2: Irrigated land in Marathwada

Water efficient systems like drip and sprinkler irrigation are a rare phenomenon in the region while more common are the bore wells causing depletion of ground water level. In Beed district, only 6% of land accounts for having micro-irrigation facilities. In an article published by the Daily News and Analysis (DNA), Senior Journalist and author of seven books, Atul Deulgaonkar provides a picture of the drought scenario of Marathwada vis-a-vis criticizing the inaction by both the Centre and the State Government. He holds responsible both, climate change as well as ground water depletion from an increase in the number of bore wells for the agrarian anomalies in the Marathwada region.

Food security – Cash crop vs Food crop: Climate change has adversely affected the food security of the region due to deficit in crop production. The Economic Survey Report projected a 22 per cent drop in food grain production with diminishing rains and drought anticipations that will impact both *kharif* and *rabi* crops. Total food grains production has decreased from 109.47 lakh metric tonne to 84.93 lakh metric tonne, the report stated. According to the information, the production of cereals was projected to decrease by 24% and pulses by 11% in 2015-16 respectively. However, both the area as well as production of cotton has increased. While this has been similar for other cash crops, the concern is regarding the decreasing area under food crop cultivation which states that cash crops are preferred to food crops by farmers. Food insecurity among households due to cultivation of cash crops instead of food crops and high incidence of malnutrition and anaemia among women and children is affecting their health.

Water crisis: With reduced rainfall and drought condition, the ground water level is further depleted in this region. Use of bore well, tube well, piped water etc. have exploited the water level. Lack of efficient water conservation techniques such as creation of farm ponds or bunds or rain water harvesting etc. have added to the woes. The irrigation in the state is very low at 16% as compared to the national average of 42%, coupled with the lack of assured water supply is causing serious water crisis.

High input cost and low yield: According to the study by Dilasa Janvikas Prathishthan, almost 95 per cent of the farmers who committed suicide in the preceding years were cotton cultivators. Cotton is a traditional crop of Marathwada, owing to the favourable black soil condition despite requiring more water, is produced on a large-scale. Cotton cultivation incurs high input costs which in times of crop failure render the small farming households' huge loss. In the last decade, traditional crops of the region like groundnut, *jowar* and soybean that gave sustainable food and income to the farmers with less water have totally been replaced by cash crops. Mono-cropping and preference to grow cash crops has impacted the cropping pattern of the region. Increased dependence on expensive inorganic inputs such as seeds, fertilizers, pesticides etc. has added to higher cost of production and insufficient income in the households.

Women in agriculture: The State of Food and Agriculture (2011), a report released by the Food and Agriculture Organization (FAO), states that 43% of the agriculture labour force in developing countries comprises of women and they are involved in several of the agricultural activities such as crop selection, land preparation, selection of seeds, storage, marketing etc. Despite their involvement in agriculture, they are not given recognition of farmers. Government and agriculture extension agencies have long perceived women only as labourer and beneficiaries. The knowledge and decision making capacities of women in agriculture have been overlooked by agriculturists and policy makers. Their contribution could be much greater if they had equal access to essential resources and services, such as land, credit and training.

In Maharashtra, 70%[2] of the total female workers are involved in agriculture activities, and small and marginal women farmers hold 1,12,000 ha of land from a total of 6,95,000 ha of land. Despite their knowledge and active involvement in farming they are barely recognized as farmers. They have very limited say when it comes to crop cultivation, production and sale. As women do not have right to entitlement of land they are not able to access agriculture extension services. Most of the decisions related to agriculture inputs, crop cultivation, farming practices, sale of produce etc. are taken up by the men who are more inclined towards growing cash crops as they have the major responsibility of just earning bread and barely possess an idea about the foods that are required in the kitchen. Given the uncertain climate, growing cash crops is nothing less than a gamble. In such situation, the nutrition security of the families is threatened leading to higher risk in health and income. Studies show that women are differently affected by climate change than men. A significant, yet often, undermined perception is about the participation of women in agriculture, their challenges in times of climate change as well as their roles in addressing several of the aforesaid issues. This is partly attributed to the fact that women are involved in agricultural activities worldwide in large proportion and partly also because they have lesser earning opportunities than their male counterparts.

To address a large number of issues arising due to climate change and its impact on agriculture and women farmers in particular, SSP promoted the Women-led Climate Resilient Farming Model that connects the vital dots between women smallholder farmers, climate change, food security, diversified and sustainable livelihood.

3. SSP's Solution - Women-led Climate Resilient Farming (WCRF)

Having worked in the Marathwada region for more than two decades, SSP realized the gravity of the issues and following its vision and mission to empower women, started building women's capacities in sustainable agriculture techniques. SSP's experience in working with grassroots women shows that women not only possess knowledge of agriculture, are actively involved in the agriculture production process but also lack access to and control over resources – agriculture inputs, finance; information, training and technology.

3.1 Evolution of the Model

Considering the fact that a large number of women households belonged to small and marginal farming category in the drought affected Marathwada region, and were vulnerable to climate change implication than the large scale farmers, fostered the evolution of a model which will be sustainable and develop resilience of the communities during climate change. SSP's experience in working with women in these communities revealed that women were severely anaemic in the region and further digging into their eating and cultivation pattern

[2] http://labourbureau.nic.in/Statistical_Profile_2012_13.pdf

provided interesting insights into the problem. Women not only were disregarded by their families when it came to making choices in agriculture related to input selection, crop cultivation, consumption and marketing but also had limited consumption of food items i.e. women were found not to be eating vegetables and other pulses at all which resulted in their low haemoglobin levels as well as had effects on their children who were found to be mostly malnourished in the region. In order to resolve these problems, the organization came up with an approach that involves women farmers to practice climate resilient farming techniques that not only empowers them and their families but also promotes sustainable community development in an integrated manner.

The climate resilient farming model has evolved over the years and is mostly a learning outcome from the grassroots rather than a top down approach. From 2015 onwards, SSP defined the adoption criteria of the model in a more integrated manner which can be agglomerated under climate resilient farming practices.

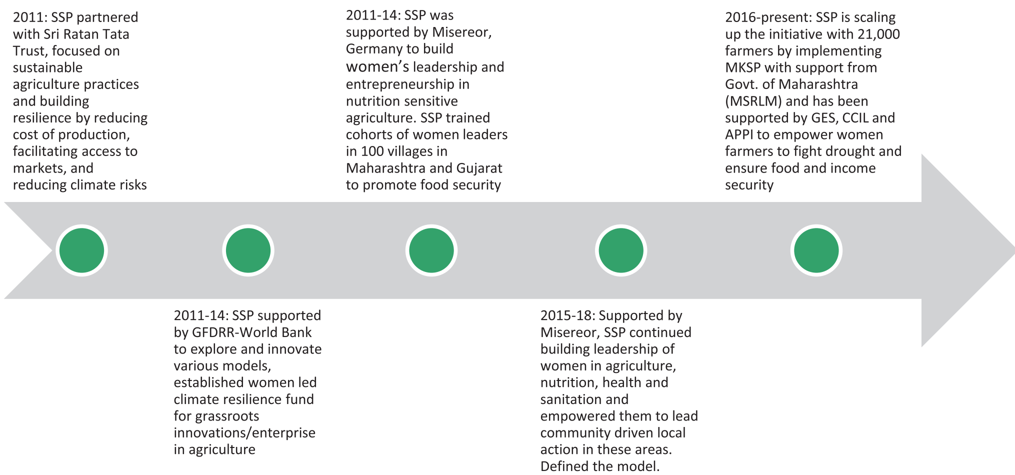


Figure 3: Evolution of the model[3]

3.2 Farming Practices and Adoption Criteria

Based on approaches that sustain farming under adverse climatic conditions and provide sustainable livelihood solution to small and marginal farmers, the following farming practices are promoted:

1. Use of bio-pesticides over chemical pesticides such as dasparni ark, neem ark, use of traps, etc.
2. Use of bio-fertilizers like cow dung, slurry, NADEP, vermi-compost
3. Use of local/traditional seeds (germination test and use)

[3] APPI-Azim Premji Philanthropic Initiatives, GES- Great Eastern Shipping Co., CCIL-Clearing Corporation of India Ltd, MKSP-Mahila Kisan Sashaktikaran Pariyojana, MSRLM- Maharashtra State Rural Livelihood Mission

4. Diversification of food crops to five to seven varieties (pulses, cereals, vegetables, oilseeds)
5. Water management systems through use of drip, sprinklers and rain pipes as well as conservation structures such as farm ponds, farm bunds/trenches, rain water harvesting, well recharge etc.

The first four practices define the adoption criteria of this model. In addition to the above, the other practices promoted in this model are fodder cultivation, cattle feed supplementary, soil testing and planting of trees on farm as a measure for water and soil conservation and homestead gardens. This model addresses the issues of food security, income security, natural resource management and women empowerment all at the same time and can be replicated in similar geographies.

SSP encourages women farmers to gain cultivation rights to grow food crops, from their families on a small piece of land around one acre approximately. On the given piece of land the women leads the complete decision making around what to cultivate, what to sell, what to keep and eat, and where to sell, thus gaining control over income. On the acquired piece of land, usually to start with half or one acre, women practice water efficient, organic farming cultivation of vegetables, millets, cereals and pulses through a mixed cropping, diversifying to 5-7 food crops and by increasing crop cycles. Crop diversification increases household food security levels and reduces risk considerably in the short term. Access to targeted credit and diversification of livelihoods include livestock, agri-allied enterprises and small trades/businesses contribute to more sustainable incomes. Additionally special efforts to promote livelihoods/ventures around agriculture, land, water, energy protection of natural resources affected by climate change such as community/group enterprises around bio inputs (vermi-compost, bio pesticides etc), goat rearing, seed banks, vegetable selling groups, dairy, and poultry diversify income sources and again reduce risks of the farmers. Over a given period of time, it is expected that family members realize the benefit of cultivation of food crops vis a vis cultivation of "only cash crops", which have high input cost as well as are highly dependent on external volatile markets.

3.3 Approach

The innovative aspect of the WCRF model is, to centre stage women as farmers and decision makers. This model seeks to empower and recognize rural women as farmers and change makers to promote food secure agriculture model and further as leaders and mentors for innovation transfer and replication to scale up the impact and outreach in similar newer geographies.

Figure 4 below represents the approach to the women-led climate resilient farming model.

Figure 4: Approach to women-led climate resilient farming

4. Process

Implementing the WCRF model entails a systematic process which includes capacity building of women farmers in sustainable agriculture, demonstrations, exposure visits/ learning exchanges, farmer field schools, leadership workshops, agri-allied and other business training, dialogue workshops and convergence with government departments and institutions. The detailed processes and interventions within the model have been narrated below:

Selection of Villages: The villages are selected using a cluster approach whereby they are located within 20-25 km radius and on the basis of their drought situation. Another criterion for selection of villages is that the villages must have the presence of Self Help Groups (SHGs) through which entry point activities can be conducted.

Selection of CRPs: The next step is to identify Community Resource Persons (CRPs) known as *Samvad Sahayaks* from among the SHGs. Women farmers' families with landholdings, having good rapport with the community, having completed at least 8th or 10th standard, and willing to impart capacity building and transfer the knowledge to other women farmers either in their own villages or across nearby villages are selected. The CRPs are paid honorarium on a monthly basis. The CRPs are first self-empowered through capacity building programs and then they transmit the learning to fellow women farmers in their villages. The CRPs undergo class room training programs on sustainable agriculture and leadership development, on-site demonstration, farmer field school, learning exchange through exposure visit, dialogue workshop with government departments (for advocacy and convergence with schemes and programs).

Selection of Women Farmers: The CRPs identify poor women farmers from each village through SHG meetings and household visit. Small and marginal farmers are identified through secondary data source of the government at the village level. The list of small and marginal farmers with less than five acres of land is collected from the village *talati*.

Additionally, social mapping and household surveys are conducted for final selection of women farmers.

Awareness Campaigns: SSP conducts awareness campaigns and farmers meeting to generate awareness about the model in the drought affected villages as well as share its benefits. The awareness campaigns usually take place before beginning of each agricultural season.

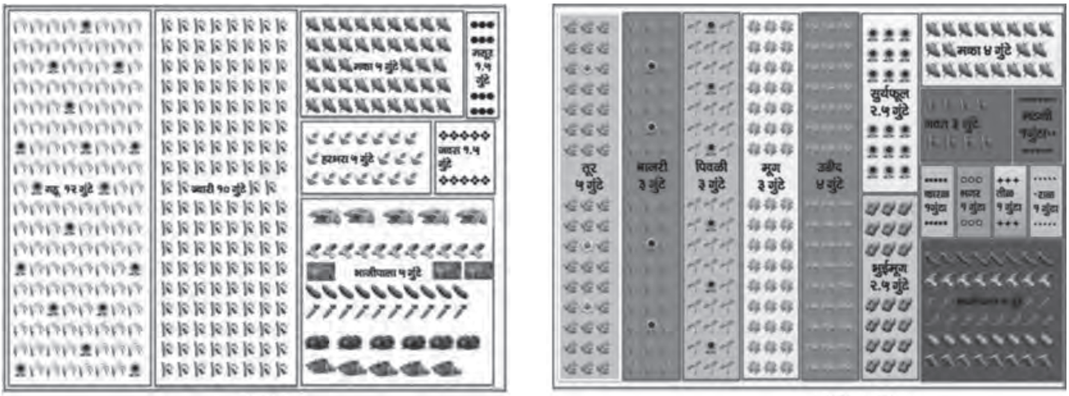
Capacity Building of Women Farmers: Awareness building is an on-going process in the villages. However, for building capacities of women farmers, they are federated into farmers' collectives of 20-25 members each and then trained on key resilient practices and its economic as well as health benefits.

- Agriculture – bio fertilizers and pesticides, indigenous seed collection and preservation, germination test, soil test, crop diversification, cultivation of cattle feed supplementary and fodder like azolla and hydroponics
- Health and Nutrition – importance of nutrition rich food, vegetables, importance of homestead garden
- Water management – water conservation structures like farm ponds, bunds, recharge structures-wells, bore wells and management systems like drip, sprinkler, rain water pipe
- Enterprise – agri-allied business such as dairy farming, goatery, poultry, sale of vegetables, fertilizers, pesticides, fodder, and other non-farm enterprises as well.
- Producer groups and market linkage – formation and importance of farmer groups for input sharing, labour sharing, procurement of inputs and sale of outputs, exposure visits to weekly market and district level market.

The table 1 presents season-wise crops and inputs that are suggested for cultivation. Besides, during drought women farmers are advised to cultivate **short-term and less water intensive crops, traditional and wild variety of vegetables** to ensure food security of their families and communities.

Table 1: Season-wise farm inputs and crops

S. No.	Season	Farm Inputs and Crop Selection
1.	Rabi	**Crops** • Pulses: Gram, Masoor • Grains: Jowar, Wheat, Sorghum • Vegetables: Beans, Chilli, Tomato, Potato, Cucumber, Spinach, Bitter gourd, Fenugreek, Brinjal, Ladies Finger, Green leafy vegetables • Oilseeds: Javas • Fodder: Maize **Pest Control** • Local Natural Pesticides – Dasparni Ark, Neem Ark, Neem Astra, Agni Astra, Brahmastra • Bio-logical pest control – Trap, Border crop traps **Soil nutrient management** • Jeevamrut **Seeds** • Preparation of own seeds • Germination test • Seed treatment
2.	Kharif	**Crops** (only with farmers that have irrigation) • Pulses: Red Gram, Green Gram, Black Gram • Grains: Bajra • Vegetables: Beans, Chilli, Tomato, Potato, Cucumber, Spinach, Brinjal, Ladies Finger, Green leafy vegetables • Oilseeds: Til,Mustard, Soyabean • Fodder: Maize **Pest Control** • Local Natural Pesticides – Dasparni Ark, Neem Ark, Neem Astra, Agni Astra, Brahmastra • Bio-logical pest control – Trap, Border crop traps **Soil-testing** **Seeds** • Preparation of own seeds • Germination test • Seed treatment
3.	Summer	**Crops** (only with farmers that have irrigation) • Pulses: Gram • Grains: Wheat, Sorghum • Vegetables: Beans, Chilli, Tomato, Potato, Cucumber, Spinach, Bitter gourd, Fenugreek, Brinjal, Ladies Finger, Green leafy vegetables • Oilseeds: Groundnut • Fodder: Maize **Fertilizer Management** • NADEP • Bio-compost • Vermi-compost • Green manure • Green fodder (Hydroponics) • Cattle feed supplementary (Azolla)



Rabi Kharif

Figure 5: Cultivation as per WCRF

Considering the changing climatic conditions, its implication on household food security and related health issues along with the lack of irrigation facilities for majority of the farmers, the organization promoted the *Sakhi Arogyadai Parasbag* (vegetable/ kitchen garden) where women can cultivate vegetables using less water. For this, two models were suggested depending on the size of the land. One is circular in shape covering 1000 sq. ft. area and the other is square shaped spread over 100 sq. ft. In both the models, growing six to seven types of vegetables were recommended.

Figure 6: Sakhi Arogyadai Parasbag (Vegetable Backyard Garden)

Knowledge exchange through model farms: SSP organizes exposure visit of women farmers to model farms and demo plots for learning and sharing knowledge. On site demonstrations of best practices are conducted through model farm creation - local seed production, fertilizer production, crop diversity techniques, and fodder production etc. The model farms serve as centres for learning and sharing through demonstrations.

Block level network meetings: SSP teams facilitate peer learning meetings at the cluster/ block level for learning by sharing experiences and best practices. Besides, women farmers become members of these larger networks through which they collectively learn from and share with each other.

Community resilience fund: In order to provide fund support to women farmers for innovations in agriculture and starting new enterprises, SSP has created the community resilience fund that is completely managed and owned by women groups. It is a revolving fund which is lend to women at a relatively low rate of interest.

Partnerships: In all the training programs and workshops, SSP has immensely been supported by the Krishi Vigyan Kendra, the Agriculture University, the Ground Water Survey and Development Agency, the MGNREGS (Mahatma Gandhi National Rural Employment Guarantee Scheme) department and the Agriculture and Technology Management Agency (ATMA) with whom SSP has partnership to transfer required knowledge to women farmers and trainers.

Dialogue workshops for advocacy and convergence of schemes: SSP organizes and facilitates networking and dialogue workshops at the block and district levels with the participation of women leaders and government line department officials to discuss their needs and challenges with respect to capacity building and access to various schemes. Women leaders present the status of various applications submitted to government departments and lobby on behalf of women farmers to help them receive the schemes besides advocating for land ownership by women with village level Talati, other officials and families of women farmers.

5. Impact

In the last three years (2015-18), SSP has empowered 41,000 small and marginal women farmers in climate resilient farming. Having initiated farming on 10 *Guntha* of land[4] women have eventually spread it to one acre and more. SSP's WCRF model has been adopted by women in Osmanabad, Washim, Nanded, Latur and Solapur districts.

The WCRF model offers a variety of outcomes linked to social, economic as well as environmental development and sustainability. In the context of sustainable livelihood and climate resilience, this case study focuses on some of the key impacts that have been achieved by implementing the WCRF model. These include:

5.1 Increased Agricultural Productivity

1. Minimum savings of 25% per acre per crop cycle through use of bio fertilizers, bio pesticides and home-grown seeds
2. Average annual savings of INR 35,000 per household by consuming farm grown food and using natural farm inputs
3. Increase in average yield of food crops by 25% through intercropping and mixed cropping techniques

SSP calculated the savings generated by comparing use of bio-pesticides, bio-fertilizers and use of local seeds before and after the intervention. The women farmers have reported that due to use of bio-inputs such as bio-pesticides, local seeds and fertilizers the cost of inputs for cultivation has come down and they have been able to save money which earlier incurred a great amount.

1 acre=40 Gunthas

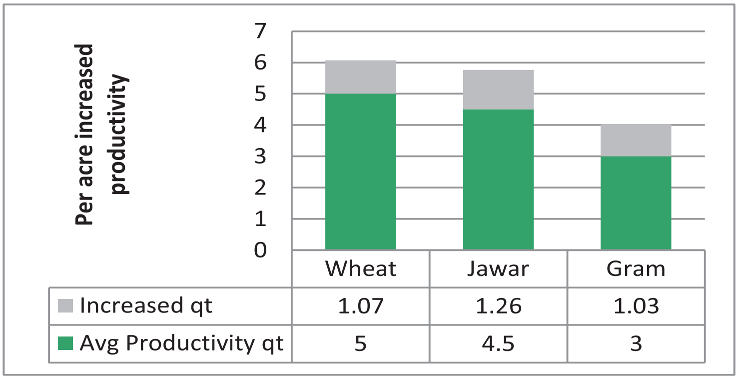


Figure 7: Increase in productivity due to pest control and seed germination test

Due to seed germination test and use of bio-pesticides there has been increase in crop productivity. The figure 7 above presents information on the basis of per acre production of wheat, jawar and gram in quintal. Before adopting the model, the average productivity of wheat, jawar and gram was 5 quintals, 4.5 quintals and 3 quintals respectively and after adoption, the increase per acre has been 1.07 quintals, 1.26 quintals and 1.03 quintals respectively for wheat, jawar and gram. The percentage increase in productivity per acre is calculated to be over 25%. This shows that the model has been successful in increasing crop productivity with low cost inputs and has scope for scaling to more number of acreages by more number of farmers.

5.2 Improved Food Security, Health and Nutrition

1. Cultivation and consumption of traditional food crops like local cereals, pulses, fruits and vegetables
2. Increased consumption of milk, chicken and eggs by integrating livestock in farming model
3. Elimination of chemical-infused food through bio-farming

Women farmers have reported cultivating about 40 types of food crops on the one-acre farm land. About 2/3 of these food crops are kept for self-consumption and the remaining is sold at the market. Women also reported that the consumption of meals in their household has improved from two to three times a day with a dietary variety of pulses, grains, vegetables, food from livestock etc, as compared to yesteryears that were severely affected by drought. SSP also encouraged women to sell the surplus in the market so as to gain income out of it and although about 20-30% is engaged in such activities, the first priority always remains food for self-consumption.

5.3 Strengthened Socio-economic Conditions

1. Diversified livelihoods through agri-allied businesses
2. Steady cash-flow by selecting shorter duration crops than cash crops like sugarcane and soyabean

3. Cessation of forced migration in search of labour work during lean seasons
4. 41,000 marginalized women recognized as farmers and agriculture decision makers by their family, community and government

More than 70% of the women farmers are engaged in agri-allied and small enterprises. These include dairy, goat keeping, poultry, and sale of seeds, bio fertilizers and bio pesticides, vegetables and other non-farm business. Diversification of livelihoods have secured the income of women and their families.

Women have also reported participating in decision-making in issues pertaining to income, their own and children's health, education, and other priorities. Women are now taking decisions related to the types of crops to be taken for cultivation and the inputs.

5.4 Improved Ecology

1. 30,000 acres under bio-farming through soil conservation by use of bio-inputs
2. Water conservation by micro-irrigation and selecting less water-intensive local crops

Due to the WCRF initiative, about 16,000 women farmers have adopted micro-irrigation techniques on their farm through use of drips, sprinklers and rain pipes.

Table 2: Summary of Impact/Major Shifts due to WCRF

S. No.	Aspects	Before Intervention	After Intervention
1.	Women's role in agriculture	Worked mainly as a labour with no decision making related to crop and input selection; involved in watering, weeding, harvesting	Farmer and decision maker in agriculture – crop and input selection, sowing, weeding, harvesting, watering
2.	Cultivation of crops	Single cash crops like sugar cane, soybean	Diversified food crops and vegetables along with cash crops
3.	Use of chemical inputs	Application of expensive chemical fertilizers, chemical pesticides on entire farm land	Application of low cost bio-fertilizers and bio-pesticides on the land where they have adopted the model
4.	Water management systems	Large dependence on flood irrigation	Adoption of micro-irrigation practices by 40% women farmers
5.	Income and control over income	Women had no control over the income that they earned as wage labour (Approx. INR 4500 per month)	Women earn between INR 10,000-15,000 due to agri-allied business and sale of vegetables per month. They use their income for priorities like their own and children's health, education, buying other necessities.
6.	Livelihoods	Single source of income from farm	Multiple sources of income from farm, agri-allied business and non-farm business 28,000 women farmers have diversified their livelihoods through 2-3 allied businesses

Impact of the initiative in the words of our women farmers:

"By cultivating crops under the one-acre model, I have been doing what the doctor does for people – providing good health," says Vanita Manshetty, Chiwri village in Osmanabad district.

"Two years ago, we could not even grow basic vegetables like onions and tomatoes for our consumption. Today, my one-acre patch has 13 types of crops and vegetables, which we grow in rotation throughout the year. We are able to feed ourselves and also get a good income." says Shailaja Narwade from Masia village near Solapur in interior Maharashtra.

Anusaya Baburao Kale from Boregaon village in Latur district exclaims, "Earlier, my husband was the decision maker in agriculture and had complete ownership of the farm but now I am taking the decisions related to crop selection, inputs, where to sell the produce and how much to sell."

6. Challenges and Way Forward

The *key challenges* faced with regard to implementing the model are:

- Switching from cash to food crops: marginal farmers and among them women face increased risks – mono cropping, high use of chemical inputs and water
- Since women do not own land, it is a challenge their families to agree to give women even a small piece of land to practice the new farming model
- Women are generally not counted as farmers and not recognized as beneficiaries for Govt. sponsored subsidies, extension services, training and credit.

6.1 Opportunities to Scale-up

SSP has over two decades of proven experience in disaster risk reduction and entrepreneurship programs across Six Indian states. SSP has in-house capacities of experienced team members and trained CRPs and leaders to transfer the innovation. SSP has strengthened the leadership of women who are acting as grassroots' advocates to forge partnership with the government to scale up this model to other districts and places.

SSP has partnership with Krishi Vigyan Kendra, Agriculture Technology and Management Association (ATMA) and Agriculture Universities at block, district and state levels to transfer required knowledge to women farmers and trainers. Other existing partnerships supporting the organization to scale this initiative include Govt. of Maharshtra (MSRLM), Misereor, Germany, Azim Premji Philanthropic Initiatives, Great Eastern Shipping Co. Ltd., and Clearing Corporation of India Limited across 500 villages in Maharashtra. SSP is a member of the GROOTS international network which has a membership of 40 countries where the initiative can be scaled at a larger level.

Besides, SSP teams are lobbying for implementation of a recent directive by the Ministry of Agriculture, Govt. Of India, 30% of State level funds for agriculture to be compulsorily allocated for women farmers. SSP is advocating to direct resources and entitlements under PoCRA (Project on Climate Resilient Agriculture) – implemented by the Government of Maharashtra and funded by the World Bank.

6.2 Sustainability of the Initiative

The overall change SSP wants to see through this initiative is agency/leadership of women as farmers and decision makers in their farms, families and communities that will expand and sustain beyond the project period. Women will have gained enhanced social capital (new economic and social identities) as farmers, decision makers in agriculture and in their households, and additionally as entrepreneurs, grassroots advocates in local development. SSP will strengthen the leadership of women who will act as grassroots' advocates to forge partnership with the government to scale up this model to other districts and places and create demand for organic produce. Further, SSP has facilitated the registration of two Farmer Producer Company to ensure market linkage and sustainability of the model.

6.3 Learning/Policy Level Changes Required

- Radical shift required in policy making and programs to recognize women's strategic role in climate smart sustainable agriculture practices
- Investment in skills and capacity building of women to train them as Climate Champions
- Recognition of women as important stakeholders in agriculture policy planning and decision making

7. Conclusion

The model has generated positive impact on the lives of small and marginal farming households. Use of organic/bio-farming practices and mixed cropping pattern has reduced their expenses related to food consumption and production and increased productivity per acre. Also the frequency of consuming home grown nutritious vegetables, cereals and pulses in a day has considerably improved addressing issues of food security in their families. Water management practices using drip irrigation and building farm bunds, farm ponds etc. in areas where the women faced shortage of water has helped in saving water and growing the crops in an efficient manner. These practices coupled with tree plantation on farm have together led to sustainable impact on soil, water and environment as a whole in the long-term.

Many of the women reported that the income earned by them from sale of surplus and agri-allied businesses has added to their individual and family income and they are able to use it for various purposes such as small household expenses, healthcare needs of family and education of children, etc. Social mobility has also increased to a considerable extent and women find themselves in decision making roles in agriculture and households (which were earlier a big constraint) thus, repositioning them as farmers and decision makers in agriculture.

The climate resilient farming model has been successful in bringing shifts in farming practices that can be termed as crucial to mitigate global climate change implications on agriculture and water resources. Besides, providing a sustainable farming and livelihood solution to small and marginal farming households, it has become an important tool in empowering women and recognising them as farmers and decision makers in agriculture.

The Climate-Smart Village Approach for Building Resilient Agriculture in India

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1. The Issue

India is amongst the most vulnerable regions to climate change in the Inter-Government Panel on Climate Change (IPCC)'s Fifth Assessment Report released a year ago, and in other similar reports. Rise in average temperatures, changes in rainfall patterns, and increasing frequency of extreme weather events such as severe droughts and floods have been observed in different agro-ecological zones of India, which poses a major threat to India's food security. Despite impressive progress in food production in recent years, India remains home to almost 40% of the world's poor, 20% of the world's hungry and 40% of the world's malnourished children and women. The majority of poor and under-nourished live in rural areas and depend on agriculture for food and livelihoods. The impressive economic growth and remarkable increase in food production during last few decades have not contributed to alleviating poverty and reducing hunger in rural areas. Therefore, future growth strategies should include sustainable agricultural development.

Compounding food security and related livelihood related issues, is the significant amount of Green House Gas (GHG) emissions from the agricultural sector. Agriculture both affects and is in turn affected by climate change. The sector is responsible for a third of global GHG emissions, with India's contribution amounting to 18% (Sapkota et al. 2018). From another lens, the Indian population continues to grow. This, accompanied with rising per capita income, and urbanization will lead to an increase in demand for food grains and a gradual shift of expenditure from cereals to meat, milk, fish and other animal products. It is estimated that by 2050, our food grain requirements will be almost 50% more than the current demand. On the other hand, the large population and agricultural pressure on land has been very demanding on natural resources, especially water and land, and has resulted in their degradation over time. The additional food will have to be produced from the same or even shrinking land resources due to increasing competition for land from the non-agricultural sectors. The tasks of alleviating poverty and attaining food security at the household and sub-national/regional level are thus major challenges.

Several studies have shown that, unless we adapt now, India could lose 10-40% of crop production by the end of the century due to global warming, despite the beneficial aspects of increased CO2 (Aggarwal, 2009; Nelson et al., 2009; Knox et al., 2011). In fact, there is some evidence that changing climate has already impacted rice and apple yields. Projections indicate the possibility of losing of 4-5 million tons of wheat production with every rise of 1oC temperature throughout the growing period (Aggarwal, 2009). Recent simulation analysis has indicated that rainfed maize, sorghum and rice yields are likely to be adversely affected by the increase in temperature. The projected increase in drought and flood events could result in greater instability in food production and threaten the livelihood security of farmers.

Thus, the greatest challenge lies in attaining food security for the nations' bludgeoning population under a climate affected agricultural system while at the same time ensuring that food production follows a low emissions and sustainable trajectory. Through scientific innovation, partnerships and policy support, Indian agriculture needs to be infused with resilience while operating within the larger framework of achieving the Sustainable Development Goals of 'No Poverty', 'Zero Hunger', 'Climate Action', 'Partnerships for the goals' among others.

2. How is this being Addressed?

As a composite solution to advance climate-smart agricultural technologies and practices, CCAFS has developed the Climate-Smart Village (CSV) approach. Started in India in 2012 as an 'Agricultural Research for Development' (AR4D) approach, the CSVs are platforms, to test through participatory methods, technological and institutional options for dealing with climate change in agriculture (Aggarwal et al 2018). The CSV sites are generally a cluster of villages where such options are tested in collaboration with multiple stakeholders (farmers, researchers, local institutions etc.) to generate evidences on synergies as well as trade-offs between different options in terms of productivity, adaptation and mitigation. The options so chosen are geared towards attaining multiple benefits of: *resilient agricultural communities; higher yield potential and thereby higher farm incomes; enhanced livelihood opportunities; gender and social inclusion in agriculture strategies* among others.

2.1 Key Features of the CSV-AR4D Approach

- Sites for testing, through participatory methods, technological and institutional options.
- Sites where climate change in its broadest context is considered, but in relation to local realities: long-term adaptation, avoiding maladaptation, climate risk management and low emissions development.
- Embodies a holistic vision for climate change action – not a silver bullet approach.
- A platform for socially inclusive, multi-stakeholder collaborative work.
- Founded on the principle of bringing CSA to scale.
- Links global and local knowledge.

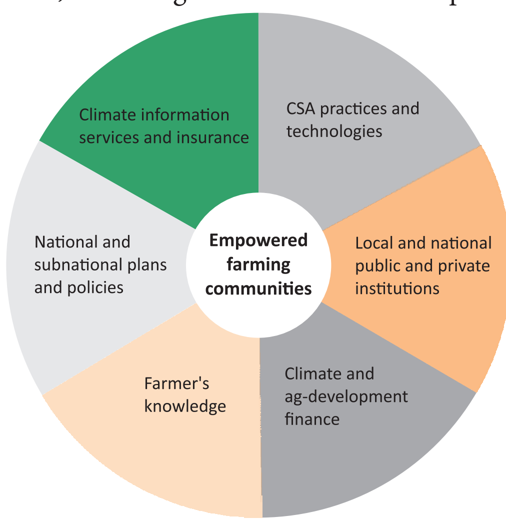

Figure 1: Components considered in a CSV-AR4D site

2.2 Steps in Developing Climate-smart Villages

In establishing a CSV AR4D site, the very first step is to build trust and partnerships amongst diverse stakeholders; and to get agreement and buy-in to a common approach (Aggarwal et al. 2018). Once partners have agreed on the establishment of a CSV site, the major steps include:

1. **Baseline assessment:** including climate risk analysis and gender and social inclusion analysis;
2. **CSV design:** Identification and prioritization of climate-smart technologies, practices and services based on biophysical, socio-economic, gender, policy and institutional context; also considering possible synergies and trade-offs amongst individual activities;
3. **Creating evidence:** Evaluation and development of portfolios of climate-smart interventions (e.g. providing value-added weather services to farmers, promoting weather-based insurance, building capacity in climate change adaptation and facilitating community partnerships for knowledge sharing);
4. **Scaling:** This involves scaling up through policies and institutions, and scaling out to large areas through farm-to-farm and ICT-based approaches (Figure 2).

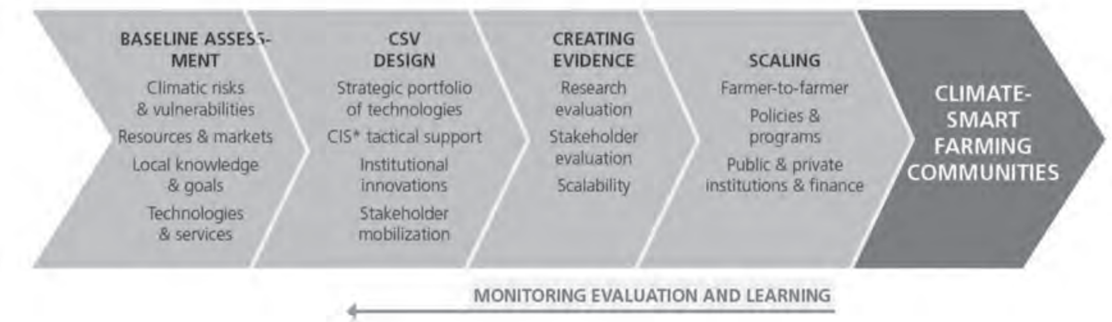

Figure 2: Steps for the implementation of the CSV AR4D approach. Implementation steps are based on stakeholder engagement and seldom follow a simple linear model.

The CSV approach usually results in a portfolio of CSA options and institutional and financial mechanisms which can be scaled up/out by the national/sub-national governments, NGOs and private sector actors in the region. A number of tools such as the Climate-Smart Agriculture Prioritization (CSAP) toolkit, choice-experiments for CSA prioritization, CCAFS Mitigation Options Tool (CCAFS- MOT) for emission measurement, Gender and Social Inclusion Toolbox, crop simulation models, and climate analogues, are used in the process. CSVs established in the states of Punjab, Haryana, Bihar, Odisha, Uttar Pradesh, Madhya Pradesh, Maharashtra, and Telangana have yielded models of CSA portfolios that can be scaled further and lessons drawn from it can be used by policy makers from local to global levels.

2.3 Climate-Smart Agricultural (CSA) Interventions in CSVs

The options tested as part of the CSV research agenda for dealing with climate change and variability include: weather-smart activities (weather forecasts, climate-informed agro-advisories, weather insurance, climate analogues as a tool for forward planning, strategies to avoid maladaptation), water-smart practices (aquifer recharge, rainwater harvesting, community management of water, laser-land leveling, micro-irrigation, raised-bed planting, solar pumps), seed/breed smart (adapted varieties and breeds, seed banks including community-based activities), carbon/nutrient-smart practices (agroforestry, minimum tillage, land use systems, livestock management, integrated nutrient management, biofuels) and institutional/market smart activities (cross-sectoral linkages; local institutions including learning platforms or farmer-to-farmer learning and capacity development), contingency planning, financial services, market information, gender equitable approaches, and off-farm risk management strategies.

There is no fixed package of CSA interventions to be tested however or a one-size-fits-all approach. Interventions selected differ based on the region, its agro-ecological characteristics, level of development, capacity, and interest of farmers and the local government.

3. How is the CSV Approach Scaled up?

Scaling mechanisms tested across the regions include:

- Horizontal scaling (Scaling out) of climate-smart options: CSVs provide demonstration sites for farmer-to-farmer learning (often via self-help groups or producer organizations) and/or enable local promotion of CSA options through local government plans, programs and policies or through private sector business models.
- Vertical scaling (Scaling up): CSV research and lessons learned provides evidence for the efficacy of practices, technologies, services, processes and institutional options and is thus able to: influence large-scale CSA investment

3.1 Case Study: Scaling the Climate-Smart Village Approach and Advancing Climate-smart Agriculture in Betul (Madhya Pradesh), Nalanda (Bihar) and Mathura (Uttar Pradesh)

A project collaboration has been made with the United States Agency for International Development to help scale the Climate-Smart Village approach and thereby advancing climate-smart agriculture (CSA) in Betul (Madhya Pradesh), Nalanda (Bihar) and Mathura (Uttar Pradesh). As part of the project implementation plan, 16 CSA technologies were implemented in 75 villages in the three aforesaid districts. As a result, more than 11,000 farmers were covered for adoption of CSA technologies, practices and services to build climate resilience in agriculture. Results of the model implementation highlighted improvements in resilience, reduction in greenhouse gas emissions and potential decrease in labour hours. Increased resilience was measured through increase in yields for all major crops across the three districts with simultaneous improvements in gross income. It also resulted in increase in nutrient use efficiency by more than 100% for all crops. Average emission intensity reduced by more than 20% overall as a result of multiple interventions including Integrated Nutrient Management, Solar irrigation and Biogas. Additionally, gender integration in the form of improved incomes and reduction in labour by more than 1,000 days also indicated improvement in adaptive capacity for women farmers.

4. The CSA Technology Transfer Model within the CSV Framework

The CSA technology adoption model (Figure 3) aims to highlight the process of building climate resilience of a large number of farmers in a systematic and sustainable manner. The model promotes the adoption of CSA technology and services through multiple activities centred on the hub and spoke model. The hub and spokes are supported by the various elements of the enabling environment, which continuously interact with the key actors of the model, the Super Champion, Champion and CSA farmers. At the same time, the model also encourages incorporating the impacts of technology adoption to make the model more relevant for scaling out.

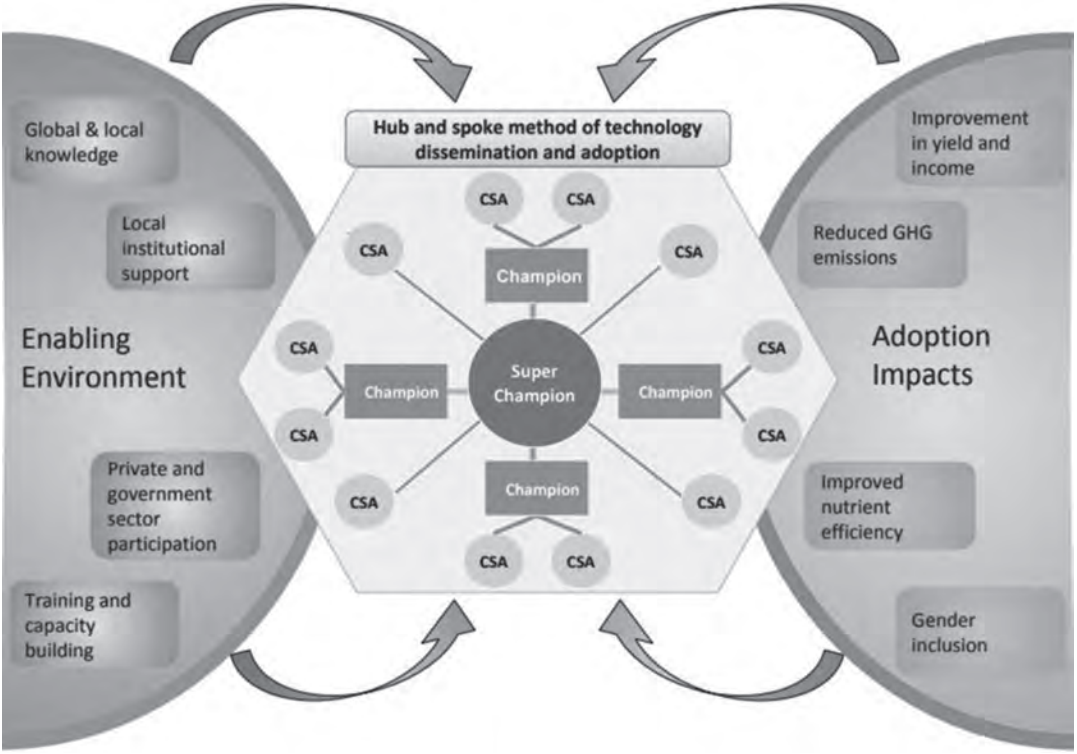

Figure 3: A schematic illustration of the CSA technology adoption, highlighting the inputs to and the results of technology dissemination and adoption through the model for building climate resilience.

4.1 Technology Transfer by Farmer Type

The hub and spoke model: The hub and spoke is the focus of the model that involves the key participants of the process, the farmers. There are two levels of hubs, the Super Champion and the Champion farmers. The Super Champion is the main hub who acts as influential supporters as well as promoters of CSA technology for Champion as well as the CSA farmers. The Champion farmers are another level of hub with whom CSA farmers can be connected. The Super Champion farmers are implementing a portfolio of 15 CSA technologies related to agriculture and livestock, while the Champion farmers are implementing a list of 9 CSA technologies, practices and services. Each of the 75 villages includes 1 Super Champion, 14 Champion and 135 CSA farmers. These farmers were selected based on their willingness and ability to participate and contribute financially to the process of technology adoption. The hubs are the focus of all technology linked implementation, which as a result also becomes the testing grounds for learning and adoption of best practices by other farmers.

A number of participatory activities such as farmer field visits and farmer fairs facilitate the working of the hub and spoke model. Champion, and CSA farmers are regularly taken to the demo fields of Super-Champion farmers to understand the climate-smart interventions on the field and the difference in outputs between the demo and regular plots. Similarly, during farmer fairs, the participants are exposed to the different types of climate-smart technologies and practices that the Super Champion and Champions are implementing. They are also shown some of the demo plots to understand the benefits of changing the traditional cropping practices. This ensures the spread of knowledge and the initiation of interactive learning among the farmers.

Enabling Environment

The enabling environment consists of all the activities, support systems and mechanisms that continuously feed the hub and spoke system of the model. These also act as enabling factors for CSA technology adoption and play an important role to keep the model sustainable in the long run. The components of the enabling environment are:

i. **Global and local knowledge:** The process of selecting a locally relevant portfolio for technology adoption involves bringing in existing global CSA related knowledge to the fields and then testing it using participatory processes to shortlist the most favourable options. Therefore, a list of 34 CSA technologies, practices and services was developed based on a global literature review of past studies and in consultation with researchers and local stakeholders in the region. The local cropping pattern and climatic risks prevailing in the three districts were considered during the process. Subsequently, a CSA prioritization exercise was conducted with the local stakeholder including the villagers, local NGO partners and local farmer organizations, to finalise the list of CSA interventions.

   In addition, a baseline was conducted across the three districts of 1,125 farmers to understand the locally prevailing conditions with respect to the climate risks, current farm productivity, demographic characteristics, and farmers experience with CSA technology adoption. This information is also considered as the base for assessing the results of CSA technology adoption.

ii. **Local institutional support:** Local institutions support the CSA technology adoption process by keeping all stakeholders connected with each other. These are primarily community based approaches that support collective action and decision making to promote climate change adaptation. Three types of institutions have been formed to enable technology access to the farmers in the hub and spoke. These include the Village Climate Management Committee (VCMC), Custom Hiring Center and Cattle Development Center.

   The Village Climate Management Committees (VCMC) have been formed in every village to drive the implementation of CSA interventions at the local level. The members of this institution comprise of the Super Champion and Champion farmers. As a group, they are responsible for ensuring technology access to all kinds of farmers and therefore act as a link between the farmers and the external agencies such as the private sectors and government. The VCMCs act as a self-governing mechanism by tracking activities and ensuring compliance of all farmers with respect to their financial contributions, capacity building and awareness raising related to CSA technologies and practices.

The institution of Custom Hiring Centers (CHC) have been established with the objective of ensuring technology transfer to the local community through an institutional and business oriented approach. Managed by women farmers, these institutions also contribute to gender integration and empowerment in the farm community. Given the small landholdings of farmers combined with a minimal investment capacity for new technologies, the CHC promotes a technology hiring mechanism to overcome affordability barriers. Therefore, by making CSA technologies available at a rental cost, the CHCs are enabling farmers to overcome the technology access issue, facilitating efficient use of inputs, promoting use of CSA to farmers in and around their locality, and earning a source of income for its members. A total of 11 such institutions are currently running in the three districts.

Livestock in the study areas is characterized as low yielding cattle having a poor rate of conception, poor quality germplasm, and inadequate animal health care. Further, climate stresses such as drought, heat stress and excess rainfall further affect the health and productivity of the animals. Therefore, Cattle Development Centers, one each in the three districts have been established to promote improved breeds of cattle, provide better healthcare for the animals and build capacity of farmers to better manage their livestock to reduce adverse climatic impacts on them. Youth participation is encouraged for managing the activities of the institution and promote the use of CDC interventions to farmers in their villages. These institutions are directly linked with the local research centers to update them about the latest technologies, practices and breeds in the field.

iii. **Private and government sector participation:** Private and government sector partnership forms a key role in providing the CSA technologies, services and related practical knowledge. Across the three districts, several private players are supplying the different technologies and services through the NGO partner, ensuring access to new technologies for all farmers. For instance, IFFCO Kissan Sanchar Limited is providing ICT based weather, agro-advisory and market information in the villages through voice messages and SMSs to the farmers. Similarly, farmers are linked with government's agriculture insurance scheme to help them mitigate climate impacts on crops.

Additionally, the CSA technology adoption related activities are undertaken in coordination with multiple government departments and agencies. As a result, there is convergence of these activities with those of other government schemes and programs. This is enabling the spread of CSA technologies and practices to other farmers beyond the selected 75 villages. In two of the study districts, these convergence activities have been able to cover more than 6,000 additional farmer households as part of their on-going schemes related to CSA.

iv. **Training and capacity building:** To ensure continuous interactions of the hub and spoke process with the enabling environment requires continuous efforts for training and capacity building of all stakeholder, especially the farmers. Regular trainings are required for efficient and effective adoption of CSA technologies and practices. The training mainly includes implementation of CSA package of practices in the farmers' field, time and method of CSA technology application, preparation and importance of organic fertilizers, pesticides and vermicompost, as well as livestock related activities. Trainings on use of weather information and agro-advisory services and enrolment in the agriculture insurance program are also provided.

5. Impact Estimation

The impacts of CSA technology adoption have been measured in three major forms: increased resilience through improvement in yield, income and nutrient use efficiency, reduced greenhouse gas (GHG) emissions and reduction in labour hours for women farmers. All these are expected to enable farmers to sustainably improve agricultural production by developing their adaptive capacity and resilience to climate risks.

Improvement in yields, income and nutrient use efficiency

A midline survey was conducted in the three districts to collect yield data post technology adoption. The surveys covered two cropping seasons, Rabi and Kharif. The improvements in yields and income have been calculated as an increase from the baseline levels. Similarly, a livestock survey was conducted in two of the three project districts to evaluate the impact of climate-smart livestock interventions on animal milk yields. Data was collected from all farmers who are receiving livestock based interventions. The sample size was 225 and 90 in Mathura and Nalanda district, respectively. Given the majority usage of nitrogen rich fertilizers in the study districts, the nutrient use efficiency has been calculated by diving the crop yields with the nitrogen content of fertilizers.

Reduced greenhouse gas emission

Three CSA technologies and practices have been identified as a source for reducing greenhouse gas emission levels. These include nutrient management, bio-gas and solar pumps. Emissions from integrated nutrient management have been calculated using the CCAFS MOT tool (Feliciano et al., 2017). Emission reduction from biogas have been estimated in two forms, from the use of surplus cow-dung produced by cattle, as well reduction in firewood burning as fuel. Primary and secondary data sources have been used for these estimations. The emission from fuel wood is based on the following formula (IPCC, 2006):

$$\text{Emissions}_{\text{GHG, fuel}} = \text{Fuel Consumption}_{\text{Fuel}} \times \text{Emission Factor}_{\text{GHG, fuel}}$$

Where, $\text{Emissions}_{\text{GHG, fuel}}$ = emissions of a given GHG by type of fuel (kg GHG), $\text{Fuel Consumption}_{\text{fuel}}$ = amount of fuel combusted (TJ), $\text{Emission Factor}_{\text{GHG, fuel}}$ = default emission factor of a given GHG by type of fuel (kg gas/TJ).

The emission reduction potential from solar pumps has been estimated for its replacement with diesel and electric pump using secondary data.

Gender Inclusion

Gender inclusion is an essential part of building resilience of farmer communities. All three districts are characterized by different social structure and therefore women's role in agriculture as well as their level of participation in public forums and interventions differs across the districts. Benefits of the technology adoption model for women farmers has been measured in terms of improvement in incomes, and reduction in labour hours.

6. Results: Impacts of Technology Adoption

6.1 Improving Resilience through Increased Yields, Income and Nutrient use Efficiency

Increase in crop yields and income

Figure 4 highlights the improvement in overall yields and income for the major Kharif crop of Rice and Bajra in two of the study districts. Average Rice yields in Nalanda improved by 101% increasing farmer's gross income by 113%. Major technologies adopted during the season included System of Rice Intensification including line sowing and improved seeds, which prevented crop falling due to strong monsoon winds. Similarly, in Mathura, the crop yield growth post technology adoption was 24% more than the baseline with a consequent increase in gross income of 30%. A change of sowing practice from broadcasting to line sowing combined with improved seeds prevented Bajra yield loss during excess rainfall in the district in Kharif 2018. Additionally, a smaller range in the midline highlights more farmers benefitting from improved Rice and Bajra yields and income.

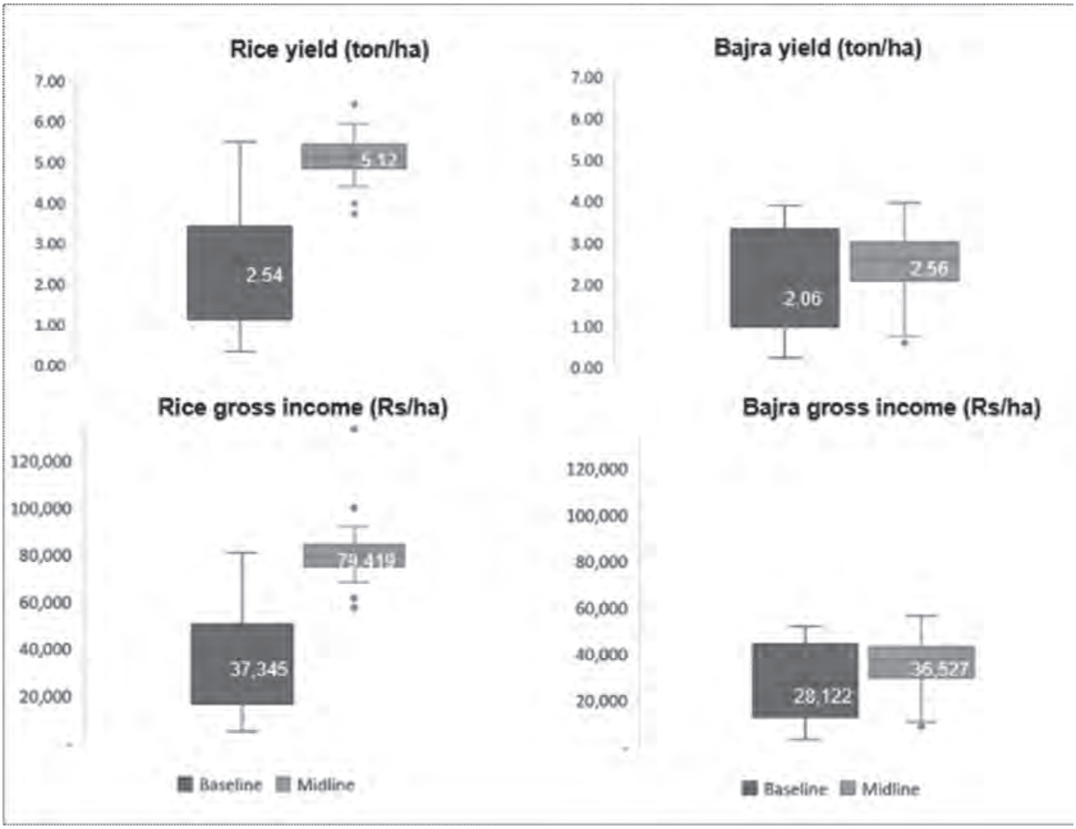

Figure 4: Change in yields and income of Kharif crops, Rice and Bajra, in Nalanda and Mathura districts respectively, as a result of technology adoption

Wheat is the major Rabi crops for the three districts. Cold waves in Betul and excess rainfall in Mathura during the harvesting stage of Wheat are mostly responsible for the loss in yield in the two districts. Similarly, in Nalanda, a delay in sowing of Wheat crop usually results in damage due to increased pest infestation. Therefore, the use of early maturing seed variety in Betul and adoption of line sowing method combined with contingent crop planning and agro-advisory based information in Mathura, has resulted in yield improvements by 39% in Betul and 68% in Mathura. Simultaneously, gross incomes increased by 48% and 78% in Betul and Mathura, respectively (Figure 5). In Nalanda, the use of Zero Tillage to enable timely crop sowing has helped in avoiding the expected damage and enabled a yield and gross income increase of 16% and 24% respectively. For Wheat crop as well, there are more number of farmers benefitting from improved yields and income in the baseline than in the midline, as highlighted by a shorter range of yields and income per hectare in all the districts.

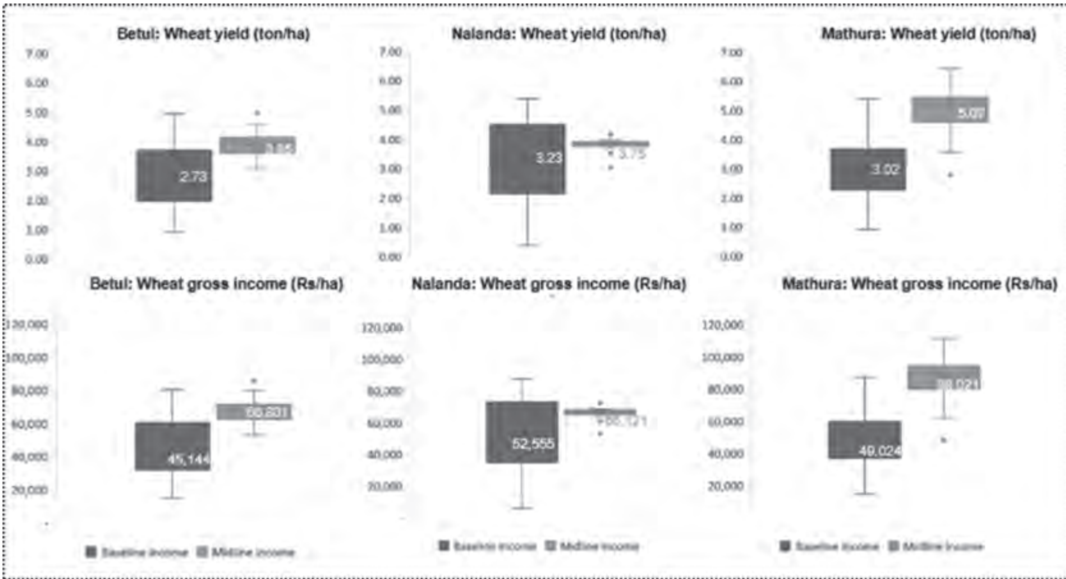

Figure 5: Change in yields and income of Rabi crop (Wheat) in all the three districts, as a result of technology adoption.

Increase in livestock yields

Promotion of several CSA livestock based practices and technologies through the Cattle Development Centers in two districts has helped in improving milk yields of the existing cattle breeds as seen in Table 2. Major CSA technologies include improved cattle breed (through Artificial Insemination), preventive animal health care, climate-smart housing for livestock and infertility camps among others. Over 1,000 farmers have opted for better breeds of animals through Artificial Insemination. Of the 1,570 animals inseminated, the success rate for pregnancy diagnostics has been 62% on an average, while 55% of those diagnosed have confirmed pregnancy. These new calves are expected to be more productive and less vulnerable to the climate stresses.

Table 2: Increase in milk yields of current cattle

Increase in milk yields	Mathura			Nalanda		
	Litres/day (before model)	Litres/ day (after model)	Change in yield (Litres/day)	Litres/day (before model)	Litres/ day (after model)	Change in yield
Cow	10.5	12.2	1.7	9.4	12.1	2.7
Buffalo	10.1	11.8	1.7	6.1	11.2	5.1

Increase in nutrient use efficiency

There is excess use of fertilizers including Urea and DAP across all the three districts which has been controlled through the CSA practice of soil management (Table 3). Additionally, capacity building and soil testing have been the major supporting activities to reduce the fertilizer inputs. As a result, nutrient use efficiency, specifically for nitrogen, has improved significantly across districts. Reduction in fertilizer input with a simultaneous increase in yield outputs have been the major driving factor for this improvement.

Table 3: Change in nitrogen use efficiency per ton per hectare of crop produced

Crop	Reduction in fertilizer (t/ha) from baseline	Increase in yield from baseline (t/ha)	Nitrogen use efficiency – baseline (yield output/ nitrogen input)	Nitrogen use efficiency – midline (yield output/ nitrogen input)	% improvement in nitrogen use efficiency per hectare
WHEAT					
Betul	-0.2	1.1	17.8	45.6	156.9%
Mathura	-0.3	2.1	15.5	53.5	245.4%
Nalanda	-0.5	0.5	6.6	13.8	109.5%
RICE					
Nalanda	0.6	2.6	6.4	53.0	724.0%
GRAM					
Betul	0.2	-0.4	14.8	45.7	210.0%
BAJRA					
Mathura	0.1	0.5	19.9	53.7	170.2%

6.2 Reducing Greenhouse Gas Emissions

Reduction in emissions through Nutrient Management

The CSA practice of Integrated Nutrient Management was adopted in all districts to manage the soil quality by reducing the use of emission intensive inorganic fertilizers such as Urea. The excess usage of these fertilizers was reduced by partially replacing them with organic fertilizer such as vermicompost. This resulted in more than 37% reduction on an average in overall CO2 emission per ton of crop production as seen in Table 4. This reduction has been the maximum for rice crop where the fertilizer usage was reduced by 0.6 tons per hectare, the highest among all crops and districts.

Table 4: Reduction in emission intensity

Crop details	Emission intensity – Baseline (Kg CO2 per Kg production)	Emission intensity – Midline (Kg CO2 per Kg production)	% change
WHEAT			
Betul	0.57	0.35	-39%
Mathura	0.52	0.28	-46%
Nalanda	1.01	0.55	-45%
RICE			
Nalanda	4.35	1.76	-59%
GRAM			
Betul	0.59	0.56	-6%
BAJRA			
Mathura	0.28	0.2	-29%

Reduction in emission through Manure Management

Livestock manure also contributes to greenhouse gas (GHG) emissions and its effective management can help in reducing these emissions. The CSA technology of biogas is helping reduce methane emissions through the use of surplus cow-dung produced by cattle, as well reducing firewood burning as fuel in the study districts. Table 5 explains the estimated amount of GHG reduction through the use of Biogas in project districts. There are a total of 26 Biogas units, each of 2 cubic meter capacity in the three districts, with 6 being used to replace firewood as a cooking fuel.

Table 5: Estimated reduction in GHG emissions from usage of biogas

Estimated GHG reduction from using cow dung	Details
Amount of cow dung used per Biogas	25 Kg/Day
Dung produced per animal	10 Kg/Day
Number of animals required to produce dung	2.50
Emissions per animal per year	1.6 tons of CO_2 eq.
Yearly emissions by animal per Biogas	4.00
Total number of Biogas in project areas	34
Total annual GHG (methane) emission saving from project Biogas	136 tons of CO_2 eq./year
Total estimated GHG reduction from replacing firewood	Details
Firewood usage before Biogas	1.760 Ton/Year
Firewood usage after Biogas	0.208 Ton/ Year
Firewood usage reduction	1.552 Ton/ Year
Number of Biogas replacing firewood	6
Total firewood saved	9.31 Ton/ Year
Amount of fuel combusted	0.015 TJ/Ton
Emission factor for wood	112 Kg CO_2/TJ
Total estimated GHG (CO_2) emission saving from firewood replacement	15.6 tons of CO_2/ year

Reduction in emission through Energy Management

Clean energy fuels such as solar are helping farmers replace the fossil fuel and other high emission energy sources. In one of the study districts, Betul, solar pumps of 1HP each have been introduced through the Custom Hiring Centers to provide farmers with access to clean energy irrigation sources, primarily for wheat crop in which less winter rainfall results in water scarcity impacting crop yields. The estimated GHG emission reduction potential of these pumps is 0.93 tons of CO_2 Equivalent (Table 6). This technology, therefore, when scaled out, has the potential to fulfil the farmers' water requirements in adverse climate conditions while contributing to emission reductions at the same time.

Table 6: Estimated reduction in emissions from usage of solar energy

Emission reduction by using solar pumps	Details
Total Number of pumps in Betul	4
Total estimated area covered by the pumps	81 Ha
Estimated GHG reduction by replacing diesel pumps	Details
Irrigation from diesel pump	175 mm
Ground water depth	10 mm
Irrigation pump efficiency	30%
Diesel requirement	35 litres.
Emissions from diesel irrigation per pump	0.10 ton of CO2 Eq.
Total estimated emissions replaced from diesel irrigation	0.40 of CO2 Eq.
Estimated GHG reduction by replacing electric pumps	Details
Irrigation from electric pump	175 mm
Ground water depth	10 mm
Irrigation pump efficiency	30%
Electric units consumption	147 KwH.
Emissions from electric irrigation per pump	0.13 ton of CO2 Eq.
Total estimated emissions replaced from electric irrigation	0.53 ton of CO2 Eq.

6.3 Gender Inclusion in Technology Impacts

Increase in income

The institution of Custom Hiring Center, serves as a source of income for women farmers. The regular flow of income through renting technologies helps women build their adaptive capacity to deal with weather risks in agriculture and encourage them to be equal contributors to improved productivity. During the Kharif season in 2018, 3 of the CHCs have earned more than INR 5000 by renting out more than 6 types of CSA technologies.

Reduction in labour hours

CSA technologies including Direct-Seeded Rice (DSR) and Biogas are playing a key role in reducing the labour contribution of women in agriculture and related activities. While DSR eliminates the activity of transplanting rice, a task primarily performed by women farmers, the use of Biogas for cooking eliminates the need for firewood collection as fuel and also reduces the time taken to make cow dung cakes by women. Estimations show that there is a potential of reducing 1,800 labour days for women farmers in the study areas of Nalanda and Betul. At the same time, biogas plants can reduce more than 1,500 hours of firewood collection time for farmers in Betul district.

Transitioning Towards Climate Resilient Communities: A Cluster based Ecosystems Approach from Andhra Pradesh by LAYA

Myron Mendes

LAYA is a resource centre based in Visakhapatnam, Andhra Pradesh. The main thrust of its activities are around the livelihoods issues of the *adivasi* communities located in six Scheduled Areas of Andhra Pradesh. The area, which is fairly remote, is rich in natural resources – water, forests and minerals. Major issues affecting the *adivasis* in the region relate to displacement and land alienation. The region's high natural resource base is under threat of complete depletion because of multiple demands of agri-business, mining and hydropower sectors. Though there are special protective laws for these Scheduled Areas, they do no prevent violation of the rights of the *adivasis* particularly in the context of access to and control over the natural resources, threat to their livelihood, and identity. The nature of violations becomes increasingly complex in an environment of unabated exposure to the market forces.

It is well known that the impacts of climate change affect the marginalized the most. Ironically, they are the people who contribute the least to the problems of climate change. Micro level planning has its important implications at the grassroots level both in terms of mitigation, because of the need to reduce emissions without compromising the goals of development, and adaptation, for mainstreaming climate change into the development agenda to enhance community resilience to the impacts of climate change. Therefore, there is an urgent need to develop practice models at the micro level which will feed into the climate change and sustainable development discourse at the grassroots level.

The livelihoods of the *adivasis* in the project area are primarily land-based with majority of the population depending on agriculture and collection of Non-Timber Forest Produces (NTFPs). Agriculture however is mostly limited to one season, *kharif*, lasting from June to September coinciding with the monsoon season. Limited access to water for irrigation makes raising second crop in a year difficult in the area. There are some farmers who cultivate a second crop on slope lands requiring less water. Many farmers are engaged in cattle rearing, which is on the decline due to lack of fodder availability and veterinary services. Backyard poultry has been taken up and revived under a government scheme. Cash income to the *adivasi* households comes mainly from government promoted schemes like the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). Subsidised food and daily ration are made available on a monthly basis through the Public Distribution System (PDS). Overall, the livelihoods of the *adivasi* communities impacted by climate change is increasingly becoming dependent on government doles and giveaways. This has a negative impact on the development of communities' life skills and capacity to become self-reliant that could build resilience to endure the ill effects of climate change.

The ecological situation is increasingly becoming a matter of concern. The farmers are experiencing erratic and untimely rainfall with long dry periods, short sharp winters and extreme events faced by increasing climate variability. This area has witnessed as many as eight such extreme events since 2010 as gathered from a local study on weather patterns and disasters, 2010-2017. There has been a gradual loss of forest cover and biodiversity. Some perennial streams are also seen to be getting dryer with every passing year.

1. Building Community Resilience: Grassroots Actions and Engagements

The key areas of focused intervention have been limited to exploring alternative solutions to address the effects of climate change by building resilience among communities. LAYA, in collaboration with the Indian Network on Ethics and Climate Change (INECC)[1] and *adopting* its diverse processes has seen a transition from its understanding of adaptation to a more robust community resilience building practices. This has translated into developing a clutch of good practices which, when applied together, work as a pragmatic model towards building community resilience to climate change.

The key aspects that these processes and interventions aim to address are:

Lack of a critical number of successful demonstrable projects at the grassroots level to contribute to a meaningful discourse on climate policy and community resilience.

In the face of the current techno-centric and growth based development paradigm discourse, at the national and international levels, there is little alternate articulation that addresses the concerns of the vulnerable and the marginalized groups across the country. Therefore, it is also understood that that the current climate change discourse is not seen as an opportunity for addressing sustainable development using the low-carbon pathway. The cluster approach will provide insights for a long term strategic thinking ensuring well-being and also an environmentally sound way forward.

There are very few or hardly any demonstrations of coping with climatic changes to improve resilience of local communities or to promote decentralized renewable technologies managed by the vulnerable and marginalized communities to enhance quality of life at the community level. There is a need to demonstrate the perspective at the grassroots level as well as highlight the various kinds of initiatives that are being undertaken with the objective of feeding into the climate discourse at various levels in the country.

Inadequate attention to the value of climate change education

Inadequate understanding of the ill effects of climate change among various groups of people is an important concern. Because of lack of information and exposure, people do

[1] LAYA is currently the secretariat for INECC.

not seem to have a sense of how urgent the climate change problems really are, and what they mean for all of us. A widespread support for climate change awareness and education is largely missing as a national response to address the crisis. Given the far-reaching implications of the climate change crisis, the youth will have to play leadership roles in responding to the crisis in a meaningful way. Hence, it is important to invest in climate change education at various levels.

2. The Primary Stakeholders

The primary stakeholders of LAYA constitute farmers from 3 districts of Andhra Pradesh-Visakhapatnam, East Godavari and Srikakulam. Since 2016, LAYA has reached out to around 900 *adivasi* households mainly of the Konda Reddy Particularly Vulnerable Tribal Groups (PVTGs). They are drawn from 40 villages from 4 Panchayats of Y. Ramavaram Mandal of East Godavari district. The four Panchayats have 48 ward members of which 19 are women and two of the Sarpanches are also women.

To select activities for interventions, a discussion is held with the target communities and their suggestions are sought. To make the process more participatory and robust, the community members are part of the monitoring process through field observations, monthly reporting and preparation of annual report cards on composite interventions in each of the 4 Panchayats and Focused Group Discussions with the beneficiaries for annual feed-back. The 740 farmers are also tracked along with the number of sustainable farming practices and local technology initiatives they adopted.

3. The Intervention

3.1 Climate Friendly Sustainable Farming

This is a pathway to develop long-term resilience through ensuring climate responsive local food security systems. Farming (as opposed to agriculture) gains prominence in a context when the pressure of commercialization and cash demands is pushing communities into unsustainable farming practices. Climate variability and extreme events are forcing communities to depend on unsustainable use of chemical inputs to sustain and raise crop productivity. Over time, LAYA has identified these challenges of the livelihood security needs of the community. The challenges have two major dimensions as given below.

- Facilitating processes for optimum use and regeneration of natural resources in order to maintain crop productivity on a sustained basis; and
- Introduction of a set of coherent Package of Practices (POPs) that that enables sustaining or even increasing crop production following ecologically sustainable PoPs.

The resilient farming system, in this context therefore integrates the following bundle of practices:

3.2 Promotion of System of Rice Intensification (SRI) in 'Pallam' Lands (Wet Lands)

SRI is a combination of several practices including changes in nursery management, time of transplanting, water and weed management etc. SRI is a system of production with four main components, *viz*., soil fertility management, planting method, weed control and irrigation management. The practice has had a proven yield in the area with an average increase of 30 to 40 per cent in productivity as compared to conventional rice cultivation (field studies have shown that the average yield per acre, of conventional rice cultivation is 750 kg whereas in SRI it is 1,050 kg, i.e. an increase of 300 kg).

3.3 Promotion of Mixed Traditional Crops

Mixed cropping is the traditional practice of growing two or more crops together on the same piece of land in a crop season. It is a traditional practice of the tribal communities. The induced technologies/practices promoted by the government have changed their cropping patterns. The technologies for cash crops such as cotton, tobacco and tapioca are often not relevant to the local conditions and there are a lot of fluctuations in crop productivity, particularly in the East Godavari tribal area. Hence, the need to facilitate *adivasi* farmers to restore their traditional practices of mixed cropping.

3.4 Agro-Forestry and Forest Regeneration in Forest Areas with Economically Viable Species

This is especially relevant in degraded 'podu' (hill-slope) lands, where there is sparse vegetation on the hills and surrounding areas. It is important thus to promote fast growing NTFPs species as well as fuel-wood species to meet local livelihood needs in the villages and in the reserved forest areas.

3.5 Growing Fruit Trees or Horticulture

As part of a future income security measure, LAYA facilitates planting of fruit trees in the adivasi areas. The species promoted are mango, sapota, custard apple, pineapple, guava, citrus and cashew varieties. They meet the nutritional needs of the households to an extent. Cashew plantation is most sought after because of higher returns.

3.6 Promotion of Vegetable Cultivation

LAYA encourages the *adivasis* to grow a variety of vegetables in their backyards as well as *garuvulu* (less-gradient) lands by providing dry fencing on a plot size of about 50 cents. The communities are provided vegetable seedlings to grow in their kitchen gardens, which helps meet their household nutritional requirements and sometimes also leave them with a small surplus to sell in the market to get some cash.

5.7 Organic Agriculture

Under this initiative, nurseries were raised and seedlings of papaya, drumstick, gum karaya, orange, custard apple, mango; vegetables like tomato, chilli and brinjal etc. were distributed in the targeted villages. Youth from the tribal communities were selected and trained on organic farming practices, preparation of local manures, promoting crop diversity, and local agricultural practices. Exposure visits were organized to successful sites. Nearly 30 tons of vermicompost was produced in the selected villages. Besides vermicomposting, preparation of organic manures from tank silt, pig manure, decomposed litters, humus from the surrounding forests, powder of tobacco stumps, crop residues, goat and sheep manure were demonstrated.

5.8 Promotion of Crop Diversity

Under promotion of crop diversity, seed centers were established. Attempt was made to conserve 30 rare and disappearing crop varieties of millets, pulses and vegetables. Seeds were collected and distributed to the farmers for cultivation and multiplication of these rare varieties of seeds. Moreover, , local varieties of paddy, pea and beans were collected from the communit y and they were encouraged to promote crop diversity in the area.

5.9 Zero Budget Natural Farming (ZBNF)

LAYA was selected as a facilitating agency by the State Government to introduce ZBNF in 86 hamlets in 4 Panchayats covering 2,157 households.

5.10 Backyard Poultry Farming

Backyard poultry was promoted in 2,900 households with 29 breeder farms. Besides targeted egg and chicken production, it served as a potent tool to empowering women in the households. It also helped meet the househholds nutritional requirements.

4. Non-Timber Forest Products (NTFP) Related Initiatives

4.1 Training Material and Skills Based Training for NTFP Collectors

Training programmes were setup to encourage sustainable harvesting of NTFPS like gums, amla, wild fruits, adda leaves, barks and brooms.

4.2 Broom Grass Plantation

This plantation was facilitated through vegetable inter-cropping. The financial return in the first year was INR 2,500 per acre and in the second year, it was INR 3,500 per acre and continues to be a source of extra income for the farmers. Later, it was promoted in 400 acres in degraded lands with average income of INR 15,000 per acre in the first year and INR 40,000 in the second year onwards with a life cycle of 6 to 7 years.

4.3 Monitored Agro Forestry Model of Seed Dibbling

Under this intervention, seeds of tamarind, pongamia, wild mango, jackfruit and hill broom were planted. Protection by the community has resulted in the plants growing well and also ensures a good survival rate.

In addition, different types of NTFP species were strategically promoted by linking up with the nursery at Addateegala. The varieties were *jeeluga, ippa, kunkudu, goddukura, sadanapuveduru,* and *kovela*. A total of 3,500 plants were raised in the nursery. The NTFP species included tamarind, bamboo, broom grass and kanuga raised in common lands in 14 villages in the watershed.

4.4 Documentation of Wild Tubers

Documentation/enumeration of wild tubers and their harvesting methods were initiated through a participatory approach.

5. Watershed Development based Initiatives

5.1 Soil and Moisture Conservation

This is done through construction of percolation tanks, rock-fill dams, terracing, new farm bunds, stone bunds and vegetative barriers including removal of stumps and leveling. These interventions on the land facilitate in retaining soil moisture during extended dry spells.

5.2 Promotions of Organic Manures at the Household Level

The current practice of agriculture with emphasis on cash crops in some of the *adivasi* areas has caused incidences of soil erosion and therefore reduced soil fertility. Compost pits and restoration of traditional manuring helped in revitalizing the soil fertility.

Natural resources form major source of livelihood for the *adivasis*. The ecological management of natural resources therefore has to address the underlying issues that threaten a dignified and ecologically sustainable livelihoods among the *adivasi* communities. Under favorable conditions, natural resources along with some assets can provide livelihood security at the household, community and village levels.

LAYA's main objective is to improve the productivity of natural resources in a sustainable manner. In doing so, it ensures that the *adivasi* communities in high altitude tribal zones (HATZ) value and equip themselves with sustainable technologies in natural resource management in order to be 'food secure' to have basic livelihood security. This approach integrates seamlessly with the Low Carbon Farming (LCF) framework, where each of the activities can be quantified in terms of improvement in nutritional value, water conservation, and energy savings.

Locally relevant, climate-friendly and low-carbon emitting agricultural technologies can offer a good model to more equitable and sustainable future. These technologies refer to a package of decentralized technologies (adapted or developed locally) that address the local development needs while providing an efficient farming ecosystem.

LAYA is constantly exploring and introducing climate-friendly, low-carbon and low-emission technologies; which harness the natural and renewable resources to facilitate the wellbeing of the communities. At a time when increasing access to modern energy services is seen as a key development priority that forms part of the Sustainable Development Goals (SDGs), LAYA believes in adopting locally relevant approaches for livelihoods security of its people.

The implications of adopting different technologies on the local *adivasi* communities as well as an understanding of their interactions with social and environmental systems is necessary before designing technologies to the advantage of the most vulnerable. Such initiatives can be part of more inclusive policy-making that acknowledges multiple viable pathways of development based on local knowledge, skills and capabilities.

5.3 Encouraging Gravity Water Flow

After a feasibility study and tests to measure water pressure and other details, LAYA came up with the unique solution to solve the issue of water availability. Gravity Flow facilitated by holding water at an elevated level with outlet at the bottom can help the farmers in drip irrigation. This was first initiated in 2010 at Munagalapudi village with the aim to bring fallow land back into cultivation. Over time, this has not only helped in critical irrigation but allowed households access to water. In the process, it reduced the drudgery and saved energy consumed in fetching water from far away sources. Today, approximately 45 acres of fallow land and 30 farmer families are reaping the benefits of 3 Gravity Flow units.

5.4 Hydram

The hydram or hydraulic ram pump is an alternate pumping system that uses renewable energy from falling water to pump it to an elevation much higher than where it originates. This is an energy efficient way to provide adequate water supply and can be set up anywhere. The key benefit of this system so far has been in providing access to water to the households in close proximity, allowing them more time to devote on farming activities. With 6 water outlets from the stream for irrigation and 10 taps for drinking water supply to the villages, LAYA has so far set up hydrams in 4 locations bringing about 5 acres of land under irrigation.

Both these pilots have resulted in multiple benefits to the communities as they do not require electricity to operate, have minimum emissions and require minimum maintenance, while also enhancing income from agriculture and employing local youth to maintain the projects.

6. Special Programmes for Single Women

Special initiatives were undertaken for single women in different villages. The initiatives included selection of crops linked to nutritional needs by promoting traditional mixed cropping incorporating millets like ragi, sama, ganti, with pulses like red gram and green gram etc. Livelihood groups were formed including single women in 3 clusters of the East Godavari district. These groupstarted saving activities to meet as a part of microfinance initiative under the programme.

7. Accompaniment of Community based Organizations and People's Institutions

To build capacity of the community, LAYA facilitated 8 community-based organizations (CBOs) to promote Natural Resource Management (NRM) activities in their areas of operation. LAYA has organized workshops with 8 CBOs on sustainable agriculture, forest and water management. 5 of these CBOs are from the East Godavari district and 3 from Visakhapatnam district.

Exposure visits and trainings were key tools of learning when it comes to sustainable agriculture. A number of exposure visits and on-site trainings were organized for the farmers' groups on themes such as mixed cropping, cashew orchard management, vegetable cultivation, tree-based crops like coconut, mango, banana and backyard poultry, watershed approach to farming, organic farming etc.

8. Convergence with Schemes for Tribal Farmers from Government Departments

LAYA has played a key role in raising awareness and facilitating access to schemes for tribal farmers from various government departments. It has developed working relationship with the officers of the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA), the State Horticulture Department, the Integrated Tribal Development Agency (ITDA), the Central Research Institute for Dry-Land Agriculture (CRIDA), the National Institute of Rural Development (NIRD), the Regional Agriculture Research Station HAT Zone, Chintapalli and the Andhra Pradesh Micro Irrigation Development Corporation (APMIDC). Some of the schemes that LAYA has leveraged include:

- Horticulture plantations such as mango and cashew in the East Godavari and Visakhapatnam districts through the State Horticulture Mission (SHM)
- Availing SRI paddy tools, weeders and markers and paddy drum seeders for select families in Visakhapatnam district though the ITDA
- Promoting vermicomposting units and farmyard manure composting units in East Godavari district through ITDA and the State Horticultural Mission (SHM)

- Introducing small-scale lift irrigation schemes and micro and drip irrigation units among the farmers in the East Godavari district through the Andhra Pradesh Micro Irrigation Corporation (APMIC)
- Obtaining vegetable seed kits from the National Horticulture Mission (NHM)

9. Climate Change Education

Climate change education runs across all components of Laya's resilience model and is a powerful tool to address the issues relating to the adverse impacts of climate change. As part of Laya's engagement with the communities and the stakeholders at various levels, contextualizing the interventions with the local ecosystem is given priority. Engagement with diverse groups facilitates them to see a role for themselves in mitigating, adapting, and learning to cope with the challenges of climate change.

Climate change presents an additional challenge as it impacts most *adivasi* communities. It is increasing the risks in managing natural resources and sustaining agricultural productivity, on which many *adivasi* communities depend. The *adivasi* peoples' legal control and sustainable use of natural resources in their ancestral domain provide two significant benefits on the adaptation and mitigation fronts. First, legal control and sustainable use of natural resources improve the livelihoods of the *adivasi* communities, thus increasing their economic resilience and capacity to adapt to the adverse impacts of climate change. Second, sustainable agriculture and forest use have strong potential to provide a Greenhouse Gases (GHG) sink to reduce deforestation and promote rehabilitation of degraded lands, water conservation and biomass production.

The success of sustainable practices by the adivasi people, however, rests in large part on the inclusive relations between community members and the strength of the entire community, when faced with external pressures of privatization and globalization. Gender is also a very critical component to the success of such interventions.

At the community level, LAYA has made efforts to promote education, training and public awareness on climate change impacts on agriculture, forests, livestock, water, health, technologies, women, gender inequality and lifestyles. The key is to learn from the local adaptation practices introduced and make them work to the benefit of the vulnerable women and men.

LAYA's engagement on climate change education and exposure visits with young sarpanches over the past three years has created spaces for exploration and replication of activities in other districts as well.

10. Impact

The core strategy behind the intervention is that climate change can be addressed and resilience can be built through relevant smart agricultural practices that are sustainable and could enhance livelihoods. This would reduce vulnerability while conserving the ecosystem in the face of the climate change crisis. The achievements related to sustainable farming indicate that 900 farmers, including 22% women farmers have adopted the recommended PoPs. With these 900 farm households, LAYA has been able to demonstrate ecosystem based good PoPs that contribute to food security, nutritional uptake and income enhancement of community members, thereby strengthening their livelihood resilience. The lessons drawn from such experiences indicate that the selection of appropriate PoPs like soil enrichment from agri-waste, mixed cropping, soil and water management practices, bio-fencing, promotion of homesteads etc. is very effective. Since these practices have the potential to be upscaled/ adopted/ adapted in different contexts, LAYA will be engaging with 400 more farmers, 85% of who belong to PVTGs) from a different district in Andhra Pradesh to replicate the PoPs adopted by 900 farmers.

The climate friendly people centric technologies seem to have great value among the communities in locations where they have been demonstrated. The technologies related to the hydram and gravity water flow together with slow-sand water filters in particular are serving as low emission technologies, which not only enable better access and availability of drinking water but also reduces drudgery especially among the women. Further demonstrating the value of simple agriculture tools has also reduced drudgery and time consumed in agriculture related work. Greater focus is needed on gender from a climate technology perspective. The lesson learnt is that there is a need to demonstrate as many pilots as possible in various locations across different eco-regions as there are few pilots to learn from and adopt. There is a great value in having a diverse sets of technologies to suit different end users. This has go together with investments in research and development of context specific technologies. At the same time we need to explore ways to subsidise the costs and encourage community contribution for the technologies.

On the policy front, impact can be understood in relation to developing and strengthening working relationships with government officials and individuals who work as influencers. With respect to work at the grassroots, the local administrative officials especially the Integrated Tribal Development Agency (ITDA) officials responsible for water supply, horticulture, agriculture and allied programmes in particular have been reached out to for integrating them with the on-going development programmes. This has led to LAYA being identified as one of the knowledge partners and implementing agency for the Andhra Pradesh State government programme related to zero budget natural farming.

11. Conclusion

There is an increasing recognition that climate change disproportionately impacts the economically vulnerable, especially in areas of high-risk natural disasters. The adivasi communities are among the most vulnerable as they are among the most dependent on natural environment. Participation of women and youth is essential to enable the adivasi communities to adequately adapt to the effects of climate change. Addressing climate change is not only an existential imperative; it is also an opportunity to move towards a cleaner, more productive and just path of development where appropriate practices could lead us to sustainable low carbon resilient communities.

Accordingly, the following policy perspectives are recommended.

11.1 Deepen Future Research

More context specific research is needed regarding effective adaptation and mitigation strategies at local and national level for *adivasi* communities, especially in the face of the current global food and energy crises. What are good practices or failures? What aspects of their indigenous knowledge have been overlooked and could contribute to effective mitigation and adaptation? How may access to new technologies, higher-level technical education, marketing management, freedom of occupational choice and mobility specifically increase the capacity to cope with natural disasters and environmental stress? What do the *adivasi* communities identify as priorities and strategic needs? Knowledge in these areas can spur innovation and increase effectiveness of future policies and programmes.

11.2 Strengthen Participation of *Adivasi* Women and Youth in Climate Change Planning and Decision Making Processes

The *adivasi* women alongside youth and men should be adequately involved in consultation and decision-making processes in areas that affect their health, nutrition and livelihoods. This includes areas in forest and agricultural policies and programmes, renewable energy projects, biodiversity protection measures and climate change adaptation and mitigation negotiations at the national and international levels. Participation could be facilitated through:

- Enhanced training on ecosystem-contextual climate change to build knowledge
- Consultations to share knowledge between the *adivasi* women and youth leaders, academics, scientists and traditional knowledge holders
- Workshops to facilitate sharing of the best practices from similar communities;
- Fora for dialogue at local, national and international levels.

11.3 Capacity-Building for Alternative Livelihoods

Access to alternative livelihoods is essential for the *adivasi* communities to build resilience to climate change. Laya believes that any alternative livelihood is dependent on the individual, the community and the circumstances in which they live.

Weather-Based Agro-Advisory Services in the National Rural Livelihoods Mission

Karuna Krishnaswamy and S C Rajshekar

1. Introduction

This brief presents the design and early experiences with the Weather-Based Agro-Advisory Services (WBAAS) offered to small and marginal farmers as part of the World Bank-financed Sustainable Livelihoods and Adaptation to Climate Change (SLACC) project. SLACC was launched in 2015 in Madhya Pradesh and Bihar as part of the National Rural Livelihoods Mission (NRLM). The WBAAS services were delivered in partnership with Skymet and CropIn two private sector firms.

This report discusses the relevance and design of the WBAAS service, its on-ground operationalization, early experiences of effectiveness, project learning and way forward.

The report team conducted a literature review, held qualitative interviews with all the project stakeholders, and analysed the MIS data and the results of the mid-term evaluation which included a representative survey of 1350 farmers. This review was conducted between May and August 2018.

2. About SLACC

SLACC is a World Bank supported pilot project embedded within the NRLM to improve the adaptive capacities of rural poor farmers to cope with climate variability and change. This USD 12.67 million project runs from 2015 to 2019 and is funded by the Government of India and the Special Climate Change Fund administered by the Global Environmental Facility.

The project targets 12,000 women farmers who are members of NRLM-promoted Self-Help Groups (SHG) or their households in selected drought- and flood-prone districts in 640 villages in Bihar (Madhubani and Gaya) and Madhya Pradesh (Sheopur and Mandla). These are typically small to marginal farmers with average farm sizes of 0.5 and 1.4 acres in Bihar and MP.

Farmers prepare a Climate Change Adaptation Plan prioritizing the risks they face due to adverse weather events, based on which they are provided with locally customized advisory, interventions and financial services to address them. The interventions are clubbed into four quadrants. The WBAAS services fall under the Technology & Knowledge quadrant.

Table 1: SLACC Programme quadrant framework

Quadrant	Outcomes	Interventions
Production	Enhanced climate resilience	Drought and flood tolerant seed replacement Crop diversification Resource conservative practices Alternate livelihoods
Ecological	Secured ecological functions that support production	Tree-based farming Soil health improvement practices Irrigation Water harvesting techniques
Financial	Invest in technologies, shield from residual risk	Credit Crop insurance
Technology and knowledge	Enhanced capacity for informed decision making	Exposure visit and training Farm implements through Custom hiring Centres/ Village Tool Bank Local current weather data SMS-based PoP reminders Weather forecasts, advisory Climate change adaptation plans

3. Climate risks and WBAAS in SLACC

Two factors play a big role in determining the fortunes of rural livelihoods, namely weather/climate risks and market risks.

Agriculture in India is often described as a "gamble with monsoon" since most crops are rain-fed and monsoons have always been notoriously fickle. The monsoon's behaviour has a huge influence on crop production. For instance in 2009–10 the late onset of monsoons and its intra-seasonal variability caused a reduction of about 10 million tonnes from the average annual production of 95 million tonnes of rice grains[1]. Even with access to irrigation facilities cropping in say rabi (winter) is at the mercy of other climatic factors. Frost in the case of potatoes, high temperature western winds (pachua) in wheat or hailstones or unusual rains in March-April can lay waste a well-grown winter crop. At an operational level often a farmer applies expensive fertilizers or hires labour only to be stymied by rains that will wash away the fertilizer or leave the labourers idle. Weather also determines what kind of pests and diseases will attack and when.

[1] Naresh Kumar Soora & P. K. Aggarwal & Rani Saxena & Swaroopa Rani & Surabhi Jain & Nitin Chauhan. 2013. An assessment of regional vulnerability of rice to climate change in India. Climatic Change

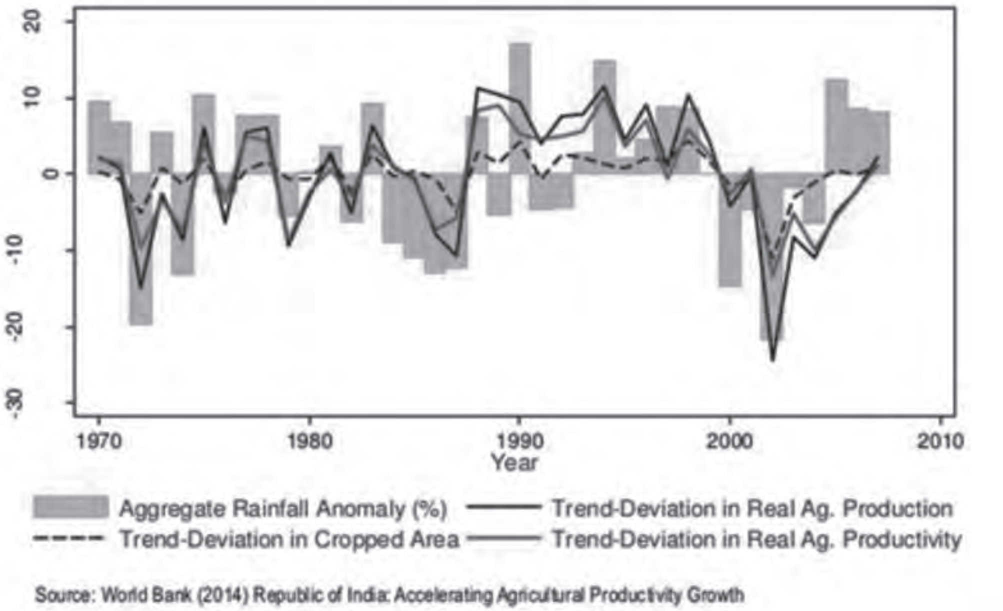

Figure 1: Trends in rainfall and agriculture production

The phenomenon of climate change is expected to make both the levels and trends of weather worse. The Intergovernmental Panel on Climate Change (IPCC) has predicted that the global mean surface temperature will rise by 1.1 to 6.4°C by 2100. Higher day- and night-time temperatures, more frequent extremes of weather in the form of erratic monsoons and increased frequency and intensity of drought and flooding are set to become more common in the near future affecting both rainfed and irrigated production systems even more[2].

Increasing atmospheric temperatures and carbon dioxide along with uncertainties in annual precipitation is expected to have major adverse effects on crop growth and yield, hydrologic balances, supplies of inputs and other management practices. For example, higher temperatures shorten crop cycles by inducing early flowering and shortening the grain-filling period, thereby reducing yield per unit area[3].

Indeed global studies project a 10 to 40 per cent loss in crop production in India by 2080-2100 due to climate change unless farmers adapt to climate change[4]. Hence there is a need to increase the current levels and stabilize farm production from weather risks to ensure food security and to increase farmers' incomes.

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[2] Sustainability 2017, 9, 1998; doi:10.3390/su9111998

[3] Aggarwal PK (2008) Global climate change and Indian agriculture: impacts, adaptation and mitigation. Indian J Agric Sci 78:911–919

[4] IPCC fourth assessment report: climate change 2007 (AR4). IPCC, Geneva.

This project seeks to improve the ability of farmers to cope with climate unpredictability and variability in the near term. Specifically, in the WBAAS component short-term weather forecasts were intended to help a farming household better schedule farm operations thereby minimizing loss or costs or both. Longer term weather forecasts were intended to help farmers make better varietal or crop choices, make appropriate arrangements to decrease the impact or even put in place adaptation mechanisms. However not every farmer is equipped (or has access to) with the knowledge in order to make these choices. Therefore, instead of merely providing forecasts, weather forecast-based agro-advisories that inform the farmer on the likely weather, its impacts on the crop and steps needed to tide over the situation were provided farmers in SLACC.

Improved capacity to learn and deal with unexpected, changing and adverse weather conditions is expected to gradually improve farmers' resilience to weather variability and hence prepare them for climate change in the longer-term.

4. Weather Forecast and Advisory Services in India

Since the early 2000s the Indian Meteorological Department (IMD), has been offering weather forecasts through the National Centre for Medium Range Weather Forecasting (NCMRWF). The NCMRWF takes data from global and national sources, then spatially scales it down using algorithms to produce a seven-day forecast.

This forecast is then converted into Agro-Advisory Bulletins (AAB) by Indian Council for Agricultural Research and State Agricultural University research stations. These advisories are issued twice a week and cover an agro-climatic zone of five to six districts each and disseminated through radio, TV, print and personal contact with farmers.

Typically, the AABs contain the following information:

- Weather
  - o Past weather, historical normal and forecast
- Crop Information
  - o Type, state and phenological stage of crops
  - o Information on pests and diseases and crop stresses
- Advisory
  - o Crop-wise regular package of practices and special measures for saving crop from malevolent weather

A study in 2008[5] found that AABs helped reduce costs of cultivation by up to 25 per cent. In cases where the costs went up (by 10%) due to implementation of recommended measures returns increased by up to 83 per cent.

[5] L.S.Rathore and Parvinder Maini, 2008: "Economic Impact Assessment of Agro-Meteorological Advisory Service of NCMRWF", Published by NCMRWF, Ministry of Earth Sciences, Government of India

However, there were several drawbacks:

- Limited acceptance due to low trust because of lack of last mile support
- Insufficient localisation to a small enough area and customisation to PoPular local crops[6]
- No facility for farmers to raise specific queries and receive personalized responses

WOTR an NGO that uses NCMRWF's weather forecast further scaled down to the sub-block level is running a WBAAS in about 70 villages in Maharashtra. However, farmers cannot ask specific questions related to their issues. Advice is customized at the level of a cluster of villages rather than at the plot level thereby decreasing the relevance of the recommendations.

In our project sites weather forecast services are also available through IFFCO-TOKIO though only at the block or district levels and are delivered directly to the farmers without sufficient awareness building and handholding support.

In India several other private players have ventured into providing weather-risk management services including WBAAS such as Reuters, Skymet, IFFCO-TOKIO and E-sagu.

5. SLACC's Design Features

WBAAS in SLACC was designed to provide regular expert advisories customized to each farmer's major crop and farm characteristics covering the major crops grown in the area. The key design principles that address the limitations of past approaches are below.

Collection of farmer level data[7] on farmer's major crops grown, and farm plot for customized and relevant advisory.

Automated forecasts of rainfall, temperature and windspeed computed by downscaling commonly available data to a 9 by 9 km area grid.

Installation of Automated Weather Stations and Automated Rain Gauges in a granular area[8] to collect weather data[9] to help farmers internalize the forecast data with their actual experiences in the season.

Setting up of an expert group of subject matter specialists (SMSp) to analyse and interpret the data to provide advisories to farmers. The SMSps are typically professors or junior scientists with a master's or doctoral degree in agriculture.

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[6] During the author's visit to Bihar, same agro-advisory on rose cultivation was being broadcast in both Gaya and Madhubani on the same day. Neither is rose grown in both districts, nor is the weather similar!

[7] Farmer name, plot, geolocation, geofencing to determine plot area, soil health card, irrigation facilities, etc.

[8] 1 AWS for every set of 5 villages with the remaining 4 villages in the set getting an ARG

[9] Rainfall, Max and Min temp, wind speed and direction, solar radiation, relative humidity, etc.

Leverage the project's existing Community-based Resource Persons (CRP) who reside in the village and visit the farmers regularly to support the other project interventions. CRPs are the link between the service and the farmers. They build trust and help the farmers understand and implement the recommendations delivered through a mobile phone.

Use of web-based software, integrated databases and mobile applications to

- Deliver advisories over SMS to the farmers.
- Enable CRPs to **collect periodic information** using mobile phones about the progress of the crop from the date of sowing till harvesting, including yield.
- Automate collation and access of weather, forecast and farmer data on **a single platform** to enable the SMSps to replace expensive and time-consuming physical visits to each farm to prepare advisories.
- Permit raising of alerts by CRPs for specific problems reported by farmers such as pest attacks or based on their own observation and receive solutions through mobile phones.
- Geo-audit of farm plots to obtain accurate farm plot size and to validate that the CRP did in fact physically visit the farm and serve as a project management tool.

6. Rollout of WBAAS in SLACC

The key stakeholders are Skymet, CropIn, SRLM's Young Professionals (YP) and the CRPs apart from the farmers.

6.1 Skymet: Weather and Forecasts

Skymet Weather Services Private Limited was selected by SRLMs through a competitive bidding process. It started operations in May 2017 and offers the following two services.

Weather forecasts: Skymet provides downscaled forecasts on temperature, rainfall and windspeed on a rolling basis refreshed daily.

- Short term: Within 48 hours
- Medium term: 3 to 7 days
- Long term: 8 to 15 days
- Seasonal: Over a four month period focusing on total precipitation and onset of monsoon

Current weather data: Skymet installed 40 AWS and 160 ARGs (roughly one per village) between October 2016 and July 2017. Skymet owns the equipment and supplies weather data (on humidity, rainfall, wind speed and direction and temperature) on a subscription basis.

Skymet provides access to the data to farmers, CRPs and project staff in four ways.

1. Electronically transmit the data to CropIn's web servers through APIs.
2. Provide an LED display unit in each village to display weather information.
3. In MP Skymet's proprietary SkyAgri app is provided to project staff and CRPs.
4. Skymet web portal.

6.2 CropIn Technologies: WBAAS System

CropIn Technologies an eight-year-old Bengaluru-based firm was selected through a competitive procurement process to set up a system to generate and deliver WBAAS. CropIn began operations in zaid (March/April) of 2017. CropIn appointed a Project Manager in each state and a Field Supervisor in each block.

From the SRLM side there are is one YP per block assisted by agriculture trainees. Last mile link with the community is through CRPs who are hired from the community by SLACC.

CRPs tend to be experienced and progressive farmers who reside in the village and are identified and trained to, in turn, support the farmers adopt all SLACC interventions recommended to them by running awareness campaigns, training, and handholding support.

CRPs are hired through the Village Organization (VO) an apex federation of SHGs in a village. In a VO meeting members nominate candidates from their family who are farmers and literate. The VO takes the final decision on CRP selection.

In all about 40 per cent of the CRPs are women. They are on average in their early thirties. A little over 40 per cent have at least passed class 12.

Each CRP handles about 40 farmers and spends about 18 days per month on SLACC out of which 50 per cent of their time goes to WBAAS work. They do all the data collection, support farmers interpret the messages, decide on what action to take, and submit user queries to the SMSps.

They receive compensation of INR 2,500 to INR 3,000 per month.

CropIn offers four types of services to farmers through SMS:

1. Package of Practices (PoP) reminders
2. Weather forecasts
3. Forecast based farming advisory
4. Farmer-specific alerts by farmers, through the CRP's mobile app, based on specific problems they face

In the last rabi (winter) season (Nov. 2017 – Feb. 2018), 6,276 farmers and 11,335 plots totalling 3,357 acres were covered under the WBAAS.

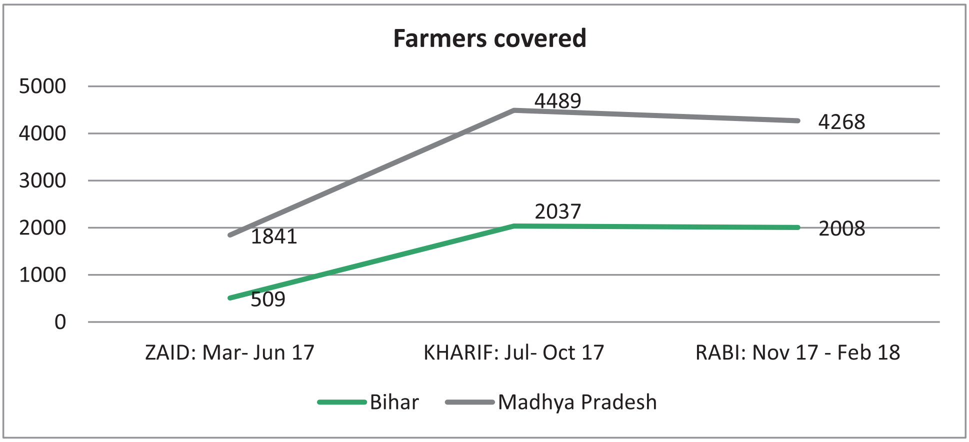

Figure 2: Farmer Coverage under WBAAS

6.3 CropIn's Processes

In sum CropIn adapted its SmartFarm ICT platform to receive Skymet's forecast and weather data electronically. The farmers' data and their PoP schedule is entered through a mobile app by the CRPs. Weather forecast, advisory and PoP reminders are SMSed automatically to farmers. All the above are viewable by the CRP on a per farmer basis on his mobile app.

Planning

Prior to the beginning of a season, CropIn and the project staff take the following decisions:

a. Crops, varieties and number of farmers to be covered

b. PoP practices and inputs advocated for each crop by SLACC

c. Number of CRPs and YPs staffed and their roles

Configuration

Detailed crop sheets are prepared by SMSps for different crop stages based on the specific PoP for the crops and varieties selected. The recommended PoP is vetted by the SLACC teams and added to the web platform.

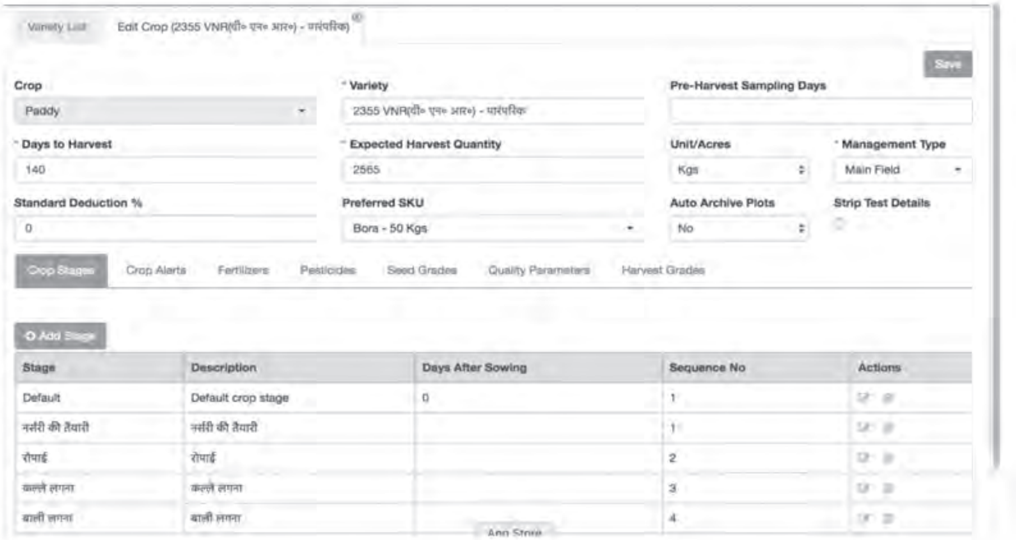

Figure 3: Sample crop sheet on web platform

User Training

Before each season the project teams are given refresher training by CropIn's field teams on how to record farmer details, geo-tag plots, relay advisories and raise alerts. YPs and other SRLM staff who manage the CRPs are trained on how to use the Smartfarm web application and interpret the reports.

Farmer data collection at start of season

At the start of the season, CRPs collect data on the crop varieties each farmer plans to grow and the acreage and enter into their mobile apps assisted by CropIn's project coordinators. Plot size is audited to avoid inaccuracies in self-reporting and location is generated automatically by the CRP using the GPS feature of the app for visual representation in the MIS.

6.3 Advisories

The following SMS advisories are sent to the farmers until harvest along with a simultaneous alert to the CRP through his mobile app. Overall over 600000 advisory messages have been sent so far.

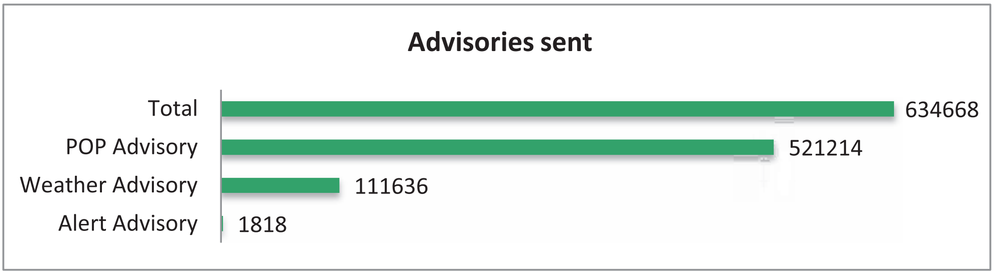

Figure 4: Agri- Advisory Status

PoP reminders

The pre-configured advisory messages are automatically sent to farmers based on the crop grown, crop stage based on a predefined number of days post-sowing from pre-sowing through harvest on recommended practices for seed treatment, land preparation, kind of inputs to be used, agricultural practices to be followed, etc. SMSps regularly monitor the advisories to ensure that they are relevant to current weather and may issue additional advisories or modify the canned ones as needed. The CRP captures whether the farmer is adhering to these practices or not.

Weather Forecast

Skymet's weather forecasts are automatically sent by CropIn to farmers to take corrective action on scheduling of cultivation practices.

Forecast based advisories

SMSps regularly monitor the weather forecasts in their designated regions and issue specific advice on any precautionary measures that farmers can take to minimise crop loss or optimise their activities. These are typically for extended dry spells, unexpected rainfall or pest attacks.

Alert-based advisories

CRPs can raise questions or "alerts" through their app during their scheduled visits to the farmers plots either if requested by the farmer or if he spots a problem for answers from the SMSps. The CRP enters details of the problem faced such as diseases, pest attack, or weeds, along with a picture of the area and extent affected into the app.

SMSps constantly review their web dashboard for alerts raised by CRPs and issue advisories within 48 hours such as what kind of pesticide or medicine the farmer should procure and apply to stop a pest attack. The farmer receives the response through SMS and the CRP through the app. The alert is closed only after the CRP visits the farmer.

A breakup of the types of advisories sent by CropIn since the beginning of the project is presented below. About 10 to 12 PoP reminders and five weather based advisories, are being sent per season per farmer. There have been few user alerts so far and are taking off only in recent months after awareness and trust in the service has been built up over time and also due to operational delays.

Table 2: Examples of Agri-Advisory to farmers

Type of Advisory	Sample from past seasons
Crop Alert Curative Advisory	Dear Rinku Devi (A001179397), an alert has been raised for your plot 1 (Paddy-Panna Masoori-Traditional) by Rajvanshi Devi. Disease: Bacterial Leaf Blight. Affected Area: 3%. Advice: Mix 20 gm of streptcyclin and 1.2 kg of Copper Oxichloride with 400 liters of water per acre and spray this solution to control this disease.
	Dear Kanti Devi (A001179365), an alert has been raised for your plot 4 (Maize-Kanchan) by Rekha Devi. Pest: Termites. Affected Area: 100%. Advice: Well composted FYM to be used as proactive measure. To control this for standing crop, Chloripyriphos 30 EC to be used with irrigation or also can be used via drenching.
Crop Alert Proactive Advisory	There are chances of invasion of Fruit Borer Pest to Tomato crop. To control this, Spinosad 45 SC 60 ml per acre or Indoxacarb 160 ml per acre to be mixed in 165 litre of water and then the solution is to be sprayed.
	In Mosaic and leaf roller disease, Potato leaves turn yellowish, white, with deep green spots on the leaves. They turned upward and start rolling on the edges. To control this, Dimethoate 30% EC to be mixed with 2 ml/litre of water and the solution to be sprayed on leaves of the plants.
Crop PoP Advisory	This is opportune time to remove grass and weeds from the field of vegetable crops. Advised to apply recommended dose of Nitrogen for optimum growth of the crop.
	At the time of Wheat crop sowing, NPK to be applied in 1:2:2 proportion.
Weather Forecast	Rainfall is expected in all the villages of Barachatti Block from 11 to 12 October.
	There is a possibility of moderate rainfall in the next 24-48 hours.
Forecast Based Advisory	During 2-3 October, there is a possibility of rain, during this period, stop irrigation.
	Considering the possibility of rainfall, the farmers are advised that for Rabi, for the next two days, do not sow peas and do not use any kind of pesticide on other crops.

7. Ongoing Data Collection

Through the season CRPs raise and close alerts, and from 2018-end onwards will capture data on PoP reminders sent and adhered to, soil test results and livestock details necessary to trigger advisories.

At the end of the season, yield and cost of cultivation details are captured by the CRPs. Reports are generated that capture activity during the entire season.

8. Effectiveness

The views expressed in this section are based on a mid-term evaluation survey conducted in March 2018 of a representative sample of 1350 farmers and FGDs and personal interviews conducted with around 20 farmers in Sheopur, MP in August 2018.

8.1 Adoption Rates

Of the farmers surveyed, 57 per cent reported receiving any of the four types of advisory messages at any point of time either through the CRP or through SMS. This figure is lower than planned due to poor network reception in some blocks and because they changed SIM cards or because the SIM card belongs to someone else and they do not have access to that phone.

These advisory messages were largely about the onset of rainfall (86%), extreme heat (60%) and about pest attacks and what to do about it (50%). Over 90 per cent reported following the advice after it was received. From field interviews it appears that farmers' confidence in the service has increased over a few months after they have seen how others have benefited. The main reasons a few did not follow the advice was because they did not understand the advisory or had lost their phones or the pesticides or fertilizers recommended were not available locally.

8.2 How Farmers are Benefiting

Based on farmer FGDs impact appears to stem largely from the following use cases. The endorsement by the farmers is high - over 90 per cent are satisfied with the service and intend to use it in future.

Forecast and forecast-based advisory: Farmers react to both weather forecasts and to the advisory that comes along with it. In the former case the forecasts are discussed in SHG or Village Organization meetings or with the CRP and remedial action collectively arrived at. With the latter the remedial action comes along with the advisory.

Forecasts of rain help the farmer either avoid expensive irrigation ahead of rains or do early harvest and prevent heavy crop loss. Forecasts of no rainfall when it is anticipated helps the farmer muster the cash and make arrangements for irrigation where available. Without it they may delay irrigation to a point when the crop withers leading to higher yield loss or simply migrate out for wage labour. Forecasts of and protection against pest attacks also have high take-up. Forecast of high wind speeds also alerts farmers of certain crops to harvest sooner to avoid crop damage.

While the medium term forecasts only have 60 per cent accuracy (scarcely better than the flip of a coin), it was felt by project staff that even if the event does not occur, it does not seem to decrease trust in the accuracy among farmers but instead at least makes them prepared for the adverse weather event should it occur.

PoP: Field interviews suggest that PoPs seem to function usefully as a reminder as well as motivate first time adoption among those farmers who have not been trained on the PoP practices yet by the project. This conclusion finds support in the mid-term survey which finds that the average number of PoPs adhered to per farmer is three among those who ever received an advisory SMS compared to one among those who never did.

Table 3: Comparative data on use of WBBAAS by farmers who followed PoP

	Never received an SMS	Ever received an SMS
Ever followed a PoP	41%	74%
No. of PoP steps followed	0.99	3.1

Alerts: While very few alerts have been raised so far, the most common use case for alerts was pest and disease attack. In the absence of this service farmers would previously rely on advice from the pesticide shopkeeper who may or may not prescribe accurately or may overstate the dosage.

Plot measurement: An indirect benefit has been that the GPS-based measured farm plot size is five to ten per cent smaller than assumed by the land owner. This means that she formerly would end up buying accordingly more pesticides and fertilizers than was needed.

Case Study of Munni Bai, Kirkhiri village, Karahal, Sheopur, MP

Munni Bai is a farmer and active SHG member in Khirkhiri village at Sheopur. In Rabi 2017-18, Munni Bai sowed chickpeas in her farm. CRP Santosh who has been advising her SHG members, selected Munni Bai's field as a project demonstration plot.

She used to receive advisories messages time to time on her mobile and she followed the recommended PoP practices.

Close to harvest time Munni Bai received a message forecasting heavy rainfall in the next 4-5 days. After consultation with the CRP she decided to harvest her crop immediately. After 3 days heavy rainfall occurred, causing heavy loss to the crops of many other farmers. However, her yield was 1.18 tonne worth almost INR 10,000. Now Munni Bai is more interested in SLACC's guidance and even sensitizes other farmers in her village.

9. Technical Assessment

9.1 Accuracy of Forecasts

Skymet's short-term forecast is based on their synoptic observations, their own lightning detection network, available satellite imagery and IMD's doppler radar data. Their medium term forecasts are based on secondary, publicly available data that other providers such as IBM use as well.

In this project Skymet believes their short-term forecast is 90 to 95 per cent accurate and medium-term, 80 to 85 per cent accurate but at a 9 km by 9 km grid level that is common to all the villages that fall in this grid area. There may be variations within this grid in reality and hence accuracy at the village level is unknown currently. The accuracy of the forecasts is currently not being measured using the village level instruments and not being systematically verified by the field teams. Anecdotal feedback from CRPs and farmers on the overall perceived accuracy of short-term forecasts ranges from 75 to 100 per cent but 50 to 60 per cent for medium-term forecasts. Their windspeed forecasts are in a pilot stage currently and the accuracy is low.

Skymet is currently more comfortable with block level estimates but not with downscaling to the village level. However, Skymet has recently entered into an agreement with weather giant University Corporation for Atmospheric Research, USA which will enable it to input its proprietary primary data into a more sophisticated automated weather prediction platform. This is expected to improve precision and accuracy downscaled to a 1 km radius.

There are also other forecast providers in the market such as IBM with reported granularity of 1 km and Aware at 5 to 10 km.

9.2 Quality of Advisory

In MP, in some cases, the forecast-based advisory sent by CropIn's SMSps was found to be unsuitable. For instance, if a pest attack is imminent the advisory recommends a generic pesticide to be applied. However, the farmer needs to rely on the pesticide shopkeeper's judgement to recommend a specific brand which is incentivized by commissions per sale. Hence MPSRLM hired its own experts who are more familiar with the local conditions to prepare the advisory based on the forecasts.

Currently the PoP reminders is only for the major crops which will not cover all the farmers since many grow crops that are not covered in the project's supported list of crops.

9.3 Role of the CRP

The CRP is critical to the success of the project especially for illiterate farmers to adopt the advice provided or to discuss and take a course of action based on the weather forecast. The more educated women farmers are able to understand the messages and additionally leverage the SHG meetings to discuss the messages and possible actions to take.

10. Way Forward

The WBAAS service has gone through a number of teething problems since inception in 2016. This service is one among a dozen interventions being launched and hence receives proportionately low management attention.

At this stage there is consistent feedback that WBAAS is a desirable intervention that looks to become increasingly more effective and that it should be continued while addressing implementation issues. Trust in farmers is increasing as they see how others are benefiting.

The project is planning on the following moving forward:

1. The project will continue the facilitation by the CRP since the messages are not reaching all the farmers directly and in some cases they are not able to act on it without further advice. It does seem that scaling of this service will require for it to be anchored within a larger farmer intervention and leverage existing last mile resource persons.
2. There is scope to improve adoption rates from the current 57 per cent by improving access to those farmers who are not able to receive the advisory directly on their phones for a host of reasons.
3. Given that it is not easy to find SMSps from the local region and to bring down costs, CropIn will test out automation of forecast-based advisories through built-in algorithms which will not need SMSps.
4. An evaluation of the effectiveness of the service and correctness of forecasts.

In addition, other rural transformation projects such as Jharkhand Opportunities for Harnessing Rural Growth and National Rural Economic Transformation Project are planning to learn lessons from SLACC and scale up WBAAS in their projects. Outreach efforts are being planned to enable state government officials working on other climate smart agriculture projects to understand the pathways of integrating WBAAS interventions into their programs.

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Dedicated to Late Sitaram Rao, mentor and guru of Indian microfinance and livelihoods movement, the Case Study Competition aims at bringing together the collective intellect of the sector and assimilating innovative solutions, breakthroughs, good experiences and best practices that help in learning from diverse sector experience and impact poverty reduction. The Competition was instituted as a pioneering initiative by ACCESS in 2009 as a tool to identify and collate models and practices that have significantly contributed to livelihoods promotion of the poor in India.

The theme for this year's Sitaram Rao Livelihoods India Case Study Competition was Climate Smart Agriculture (CSA) - Practices that Impact. The Case Study Compendium covers cases from across the country that provide evidence of sustainable transformation of agriculture sector through CSA approach.

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