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

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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.

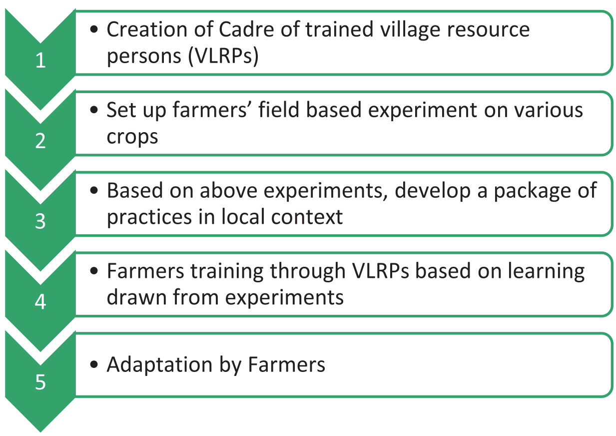

Figure 1: PSI methodology to promote SCI

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.

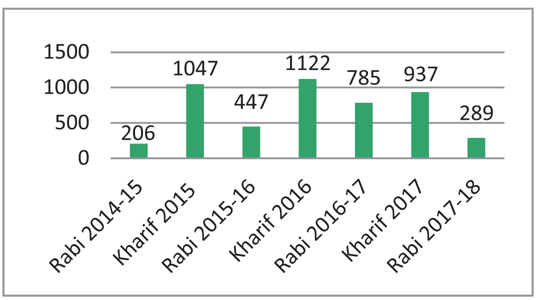

Figure 2: Number of farmers in Uttarakhand

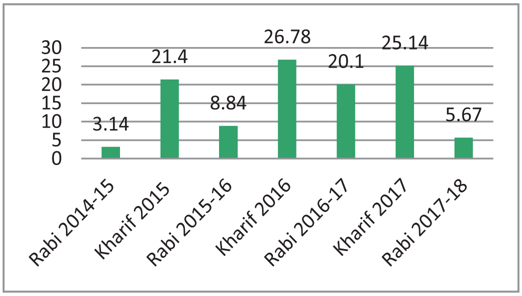

Figure 3: Area under SCI (ha) in Uttarakhand

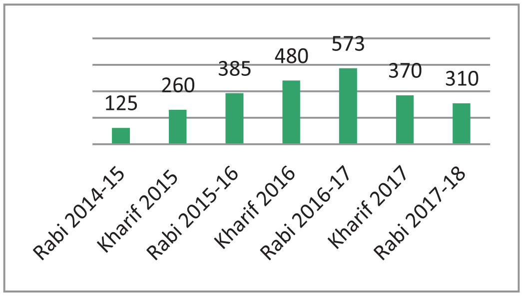

Figure 4: Number of farmers in Bundelkhand

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%.

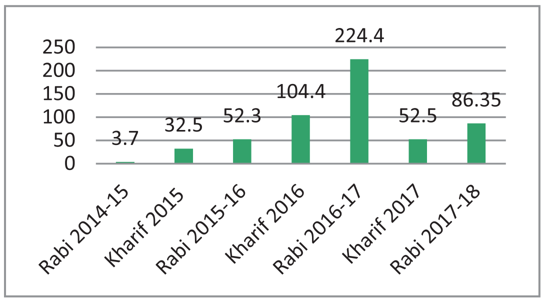

Figure 5: Area under SCI (ha) in Bundelkhand

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.

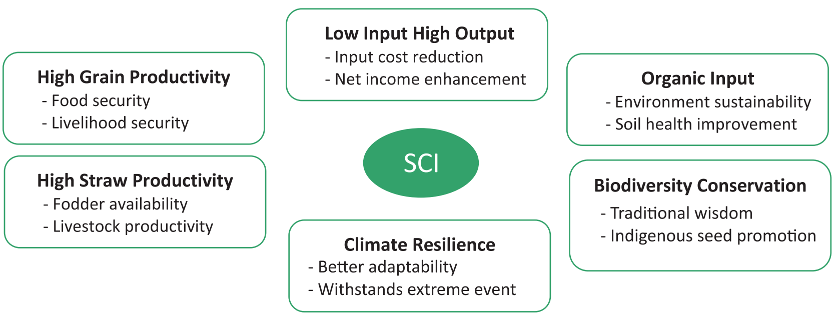

Figure 6: Benefits of SCI

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.