Research Article

Indian Journal of Extension Education
Vol. 58, No. 2 (April–June), 2022, (1-7)

ISSN 0537-1996 (Print)
ISSN 2454-552X (Online)

Conceptualizing and Validating a Framework of Climate Smart Village in Flood Affected Ecosystem of West Bengal

Sujit Sarkar[1]*, Rabindra Nath Padaria[2], Sanjib Das[3], Biplab Das[4], Ganesh Biswas[5], Dinabondhu Roy[6] and Ajit Sarkar[7]

[1]Scientist, IARI Regional Station, Kalimpong, West Bengal, India
[2]Principal Scientist, Division of Agricultural Extension, ICAR-Indian Agricultural Research Institute, New Delhi, India
[3]ADA, Maynaguri, Jalpaiguri, West Bengal, India
[4]Programme Coordinator, Krishi Vigyan Kendra, Jalpaiguri, West Bengal, India
[5]CEO, Bagjan Progotishil Sangha (NGO)
[6]Manager, Bangkandi Kirshak Bondhu FPO
*Corresponding author email id:sujitgovt@gmail.com

ARTICLE INFO

Keywords: Climate smart village, Adoption, Impact

http://doi.org/10.48165/IJEE.2022.58201

ABSTRACT

Climate change is the major issue affecting the survival of human kind in the present day scenario. Farmers are the most vulnerable communities to these changes. Many climate smart technologies were devised and tried to promote through traditional extension system. But their adoption rate is very poor doe to multiple socio-economic and technological factors. Therefore focus extension approach were thought of and concept of climate smart village was introduced to promote climate smart technologies. But the past efforts on establishing climate smart villages were revolved around only on technological dimension ignoring socio-economic dimension of climate change. Hence, the present study conceptualizes the climate smart village integrating technological as well as social factors. The concept has been experimented during 2016-2021 at field level in the village Singimari, Jalpaiguri district of West Bengal in convergence mode with other related stakeholders line Krishi vigyan Kendra (KVK), state agricultural department, National Bank for Agriculture and Rural Development (NABARD), NGOs and farming communities. The findings revealed that adoption level of climate smart technologies and practices has increased significantly after establishment of climate smart village. Therefore, more number of climate smart villages should be established specially in vulnerable ecosystem for better adaptation to climate change.

INTRODUCTION

The production system in agriculture is supposed to change throughout the world under the changing climatic scenario. The past studies have already proven that the yield variability in recent past is mainly due to climate change (Agarwal et al., 2018; Ray et al., 2015 & Harikrishna et al., 2019). Though agriculture sector is the major victim of climate change but its role in this change has drawn attention from different policy corners. Vermeulen et al., (2012) reported that an agricultural food system, responsible for 19–29 per cent of global greenhouse gas (GHG) emissions, was the second largest contributor to climate change. Hence, the scientific community put sincere efforts to come up with new climate smart farming technologies for better adaptation to changing climate. At present, there are many options to averse the negative effects of climate change on agricultural systems (Porter et al., 2014 & Khatri Chhetri et al., 2016). But the uptake of these climate smart technologies was very weak (Campbell et al., 2014 & Westermann

Received 03-10-2021; Accepted 28-12-2021

et al., 2015). For example, new water management practices in India were adopted by only 12 per cent farmers in last 40 years (Palanisami et al., 2015). Oraon et al., (2020) found that only 22 per cent farmers belonged to high level adopter category for mechanical soil and water conservation technologies under NICRA in Jharkhand.

Many new extension approaches were devised to address the problem of low uptake of climate smart technologies. Among all these, community based extension approach has gained attentions that are pluralistic, demand driven and farmer-centered (Davis, 2008; Rivera, 2011; Wellard et al., 2013; Kiptot & Franzel, 2015; Chinseu et al., 2021). To generate the evidence on the efficacy of climate-smart options, the Consultative Group for International Agricultural Research (CGIAR) research program on Climate Change, Agriculture and Food Security (CCAFS) has implemented a climate-smart village (CSV) approach in Asia, Africa, and Latin America (Aggarwal et al., 2013). The CSV approach is conceptualized to test and demonstrate the effect of different technological and institutional options in climate change adaptation. It intends to showcase the evidences on result of diverse technological options to draw out lessons for policy makers. However, the CSV approach of CGIAR is mainly based on technological parameter ignoring the social dimension. In this regard, Dumenu & Tiamgne (2020) & Dupdal et al., (2021) emphasized on the need of capturing the social dimensions of climate change, and simultaneously expressed his concern on lack of study in this direction. The major reason for lack of studies on social aspects of climate change stems from the fact that it lacks in sound methodology in climate change context, lack of appropriate indicators and difficulties in quantifying them. So devising a climate smart village concept including socio-economic indicators becomes the rising concern of researchers. Hence, the present study was conducted to conceptualize the philosophy of 'Climate Smart Village (CSV)' integrating technological as well as social dimension under the project titled as "Devising innovative extension approaches for livelihood security" of Indian Agricultural Research Institute, New Delhi.

METHODOLOGY

The present study was conducted in Singimari area of Maynaguri, Jalpaiguri district, West Bengal. All the villages within a radius of nearly 10 KM were selected for the intervention under climate smart village. The villages were near the Teesta River and situated in flood affected ecosystem. Most of the land belong to low land area with high sensitivity to rainfall and flood. The farmers mainly depend on the rainfed farming system hence their vulnerability was more. The data for the findings on adoption of climate smart technology and impact of climate smart village was randomly collected from a sample of 400 respondents. The data were analysed using descriptive statistics like mean, frequency, and percentage.

To identify the indicator of climate smart village, an exhaustive lists of items were collected on concept of climate changes, its causes and consequences on society to represent the universe of the construct. Finally thirteen criteria were finalized based the highest mean score and agreement of the experts committee. Two approaches were followed for validating the present concept of climate smart village and its effectiveness. In first approach, validation refers to institutional validation i.e. a third party institution will investigate the different interventions, its impact and benefits received by the beneficiaries under the proposed model. This has been done by state agricultural department. The state agricultural department, Govt. of West Bengal has certified the village Singimari as "Climate Smart Village" in 2020. In second approach, the impact of climate smart village was assessed and its effectiveness was studied.

The study documented the changes in different farming scenario, technology adoption status, production scenario and changes in socio-economic scenario as an indicators of impact of present extension approach i.e. climate smart village. Before-after analysis was done to trace the changes within the project period.

RESULTS AND DISCUSSION

Conceptualization of climate smart villages

A climate smart village has been conceptualized a s a village where all the villagers contribute to climate change adaptation by adopting the required climate resilient technologies, follows the mitigation measures for reducing green house gas emission, brought positive behavioural change and devise local solution to reduce vulnerability towards future climate change impacts keeping the region's socio-economic, gender and bio-physical constraints in mind through community participatory approach. After selection of criteria through experts' judgement, a conceptual framework of climate smart village was designed for future work plan. The detailed framework of climate smart village has been presented in Figure 1.

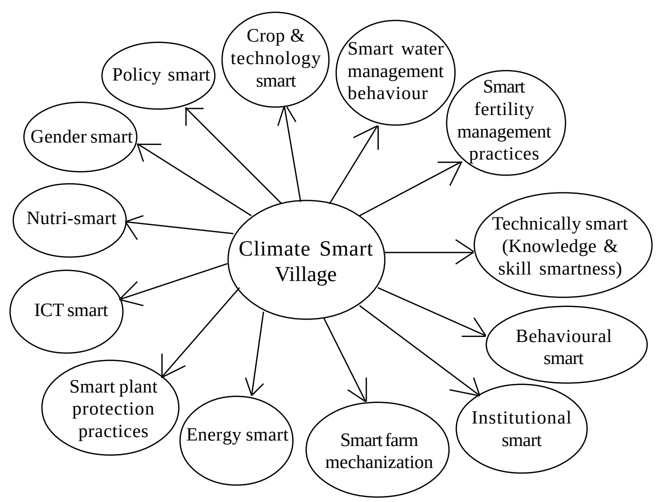

Figure 1. Conceptual framework of climate smart village

Institutional convergence framework

The study followed the approach Agricultural Innovation System theory for establishing convergence among the related institutions. Hence, the project tied up with Krishi Vigyan Kendra, Jalpaiguri; NABARD, state agricultural department, insurance Company, Bgajan Pragatishil Farmers Producer Organization for delivering different climate related products and services to the farmers of climate smart village (Figure 2).

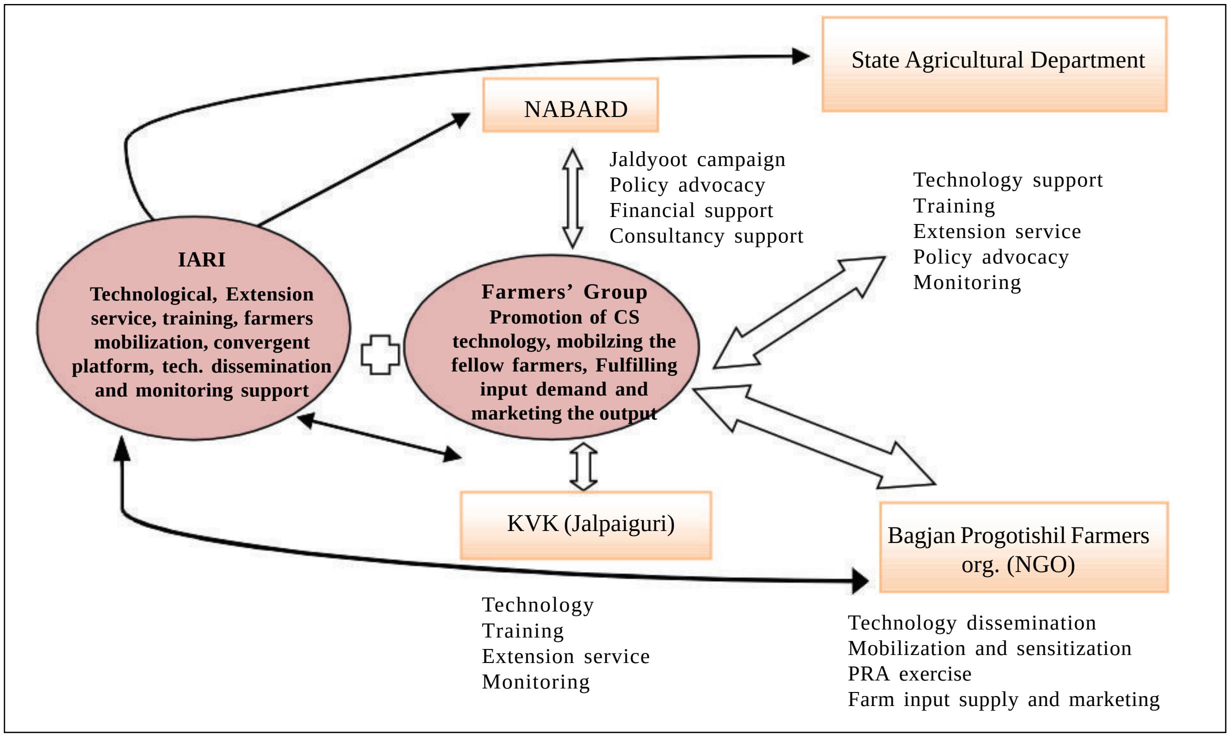

Figure 2. Institutional mechanism for establishing climate smart village

Interventions made to make the village climate smart

The major interventions made according to the different criteria of climate smart village are presented in Table 1.

Impact of climate smart village

The findings in Table 2 revealed that due to the intervention under climate smart village significnat increase in area under pulse and oilseed (65.78%) has been observed followed by irrigated area (42%), water bodies (41.02%), area under fruit/orcahrd/plantation crops (37.50%), land under forest (33.33%), area under vegetables (23.07%), area under cereals (11.11%). The decline of fallow land by 65.52 per cent indicates that unproductive or unused land was converted into farming land under the project. The introduction of pules like red gram, green gram into the cropping pattern ensured the soil helath and sustainable production system.

To unveil the impact of improved varieties and other climate resilient technologies on yield of major crops, the yield data of respective crops before the project intervention (2015) and at the time of the study (2020) were compared. The Table 3 depicted an increase in average yield for all the major crops in the project villages. Maximum yield improvement (33.33%) was witnessed in case of mustard crop. This is due to the introduction of new high yielding varieties like PM 26, PM 28 and PM30. In case of rice, the yield enhancement of 25 per cent was recorded due to adoption of climate resilient varieties like PS-5 and Swarna sub I. Among the pulses, the yield of green gram has increased by 30 per cent followed by red gram (28.57%). Demonstrations on improved varieties of off-season vegetables showed an increase in yield of Beans (Summer 25%), Peas (23.07%), Ladies finger (winter 18.75%), Cabbage (14.29%), Cauliflower (16.27%), Tomato (20%), Brinjal (summer). Zheng et al., (2014) & Edralin (2017) reported similar finding in his experiment and mentioned that due to adoption of CA practices crop yield was increased by 4.6 per cent on average. Jasna et al., (2014) found that a noticeable increase in production was achieved through introduction of improved climate smart varieties. So, all these studies proved that climate resilient technologies played a key role in transforming climate vulnerable agriculture to climate smart agriculture. Hence, more focused extension approach like 'Climate Smart Village (CSV)' should be promoted in different vulnerable ecosystem for adaptation to climate change.

Cropping intensity and diversity

Analysis of the data on average cropping intensity from all the villages has shown that average cropping intensity has increased significantly (Table 4). The cropping intensity has increased from 95.34 per cent to 127.12 per cent after the establishment of climate smart village, and the difference was statistically significant at <1 per cent level of significance. The findings indicate that there was an increase in crop diversification from 2.10 to 3.15 in the climate smart village. Jasna et al., (2017) also reported similar findings about increased cropping intensity in NICRA villages due to the introduction of climate smart technologies. Prasad et al., (2014) reported an increase in average cropping intensity across farmers by 17 per cent due to de-silting works. Medhi (2018) reported an increase in the cropping intensity even upto 204 per cent while studying impact of climate resilient technologies under NICRA project in Meghalaya.

Increased adoption of climate resilient technologies

The adoption of different climate smart technologies and incorporation of those technologies into the local farming system

Table 1. Interventions made in climate smart village

S.No.	Climate smart parameter	Interventions
1	Crop & technology smart	climate resilient rice varieties (PS-5, P 1612), flood resistant rice variety (swarna -sub I), DSR, green gram (Pusa bishal), and mustard (PM-26, PM-28, Pusa Vijay) varieties, cultivation of pulses (arhar, moong), intercropping of jute and moong, SRI, mulching techniques, raised bed panting, line sowing, crop rotation etc. were promoted in adopted villages.
2	Smart water management behaviour	Drip irrigation, sprinkler irrigation, mulching, water harvesting were promoted
3	Smart fertility management practices	Soil testing, INM, uses of micro-nutrient, vermi-compost, liquid fertilizer etc. were encouraged.
4	Technically smart (Knowledge & skill smartness)	Training on knowledge of different climate resilient technologies like DSR, zero tillage, SRI, IPM, INM etc. of different crops
5	Behavioural smart (having favourable attitude, value system and perception towards climate change and climate resilient technologies)	Awareness programme to create favourable attitude and value system towards climate change. They were encouraged to subscribe weather forecasting platforms, climate-informed agro-advisories, weather insurance as a tool for forward planning.
6	Institutional smart	Mobilizing for formation of community level institutions like producer company, water user group, custom hiring centre, seed village and linkage with different government as well as private agencies related to climate change.
7	Energy smart	Promotion of solar technologies for irrigation and spray.
8	Smart plant protection practices	INM practices, pheromone trap, yellow sticky trap, ITKs etc.
9	ICT smart	Trained to use mobile phone for accessing meteorological services
10	Policy smart	Awareness creation of different policies related to climate change like Pradhanmnatri Fasal Bima Yojana, Jaldoot, paramparagat krishi vikas yojana etc. and registering under those scheme for adapting to climatic risk.
11	Gender smart	Involving male as well as female members in each programme and intervention
12	Nutritional smart	Promotion of nutri-crops and varieties like black rice, PM-30 and PM-31 of mustard variety, iron rich leafy vegetables, nutri vegetables like moringa, broccoli, capsicum, red cabbage, summer squash, yellow cauliflower, ant-oxidant rich carrot etc.
13	ITK smart	Documentation & promotion of indigenous climate resilient technologies
14	Smart farm mechanization	Farm machineries like zero tiller, paddy trans-planter, paddy seeder, drum seeder etc. were promoted for adoption of climate smart practices.

Table 2. Change in land use pattern

S.No.	Crops	Before (ha)	After (ha)	% increase
1	Area under cereals	160	180	11.11
2	Area under vegetables	100	130	23.07
3	Area under fruit/orchard/plantation	45	72	37.50
4	Area under pulses and oilseed	13	38	65.78
4	Irrigated area	87	150	42.00
5	Fallow land	58	20	-65.52
6	Land under forest	10	15	33.33
8	Water bodies (Pond, Nala etc)	23	39	41.02

is the starting point to build up adaptation against climate change. Therefore, the present project introduced diverse climate smart technologies and practices and recorded their adoption status after completion of the project. The findings in Table 5 revealed that there was significant improvement in the adoption scenario of different climate smart technologies and practices after the project implementation. The adoption of different climate resilient cropping system like pulse based cropping system has increased from 11.25 per cent in 2015 to 52.50 per cent in 2020. The number of farmers who changed their planting or sowing time of crops to adapt with changing climate increased from 24.50 per cent to 53.75 per cent. Earlier only 19.75 per cent farmers were cultivating any climate smart crops as an adaptive measure. But now almost half of the farming communities (46.50%) adopted different climate smart

Table 3. Increase in yield level of major crops

S.No.	Crops	Mean yield before 2015 (q/ha)	Mean yield after 2020 (q/ha)	% increase
1	Rice (Amon)	30	40	25.00
2	Maize (Rabi)	18	22	18.18
3	Mustard	10	15	33.33
4	Jute (0li.)	18	21	14.29
5	Potato	200	250	20.00
6	Red gram	5	7	28.57
7	Green gram	7	10	30.00
8	Beans (Summer)	45	60	25.00
9	Peas	50	65	23.07
10	Ladies finger (winter)	65	80	18.75
11	Cabbage	210	245	14.29
12	Cauliflower	180	215	16.27
13	Tomato	200	250	20.00
14	Brinjal (summer)	145	170	14.70

Table 4. Change in cropping intensity and crop diversification

S.No.	Impact	Before	After	t-value
1	Cropping intensity (%)	95.34	127.12	7.157*
2	Crop diversification	2.10	3.15	2.89*

*Significant at P < 0.01

Table 5. Adoption status of climate smart technologies and practices

S. No.	Climate smart technologies and practices	Before f(%)	After f(%)
1	New cropping system	45(11.25)	210(52.50)
2	Change in planting time	98(24.50)	215(53.75)
3	Adoption of climate smart crops	79(19.75)	186(46.5)
4	Adoption of climate smart varieties	94(23.50)	230(57.50)
5	Line sowing	110(27.50)	250(62.50)
6	Raised bed planting	56(14)	149(29.80)
7	Crop rotation	78(19.50)	193(48.25)
8	Zero tillage	25(6.25)	210(52.5)
9	Direct seeded rice	30(7.5)	180(45)
10	Intercropping	85(21.25)	270(67.50)
11	Mulching	67(16.75)	225(56.25)
12	IPM	58(14.50)	235(58.75)
13	INM	69(17.25)	190(47.50)
14	Micro irrigation system	70(17.50)	260(65.00)
15	Water harvesting	80(20)	250(62.50)
16	Solar pump	0(0)	80(20)
17	Subscribe to weather advisory	50(12.50)	275(68.75)
18	Registration in crop insurance	40(10)	250(62.50)
19	Organic farming	25(6.25)	80(20)
20	Adoption of pulse based cropping pattern	65(16.25)	175(43.75)
21	Improved fodder management practices	50(12.50)	150(37.50)
22	Regular vaccination and deforming of animals	84(16.80)	246(49.20)
23	Adoption of fishery	90(22.50)	192(48)
24	Adoption of poultry	87(21.75)	143(35.75)
25	Adoption of goatery	63(15.75)	119(29.75)

crops to cope up with changing climate. Similarly, earlier just 23.50 per cent farmers adopted different climate smart varieties to reduce the impact of climate change in production system. As part of the project implementation plan, 18 new crop varieties were introduced in 10 villages of the Jalpaiguri district of West Bengal. The major technologies promoted were climate resilient varieties like PS-5, swarna sub-I of paddy, cultivation of pulses (arhar, moong), Pusa Vishal of green gram, PM 26, PM28, and PM 30 of mustard etc. After the project period, more than half of the farming communities (57.50%) adopted multiple climate smart varieties to enhance the production and productivity of their major crops in changing climatic scenario. Most promising response was found in case of line sowing as 62.50 per cent farmers now practicing line sowing for cereals, vegetables and oilseed. This may be due to the fact that the benefit of adoption of line sowing in term of yield enhancement, weed management, fertilizer and water management are easily visible to even small-scale farmers. Further, it involved very less risk in adoption of line sowing in their production system. Zero tillage and direct seeded rice was conceived to be as most promising climate resilient technologies and intensive efforts were made for its popularization. The study revealed that adoption of zero tillage has increased from 6.25 per cent to 52.50 per cent while the adoption of DSR has increased from 7.5 per cent to 45 per cent.

The number of farmers who now practiced intercropping as an adaptive measure towards climate change has risen from 21.25 per cent to 67.50 per cent. Mulching become highly popular among the farming communities as 56.25 per cent farmers practicing it for conserving soil moisture and arresting weed growth. The number of farmers who are following IPM as an adaptive measure has raised form 14.50 per cent to 58.75 per cent. The adoption rate of INM practices was increased from 17.25 per cent to 47.50 per cent. The importance of ICT in climate change adaptation has been highlighted by different studies and policy makers (Shafiq et al., 2014 & Adger et al., 2009). Hence, the present project registered the farmers under *Grami Krishi Mosuam Sewa* to receive weather based agro-advisory services in local language. Beside this, they were subscribed to different weather based platform for any weather related information. Findings revealed that the number of farmers subscribed and following weather based advisory services has increased from 12.50 per cent to 68.75 per cent. Similarly, the number of farmers who insured their crops against any climatic hazards has increased from mere 10 per cent in 2015 to 62.50 per cent by 2020. Now almost half of the respondents (43.75%) followed pulse based cropping pattern replacing cereal-cereal-vegetable as the major cropping pattern. Adoption of improved fodder management practices has increased from 12.50 per cent to 37.50 per cent. Regular vaccination was done by 49.20 per cent farmers in 2020 against 16.80 per cent in 2015. Almost half of the respondents (48%) adopted fishery for adaptation towards climate change beside regular farming. Similarly 35.75 per cent farmers started poultry and goatery by 29.75 per cent as off-farm enterprise for overcoming the climate related risks.

Though the findings of present study contradict with many previous findings. For example, Khati (2020) reported about the low adoption level of climate resilient technologies. Similarly, Anseera (2019) too mentioned that the results of adoptions of climate resilient practices are not very encouraging. The findings of Tiamiyu et al., (2018) indicated that adoption of most of the climate smart practices was very less due to the low awareness level. The low adoption scenario in past studies may be due to the fact that in all the past studies there was no focused extension approach unlike the present study where a specific extension approaches i.e. 'climate smart village' was followed. The climate smart technologies are highly complex in nature which need focused extension strategies for its promotion among the farming communities.

Socio-economic impact

The project interventions over the five year period made diverse impact among the socio-economic life of villagers. The Table 6 revealed that almost all the farmers (88.50%) agreed that the adoption of different climate resilient varieties and practices helped in enhancing their income while only 11.50 per cent viewed that it helps more in climate change adaptation than enhancing income. The findings of present study further reveals that majority of the farmers (77.50%) opined that the project interventions especially formation of FPO helped in accessing the different production inputs at much ease and at much lower cost. Effective local institutions are central to society's ability to respond to the impacts of climate change. Institutions link individuals with collectives and provide the framework within which households and collectives choose adaptation practices. Two local institutions name Bagjan Progotishil Sangha (NGO) and Bangkandi Farmer Producer Organization supported the CSA adoption by integrating all the

Table 6. Socio-economic impact

S.No.	Impact	Yes f(%)	No f(%)
1	Farmers with increased income	354 (88.50)	46 (11.50)
2	Increased access to production inputs	310 (77.50)	90 (22.50)
3	More accessible finance	260 (65)	140 (35)
4	More specialized local livelihood strategies	400 (100)	0 (0)
5	Changes in capacity of local actors & socially embedded institutions	325 (81.25)	75 (18.75)
6	Emergence of cultural and gender friendly local institutions	275 (68.75)	125 (31.25)
7	Changes in capacity of R&D system & associated institutions	220 (55)	180 (45)
8	Increased convergence among the stakeholders	250 (62.50)	150 (27.50)
9	Increased mobile usage among the farming communities	330 (82.50)	70 (17.50)

stakeholders with each other. This makes their farming life easy and comfortable. Just more than half of the respondents (65%) revealed that now they access different financial services very easily through farmers group without any collateral security. This helped them to take additional risk for adaptation to climate change. All the farmers (100%) unanimously agreed that the present concept of climate smart village helped them to devise more specialized and focussed livelihood strategies keeping the local resources and climatic condition in mind. Similarly, majority of the farmers (81.25%) reported that the establishment of climate smart village raise the capacity of local actors and institutions. More than half of the respondents (62.50%) reported about increased convergence among the stakeholders at block level under the climate smart village. Majority of the respondents (82.50%) perceived that the usage of mobile among the farmers has gone up significantly under the climate smart village projects.

CONCLUSION

The promotion of climate smart technology needs focussed extension approach. The significant increase in adoption rate of different climate smart technologies and practices. The farmers showed positive response and actively participated in establishment of climate smart village. The poor adoption rate of climate resilient technologies through traditional extension system can be overcome through focussed extension approach like climate smart village. The incorporation of social dimension in the concept of climate smart village accelerates the adoption rate of climate smart technologies by igniting the social diffusion process. Therefore this type of innovative extension approach should be up-scaled and out-scaled especially in the vulnerable ecosystem for better adaptation to climate change.

REFERENCES

Adger, W. N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D. R., Naess, L. O., Wolf, J., & Wreford, A. (2009). Are there social limits to adaptation to climate change? *Climatic Change*, *93*, 335–354.

Aggarwal, P. K., Jarvis, A., Campbell, B. M., Zougmoré, R. B., Khatri-Chhetri, Vermeulen, S. J., Loboguerrero, A., Sebastian, L. S., Kinyangi, J., Bonilla-Findji, O., Radeny, M., Recha, J., Martinez-Baron, D., Ramirez-Villegas, J., Huyer, S., Thornton, P., Wollenberg, E., Hansen, J., Alvarez-Toro, P., Aguilar-Ariza, A., Arango-Londoño, D., Patiño-Bravo, V., Rivera, O., Ouedraogo, M., & Tan Yen, B. (2018). The climate-smart village approach: framework of an integrative strategy for scaling up adaptation options in agriculture. *Ecology and Society*, *23*(1), 14. https://doi.org/10.5751/ES-09844-230114 .

Aggarwal, P., Zougmore, R., & Kinyangi, J. (2013). Climate-smart villages: A community approach to sustainable agricultural development. Copen-hagen, Denmark: CGIAR Research Program on Climate Change. *Agricul-ture and Food Security (CCAFS).* https://hdl.handle.net/10568/33322 .

Anseera, T.P. (2019). Influence of socio-economic characteristics on awareness of climate resilient technologies and their adoption. *International Journal of Recent Scientific Research*, *10*(7), 33685-33687. DOI: http://dx.doi.org/10.24327/ijrsr.2019.1007.3724.

Campbell, B. M., Thornton, P., Zougmoré, R., van Asten, P., & Lipper, P. (2014). Sustainable intensification: what is its role in climate smart agriculture? *Current Opinion in Environmental Sustainability, 8*, 39–43. http://dx.doi.org/10.1016/j.cosust.2014.07.002 .

CCAFS. No date. Climate-smart agriculture 101. Available: https://csa.guide/csa/monitoring evaluation-and-learning.

Chinseu, E. L., Dougill A. J., & Stringer, L. C. (2021). Strengthening conservation agriculture innovation systems in sub-Saharan Africa: lessons from a stakeholder analysis. *International Journal of Agricultural Sustainability*, pp 1-14. https://doi.org/10.1080/14735903.2021.1911511

Davis, K. (2008). Extension in sub-Saharan Africa: Overview and assessment of past and current models and future prospects. *Journal of International Agricultural and Extension Education, 15*(3), 15–28.

Dumenu, W. K., & Tiamgne, X. T. (2020). Social vulnerability of smallholder farmers to climate change in Zambia: the applicability of social vulnerability index. *SN Applied Science, 2*, 436. https://doi.org/10.1007/s42452-020-2227-0.

Dupdal, R., Patil, B. L., & Naik, B. S. (2021). Perceptions and adaptation strategies to changing climate: Evidence from farmers of northern dry zone of Karnataka. *Indian Journal of Extension Education*, *57*(3), 60-64.

Edralin, D. A., Sigua, G. C., Reyes, M. R., Mulvaney, M. J., & Andrews, S. S. (2017). Conservation agriculture improves yield and reduces weeding activity in sandy soils of Cambodia. *Agronomy for Sustainable Development, 37*, 52.

Harikrishna, Y. V., Naberia, S., Pradhan, S., & Hansdah, P. (2019). Agro-economic impact of climate resilient practices on farmers in Anantapur District of Andhra Pradesh. *Indian Journal of Extension Education*, *55*(4), 91-95.

IIRR, CCAFS. (2020). Eight guide steps for setting up a climate-smart village: A trainer's guide. Cavite, Philippines: International Institute of Rural Reconstruction (IIRR). https://hdl.handle.net/10568/107725 .

Jasna, V. K., Burman, R. R., Padaria, R. N., Sharma, J. P., Varghese, E., Chakrabarti, B., & Dixit, S. (2017). Impact of climate resilient technologies in rainfed agro-ecosystem. *Indian Journal of Agricultural Sciences, 87*(6), 816–824.

Khati, K. & Amardeep. (2020). Relationship of farmers profile with adoption of climate resilient practices in hilly region of Uttarakhand, India. *International Journal of Current Microbiology and Applied Sciences, 9*(2), 2180-2191.

Khatri-Chhetri, A., Aryal, J. P., Sapkota, T. B., & Khurana, R. (2016). Economic benefits of climate-smart agricultural practices to smallholder farmers in the Indo-Gangetic Plains of India. *Current Science, 110*(7), 1251–1256.

Kiptot, E., & Franzel, S. (2015). Farmer-to-farmer extension: opportunities for enhancing performance of volunteer farmer trainers in Kenya. *Development in Practice*, *25*(4), 503-517, http://doi 10.1080/09614524.2015.1029438.

Medhi, S., Islam, M., Barua, U., Sarma, M., Das, M. G., Syiemlieh, E. C., Bordoloi, P., & Mukhim, B. (2018). Impact of climate resilient practices under NICRA project in RiBhoi District of Meghalaya. *Economic Affairs*, *63*(3), 653-664.

Oraon, D., Kumar, A., Singh, R. K., Singh, U. K., & Alam, Z. (2020). Adoption level of soil and water conservation technology under NICRA in Chatra District in Jharkhand. *Indian Journal of Extension Education, 56*(2), 35-38.

Palanisami, K., Kumar, D. S., Malik, R. P. S., Raman, S., Kar, G., & Monhan, K. (2015). Managing water management research: analysis of four decades of research and outreach programmes in India. *Economic and Political Weekly, I*(26&27), 33–43.

Porter, J. R., Xie, L., Challinor, A. J., Cochrane, K., Howden, S. M., Iqbal, M. M., Lobell, D. B., & Travasso, M. I. (2014). Food security and food production systems. pp 485-533 *In:* C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. Otsuki Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea & L. L. White, editors. *Climate Change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects.* Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, New York, USA.

Prasad, Y. G., Maheswari, M., Dixit, S., Srinivasarao, Ch., Sikka, A. K., Venkateswarlu, B., Sudhakar, N., Prabhu Kumar, S., Singh, A. K., Gogoi, A. K., Singh, A. K., Singh, Y. V., & Mishra, A. (2014). Smart practices and technologies for climate resilient agriculture. Central Research Institute for Dryland Agriculture (ICAR), Hyderabad.

Ray, D. K., Gerber, J. S., MacDonald, G. K., & West, P. C. (2015). Climate variation explains a third of global crop yield variability. *Nature Communications, 6*, 5989. https://doi.org/10.1038/ncomms6989.

Rivera, W. M. (2011). Public sector agricultural extension system reform and the challenges ahead. *The Journal of Agricultural Education and Extension, 17*(2), 165–180.

Shafiq, F., Ahsan, K., Nadeem, A., Sarim, M., Basit, A., & Siddiq, M. (2014). Role of ICT in climate change monitoring: A review study of ICT based climate change monitoring services. *Research Journal of Recent Sciences*, *3*(12), 123-130.

Tiamiyu, S. A., Akintola, J. O., & Rahji, M. A. Y. (2009). Technology adoption and productivity difference among growers of new rice for Africa in Savanna zone of Nigeria. *Tropicultura*, *27*(4), 193-197.

Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. (2012). Climate change and food systems. *Annual Review of Environment and Resources, 37,* 195–222. https://sustainabledevelopment.un.org/content/documents/881annurev.pdf.

Wellard, K., Rafanomezana, J., Nyirenda, M., Okotel, M., & Subbey, V. (2013). A review of community extension approaches to innovation for improved livelihoods in Ghana, Uganda and Malawi. *The Journal of Agricultural Education and Extension*, *19*(1), 21-35.

Westermann, O., Förch, W., & Thornton, P. K. (2015). Reaching more farmers: innovative approaches to scaling up climate smart agriculture. CCAFS Working Paper no. 135. CGIAR Research Program on Climate Change, Agriculture and Food Security CCAFS, Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org.

Zheng, C., Jiang, Y., Chen, C., Sun, Y., Feng, J., Deng, A., Song, Z., & Zhang, W. (2014). The impacts of conservation agriculture on crop yield in China depend on specific practices, crops and cropping regions. *The Crop Journal, 2*, 289-296.