Indian Research Journal of Extension Education
RESEARCH ARTICLE

Measuring Resilience to Climate Change in Sikkim: Developing a Climate Resilience Index

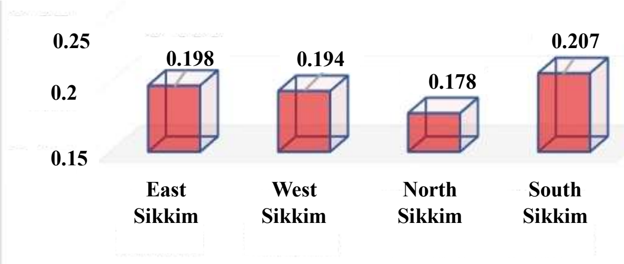
Mayanglambam Victoria Devi[1], Abujam Anuradha Devi[2] and Kursong Lepcha[3]
1&2. Assistant Professor, 3. Research Associate, Central Agricultural University (Imphal)
Corresponding Author Email: mvictoria.cau@gmail.com

HIGHLIGHTS

- The Study measures the climate Resilience capacity of organic farmers in Sikkim.
- Developed Climate Resilience Index employing Principal Component Analysis.
- The Organic farmers have very low Resilience capacity to climate change.

GRAPHICAL ABSTRACT

District wise resilience capacity of Sikkim



ARTICLE INFO

Editors:
Dr. Zakia Himeur
Dr. Kanchan Sandhu

Key words:
Climate change, Resilience, Organic farmers, Livelihood, Climatic shocks

Received : 18.10.2024
Accepted : 18.12.2024
Online published : 01.01.2025

doi:10.54986/irjee/2025/jan_mar/1-9

IRJEE METRICS

Google citations	- 10272
h-index	- 47
i10-index	- 319
NAAS rating (2024)	- 4.99
SJIF-2022	- 5.764
SJIF-2023	- 5.964
COSMOS CIF-2023	- 4.559
ABCD Index - 2023	- 6,5

ABSTRACT

Context: The organic farmers of the state Sikkim are facing low production of crops and reduction in the yield due to variation in the climate of the region. The major part of the state faced landslide, dry spell, heavy rainfall, pest and diseases infestation which is a major concerned for the organic growers. With frequent incidence of variation in climate, the agriculture sector is becoming vulnerable and livelihood of the farmers are becoming a major fretful.

Objective: To find out the climate resilience capacity of the farmers in Sikkim.

Methodology: The study covered all the four districts namely East, West, North and South Sikkim districts of Sikkim. A total of 480 organic farmers were randomly selected. Climate Resilience Index was developed through Principal component analysis for the study.

Results and Discussion: The study uncovered of organic farmers facing heavy rainfall, flood, dry spell, pest and diseases incidence frequently in the state. The farmers report of practicing resilience measures learned and adopted from progressive farmers and expressed of readiness to adopt practices which reduces stress to climate change. Farmers were found managing their income to save and ready to help family and friends at the time of need. Through the developed Climate Resilience Index in the study, it could found that the farmers of East Sikkim district, West Sikkim district and North Sikkim district has very low climate resilience capacity and the farmers of South Sikkim district also found of having low climate resilience capacity in the state

Significance: Policy makers and Extension agents of the state need to promote and train the farmers of Sikkim on climate smart agriculture, Resilience farming and build farmers capacity to deal with the climatic shocks.

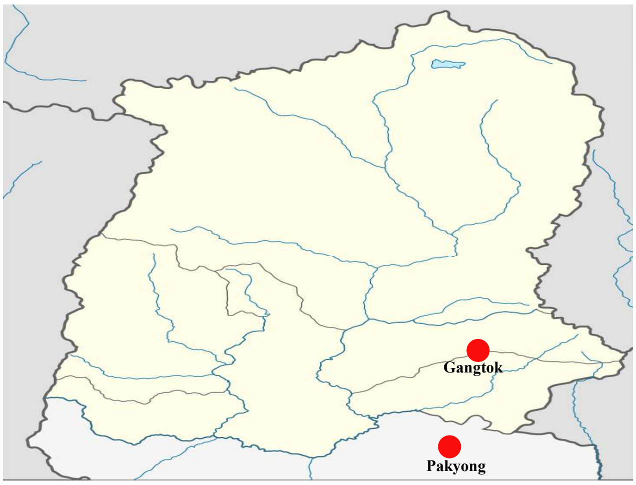
Sikkim is a small, culturally rich state located in the northeastern part of India, nestled in the eastern Himalayas. It is bordered by Bhutan to the east, Tibet (China) to the north and northeast, Nepal to the west, and the Indian state of West Bengal to the south.

The state is known for its organic farming practices since 2016 and produces crops such as cardamom, ginger, oranges and tea. Sikkim's climate is characterized by heavy monsoon rains from June to September. Climate change is altering these patterns, potentially leading to more intense rainfall events, increased risk of landslides, and variability in water availability for agriculture. Changes in temperature and precipitation patterns have affect crop yields, alter growing seasons, and increase the incidence of pests and diseases, posing risks to farmers' livelihoods (Sangeetha *et al.*, 2018; Kumar *et al.*, 2022). There are reduced in pasture lands, warming and decrease in precipitation in the state (Sharma and Rai, 2012). Productivity of several crops has decreased (Senthil, 2012). Evidence found on declines in spring water availability during the dry season, moderate exposure, high vulnerability due to high sensitivity and low adaptive capacity, varying levels of vulnerability due to climate change in the state (Tambe *et al*., 2012). Farmers used several alternate livelihood strategies to deal with lower agricultural yields (Jyothi and Venkata, 2020). Setting up of a state-wide inter-departmental authority for climate change adaptation and mitigation dealing with land, agriculture, forests, water, energy, meteorology and finance is required in the state (Bawa and Ingty, 2012). Assessing the adaptation strategies employed by Indian farmers can aid in mitigating and minimizing climate change risks. Building resilience in farmers against risk is necessary in face of an uncertain future (Meeyo *et al*., 2024).

Climate Resilience Index serves as a valuable tool for understanding, measuring and improving a community's or region's capacity to withstand and adapt to the challenges posed by climate change, ultimately promoting sustainable development and well-being. The farmers of Sikkim need to develop and adopt resilience measures in order to withstand the changing climate. The study claims the need to measure resilience level of farmers to bring sustainability in farming and also in their livelihood. The study finds the necessary to develop tools to assess and measures resilience level of organic farmers to measure community’s ability to prepare for, responds and recovered from the climate shocks.

METHODOLOGY

The study was conducted in the organic state, Sikkim. With complete enumeration, the study covered all the four districts of the state namely East Sikkim district, West Sikkim district, North Sikkim district and South Sikkim district (Latitude – 27º 25' North to 27º11' North and Longitude – 88º 53' East to 88º26' 10” East). From East Sikkim district, two sub-division namely Gangtok and Pakyong were selected purposively by considering the vulnerability to climate change and agriculturally important. Similarly, From West Sikkim district, Yoksum Tashidang and Rinchenpong sub-dividion; from North Sikkim district Dzongu and Kabi Tingda sub-division; and from South Sikkim district Temi tarku and Lingee Tumin sub-division were selected purposively. From each sub-division, two Gram Panchayat Units (GPUs) are selected randomly. In Sikkim, GPUs are more actively functional in the state, so the study considered selecting GPUs instead of blocks. From Gangtok sub-division, West Pandam and Central Pandam GPU were selected randomly; from Pakyong sub-division, Tarpin and Rhenock GPU were selected randomly; from Yoksum Tashidang sub-division, Karzi Mangnam and Dhupidara narkhola GPU were selected randomly; from Rinchenpong sub-division, Tadong Rinchenpong and Samdong Sribadam GPU were selected randomly; from Dzongu sub-division, Sakyoung pentong and Hee-gyathang GPU were selected randomly; from Kabi Tingda sub-division, Men-rongong and Phensong GPU were selected randomly; from Temi Tarku sub-division Tokal Bermiok and Namphing GPU were selected randomly; and from Lingee Tumin sub-division, Paiyoung and Lingi GPU were selected randomly.



Map of the study area

From each GPU two villages were selected. From each villages, 15 organic farmers were selected randomly. A total of 480 progressive organic farmers were selected randomly. The primary data were collected through structured schedule in the form of personal interview.

To study the climate resilience capacity of the farmers in the state, a Climate Resilience Index (CRI) to climate change was developed for the study. The resilience index was framed in terms of exposure to shocks, inherent resilience, absorptive capacity, adaptive capacity, transformative capacity, socio-economic, coping strategies to shocks, and social participation. Principal Component Analysis (PCA) was employed for the development of the CRI index. Descriptive statistics have been analysed to check the distribution of responses.

Measuring Community Resilience Score: the community resilience index have been generated with 29 sub-indicators from 8 major variables. The scores were calculate by summing up each sub indicators, and then the CRI score were calculated using min max normalisation method, which converts indicators to a range of 0 to 1. The formula for min max method are:

$$x' = \frac{x - x_{min}}{x_{max} - x_{min}}$$

Where,

x' is the min-max transformed score for the observation,

x_{min} is the minimum value and x_{max} is the maximum value.

$$\text{SUB}= \left(\frac{1}{N}\sum_{i=1}^{N} x'i\right)$$

Where, the calculation of sub-indices (SUB), for which all indicators x' belonging to a specific subdomain are summed and divided by the total number of indicators N in that subdomain.

CRI score= ExpRm+ IRRm+ ABRm+ ACRm+ TCRm+ SERm+ CSRm+ SocRm

Where,

ExpR is exposure to shocks,

IRR is Inherent Resilience,

ABR is Absorptive Capacity,

ACR is Adaptive Capacity,

TCR is Transformative Capacity,

SER is Socio-Economic,

CSR is Coping Strategies, and

SocR is Social participation

The subscript 'm' indicates that the sub-index scores are also min-max transformed prior to the addition. According to Antronico *et al.* (2023) the values of index can be categorised into five levels of resilience; 0-0.2 = Very low, 0.2-0.4 = low, 0.4-0.6 medium, 0.6-0.8 high and 0.8-1= Very high.

Development of CRI framework: The CRI of the study adapted the concept of RIMA (FAO, 2016) in developing the framework. In CRI framework, eight different indicators namely Exposure to Shocks, Inherent Resilience, Absorptive Capacity, Adaptive Capacity, Transformative Capacity, Socio-economic, Coping Strategies to Shocks and Social Participation were considered as major components of the index. Under the indicators, thirty sub-indicators were identified and included in the index. The sub-indicators were of composite structure including qualitative and quantitative nature of data.

RESULTS

The total 48 sub- indicators have been analysed in the PCA. The eigenvalues are the variances of the principal components. The size of eigenvalue is used to determine the number of principal components. Here, eight component have been extracted based on eigenvalue greater than 1, which explains 72 per cent of total variation in the data. The first component (Exposure to shocks) explain nearly 33 per cent, likewise the second component (Inherent Resilience) explain nearly 13 per cent, third component (Absorptive capacity) around 6 per cent, fourth component (Adaptive capacity) around 5 per cent, fifth (transformative capacity), sixth (Socio-economic) and seventh components (Coping strategies to shocks) explain around 4 per cent respectively, and the eighth component (Social participation) explains the least variance of around 3 per cent of the total variance in the data. The scree plot below in figure 1 & Table 1 shows the eigen value against the 30 sub-components, which helps determined the number of principal component

Table 1. Total Variance Explained

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
Exposure to shocks	9.868	32.893	32.893
Inherent Resilience	3.827	12.757	45.650
Absorptive Capacity	1.747	5.824	51.475
Adaptive capacity	1.601	5.337	56.811
Transformative capacity	1.162	3.874	60.686
Socio-economic	1.126	3.752	64.438
Coping strategies to shocks	1.100	3.666	68.104
Social Participation	1.044	3.480	71.583

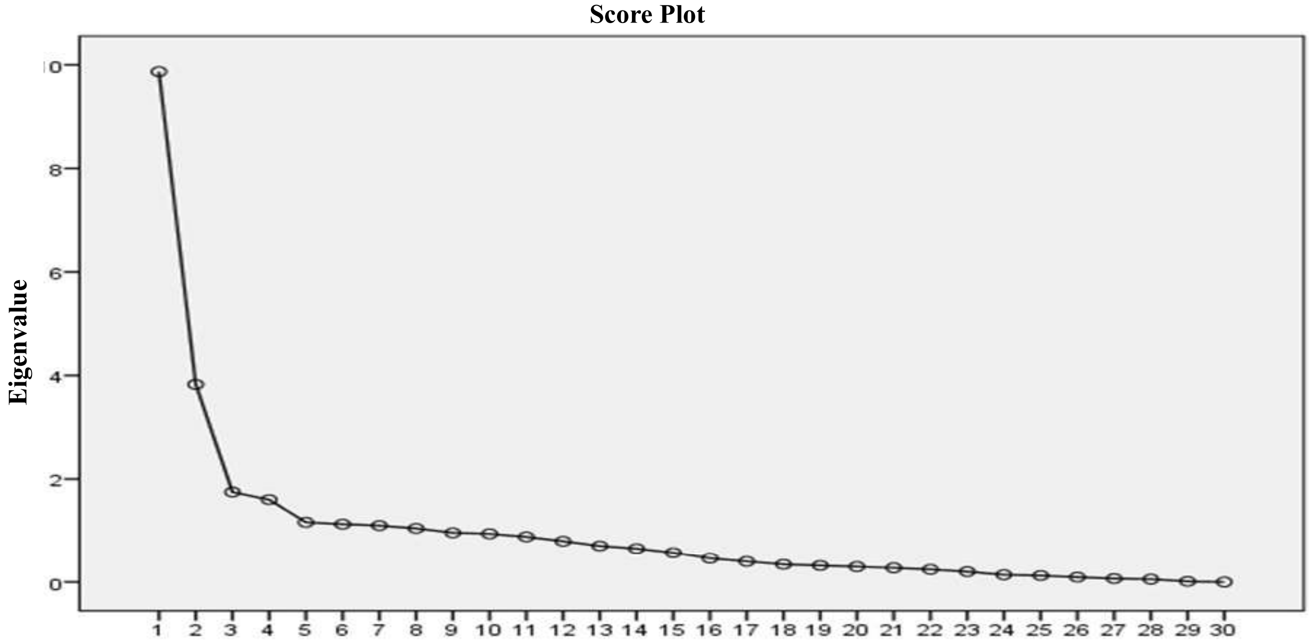


Fig. 1 Scree-plot of the components

analysis, the graph is almost flat from 8th component, meaning each successive components accounts for smaller and smaller amounts of the total variance.

The rotated component matrix in Table 2 shows the amount of variance explained by each sub-components to the extracted principal components, and number of sub-components in each of the extracted principal components. Here, out of 48 sub indicator 29 sub indicators were extracted. in the first principal component there are maximum 10 sub-indicators which explains the maximum total variance, and the last component consist of one sub- indicator, which explains 3 per cent of the total variance.

The Table 3 presents the community Resilience capacity to climate change in Sikkim. It was uncovered that, majority of farmers (45.83%) expressed of facing heavy rainfall, flood, dry spell, pest and diseases incidence frequently under 'Exposure to shocks' in the state. Under Inherent Resilience, farmers uncovered that resilience measures that they are practicing in the community were learned and adopted from progressive farmers (48.95%), and friends & neighbours (27.70%). Farmers expressed of desire to follow forefather (48.9%) and expressed of low (62.5%) awareness on climate resilient practices. Under Absorptive Capacity, majority (71.7%) have expressed that they have no other options even though the practices using in the farm are not suitable to deal or withstand the climate variation. Under adaptive capacity, farmers expressed of readiness to adopt practices to minimise the loss and ready to work together to reduce the stress to climate change but farmers also expressed that they don't want to change the traditional farming system (62.7%). Under Transformative capacity, farmers expressed of preparedness to face any climatic variation in the farm (74.4%). Under Socio-economic component, farmers expressed of managing their income to save so that they can use during stress situation, also shows readiness to expend to help family and friends at the time of climate related incidents. Farmers were found staying alert and prepared for any climate hazard occurred. Majority of farmers (84.4%) shared that they save 25 per cent of their earnings to expense for climate risk in the community and around 72 per cent farmers mentioned of storing 25 per cent of food from their harvest for their family. Majority of farmers expressed for necessary of people to stay alert and aware (69.2%), different related departments to work together to deal climate change and required to train people with different capacity to face the climatic shock. For Coping strategies, Farmers mentioned of not getting sufficient help from local government and loan from banks during the stress or climatic shock occurred. Farmers expressed of change in cropping patterns and practices of farm, relief on family savings at time of need, received help from relatives and friends, lending and borrow money or credits from relatives, etc. while farmers also expressed of not changing in the dietary pattern of family, no reduction of expenses in health, diets, educations of children, not selling land and assets

Table 2: Rotated Component Matrix

Indicators	Sub-Indicators	Variance Explained	Comp-onents
Exposure to Shocks	Climatic shocks frequently occurred in the locality.	.717	6
Inherent Resilience	Our community is ready to practice resilience measures.	.676	1
	Any resilience measures available is ready to use to deal with the changing climate.	.552	1
	The practices that I am using could withstand the climate shocks	-.727	1
	My community following the practices used by forefathers to deal with climate risk because	-.871	2
	Aware of any resilience practices.	.591	7
Absorptive Capacity	The practices using in the farm are not suitable for climate disturbance but don't have other option	.825	3
Adaptive Capacity	We need to work together to find out measures for reducing stress to climate change	.609	4
	Don't know any scientific measures against climatic shocks but ready to adopt any practices to minimise losses	.537	4
Transformative Capacity	Find it necessary to change our traditional farming approaches/systems	-.876	1
	I am prepared to face any climatic variation and its impact in my farm.	.789	3
	Received improved flood early warning systems to reduce risks to my crops and/or property	.876	1
Socio-economic	People need to stay aware about the changing climate and its effect on agriculture	.691	2
	It is important to make people alert on climate changes and its long term solutions	-.778	1
	Agricultural institutes and government departments need to come forward with the local people to deal climate change	.717	3
	There needs to make people stay inform and warn for any climatic shock and capacity training to face it	.710	2
	I manage to save my income and earnings so that I can use it in stress situation	-.829	1
	I am ready to expend my earning in climate related incidents to help my family and friends	.569	2
	We always remain alert and prepared for any climate hazard to occur	.820	2
	Willing to expense my earnings for climate risk for the community.	.894	5
Coping strategies to shocks	Reserve food and store from the total harvest for my family.	.911	5
	We go for distress sale of crops and livestock	-.675	7
	We received unconditional help from local government	.821	8
	I obtained credit/loan from bank	.691	6
Social Participation	We frequently attend awareness and campaign activities in my village on climate change and its impact	.726	3
	We actively took part in community cleaning drives	.796	1
	We plant trees in locality	.525	4
	We frequently organised social recreation activities	.557	1
	Community meeting and group drives against climate shocks frequently done.	.591	1

Table 3. Climate Resilience capacity of farmers in Sikkim

Major/Sub-Indicators	Events	Score (%)
Exposure to Shock		
Types of shocks frequently occurred		
Heavy rainfall and flood		43.75
Dry spell		6.25
Pest and disease		4.16
All		45.83
Inherent Resilience		
Community practicing any resilience measures		
Ancestors		23.33
Friends and neighbours		27.70
Extension agents		0
Progressive farmers		48.95
Type of resilience measures used to deal with the changing climate		
Use of stress tolerant crops		48.54
Replace from crop to livestock		0
Use of CSA practices		0
Skip resilience measures		51.45
The practices that I am using could withstand the climate shocks		
Very sure		0
Sure		23.3
Not sure		27.7
Don't know		48.9
My community following the practices used by forefathers to deal with climate risk		
Find it suitable		27.7
Don't know other alternative		23.3
Want to follow them		48.9
Don't want to change		0
Aware of any resilience practices.		
Very high		37.5
High		0
Low		62.5
Not at all		0
Absorptive Capacity		
The practices using in the farm are not suitable for climate disturbance but don't have other option		71.7
Adaptive Capacity		
We need to work together to find out measures for reducing stress to climate change		59.6
Don't know any scientific measures against climatic shocks but ready to adopt any practices to minimise losses		55.0
Find it necessary to change our traditional farming approaches/systems		37.3
Transformative Capacity		
I am prepared to face any climatic variation and its impact in my farm.		74.4
Received improved flood early warning systems to reduce risks to my crops and/or property		60.2
Socio-Economic		
People need to stay aware about the changing climate and its effect on agriculture		59.6
It is important to make people alert on climate changes and its long term solutions		64.8
Agricultural institutes and government departments need to come forward with the local people to deal climate change		57.9
There needs to make people stay inform and warn for any climatic shock and capacity training to face it		57.9
I manage to save my income and earnings so that I can use it in stress situation		67.9
I am ready to expend my earning in climate related incidents to help my family and friends		59.6
We always remain alert and prepared for any climate hazard to occur		69.2
Willing to expense my earnings for climate risk for the community.		84.4
Reserve food and store from the total harvest for my family.		71.9
Coping Strategies		
We go for distress sale of crops and livestock		37.7
We received unconditional help from local govt.		26.3
I obtained credit/loan from bank		18.3
Social Participation		
We frequently attend awareness and campaign activities in my village on climate change and its impact		73.1
We actively took part in community cleaning drives		71.5
We plant trees in locality		61.3
We frequently organised social recreation activities		42.9
Community meeting and group drives against climate shocks frequently done.		43.1

Table 4: Community resilience scores

Districts	CRI scores	Category
East Sikkim	0.198	Very low
West Sikkim	0.194	Very low
North Sikkim	0.178	Very low
South Sikkim	0.207	Low

nor rented, and no migration to other places. For Social Participation, farmers (73.1%) expressed of frequent attend of activities for the villages (73.1%), active participation in cleaning task of community (71.5%), plantation (61.3%), organised of social recreation in the community (42.9%) and also report to conduct community meetings (43.1%).

TheTable 4 and Radar chart of figure 2 shows the district wise Climate Resilience capacity of the state. The districts namely East Sikkim, West Sikkim and North Sikkim shows of CRI score of 0.198, 0.194 and 0.178 respectively concluding that farmers in these districts have very low Climate Resilience capacity in the state. Also the South Sikkim district has CRI score of 0.207 which means the farmers of the district has low climate Resilience capacity.

The district wise Climate Resilience score have been presented in Table 4 and Radar chart of figure 2.

DISCUSSION

The developed Climate Resilient Index has identified eight indicators namely Exposure to shocks, Inherent Resilience, Absorptive capacity, Adaptive capacity, Transformative capacity, Socio-economic, Coping strategies to shocks and Social Participation with twenty nine sub-indicators through Principal Component Analysis. The study attempted to understand climate resilience capacity of the organic farmers in the state Sikkim. Heavy rainfall, flood, dry spell, pest and diseases incidence as found under exposure of shocks can significantly impact crop production as they alter yields and production of the crop in the region which requires understanding the dynamics of climate

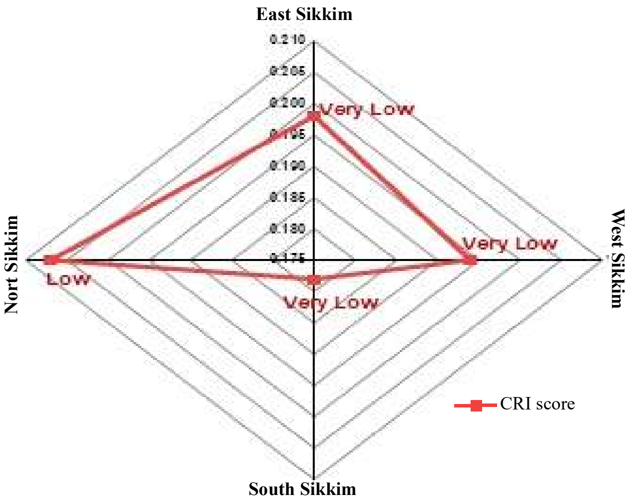


Fig. 2. Radar chart on district wise climate resilience score

variability (Kukal and Irmak, 2018). The agricultural practices used by the farmers were learned and adopted from progressive farmers, friends & neighbours and farmers in the state have low awareness on resilience practices. This is due to farmers not participating in training programmes regarding resilience measures. This leads to lack of knowledge and skills necessary to adopt modern agricultural practices, manage risks effectively, and make informed decisions. Without adequate knowledge and skills, farmers may struggle to respond and adapt to climate change (Raahalya *et al.,* 2024). The farmers expressed that they have no other options even though the practices using in the farm are not suitable to deal or withstand the climate variation. It shows that farmers have limited options and low exposures to climate resilience practices which requires of skill trainings on climate resilience measures in the state. Extension services of the state need to scale up and scale out climate resilience measures among the farmers for wider coverage of farmers through community approach. The study found of farmers' readiness to adopt practices to minimise the loss and ready to work together to reduce the stress to climate change but farmers also expressed that they don't want to change the traditional farming system. With developing resilience practices which are indigenous and traditional approach might give greater adoption in the state. Convincing farmers to opt for climate resilient approach might be easy and effective if valued the need and interest of the farmers' perspective. The study found farmers expressed of managing to save their income and used during stress time, readiness to help friends, staying alert and prepared for any climate hazard. This shows of farmers concerned for other fellow farmers, which depicts of concerned for each other and help each other at time of need.

The farmers found storing food for their family, spending their earnings for climate risk in the community, and expressed for necessary of people to stay alert to face the climatic shocks. This shows the farmers preparedness to face the climatic shocks which can prevent from huge losses due to climatic hazards. The farmers mentioned of not getting sufficient help from local government and loan from banks during the stress time. Development of Resilient agriculture and related investment need support from governments, private sector and also role for civil society organizations, which can be key factor to eradicate poverty and support adaptation (FAO, 2015). This can be improve through wider awareness programmes and reaching the unreached farmers in the state.

The farmers expressed of not changing in dietary pattern of family, no reduction of expenses in health, and education, etc. This might be due to priority of people on diet, health and education. It shows optimistic of people for betterment of family. The extreme climate has immediate and long term impacts on livelihood of poor and vulnerable farmers, contributing to greater risks of food (Mbow *et al.,* 2019).

The study also found that the farmers of East Sikkim district, West Sikkim district and North Sikkim district found having very low Climate Resilience capacity and also South Sikkim district has low climate resilience capacity. The finding was contradict with the report of Sikkim State Action plan which stated that East and North Sikkim districts were relatively resilient to climate related change (GoS, 2014). The need to build resilience and adaptation, has been increasingly realized to ensure food security and sustainable development in the region (Baraj *et al.,* 2024). Building resilience in farmers against risk is necessary in face of an uncertain future (Meeyo *et al.,* 2024). In order to create equitable, efficient, and inclusive adaptation and resilient responses to climate change, we need to focus on the role of policy makers and power in decision-making driving vulnerability, mitigation, adaptation and Resilience. Since, the study found very low to low resilience capacity of organic farmers in the state, it is a matter of primary concern. It is imperative we learn and reflect by developing aid and approaches in climate policy of the state in particular and for the region.

CONCLUSION

The study uncovered the community climate resilience by developing Climate Resilience Index covering exposure to shocks, inherent resilience, absorptive capacity, adaptive capacity, transformative capacity, socio-economic, coping strategies, and social participations. From the descriptive statistics, the regions were exposed to heavy rainfall, dry spell and pest and disease every year. Farmers were found very low capability in dealing the climate related shocks. The climate resilience capacity of the community were found very low. Also, the farmers have very low or negligible knowledge on Climate related measures and strategies. This shows of requirement for extension functional of the state to expose the farmers with adaptive and mitigate strategies to climate change in order to build community resilience to climate change. From this finding, it can be suggested that farmers of Sikkim need to be train on climate smart agriculture, Resilience farming and build farmers capacity to deal with the climatic shocks. Extension agents need to educate and empower the farmers to adapt with the changing climate.

Acknowledgement: The study is funded by Indian Council of Social Science Research, New Delhi and the authors are thankful to the agency.

Declaration of competing interest: The authors have no known competing interest to declare.

Data availability: Data would be made available on request.

Authors' contribution: First author conceptualized, outlined the paper's structure, and coordinated the collaboration among the authors. Second author critically evaluated the paper, including revisions and edits of the manuscript. Third author contributed to writing and editing.

REFERENCES

Antronico, L.; Carone, M.T. and Coscarelli, R. (2023). An approach to measure resilience of communities to climate change: a case study in Calabria (Southern Italy) *Mitig. Adapt. Strateg. Glob. Change*, 28(4): 20.

Awal, M.; Rashid, M.; Islam, A.F.M.T.; Imam, M. and Sarkar, M. (2016). Measuring climate change vulnerability and its adaptive capacity: Policies and planning for Bangladesh. *British J. Environ. Clim. Change*, **6**(4): 279-298.

Baraj, B.; Mishra, M.; Sudarsan, D.; Silva, R.M. and Santos, C.A.G. (2024). Climate change and resilience, adaptation, and sustainability of agriculture in India: A bibliometric review. *Heliyon*:**10**(e29586).

Bawa, K.S. and Ingty, T. (2012). Climate change in Sikkim: A synthesis. *Climate Change in Sikkim, Patterns, Impacts and Initiatives*: 19-48.

Dympep, A.; Singh, R.J.; Chauhan, J.; Pandey, D.K. and Hemochandra, L. (2016). Standardize index for measuring performance of farmers on mitigation and adaptation practices of climate change. *Indian Res. J. Ext. Edu.,* **16**(3): 93-96.

FAO. (2016). Analysing resilience for better targeting and action. Resilience Index Measurement and Analysis – II.www.fao-rima@fao.org

Jyothi, V. and Venkata, S.P. (2020). Livelihood diversify cation of farmers in salt affected soils in Andhra Pradesh. *Indian Res. J. Ext. Edu.,* **20**(4): 20-22.

Kumar, A.; Meena, H.R.; I. Rashmi and Kumar, K. (2022). Comparison of organic and conventional farmers based on integrated climate change adaptive capacity. *Indian Res. J. Ext. Edu.,* **22**(3): 1-9.

Meeyo, H.; Tengli, M.B.; Gaurav, S. and Sahoo, S.K. (2024). Climate change adaptation strategies and vulnerabilities of Indian farmers: A systematic literature review (ROSES Approach). *Indian Res. J. Ext. Edu.,* **24**(4): 1-11.

Mishra, M.; Khawas, V.; Singh, A.; Timsina, K.; Bhutia, K.D.O. and Bala Sundareshwaran, A. (2011). Vulnerability of highland communities to climate induced change and practical adaptive capacity. *Int. Geogr. Union Proc*.

Sangeetha, G.; Sherief Allan Thomas; A.K. and Seema, B. (2018). Comparison of organic and conventional farmers based on integrated climate change adaptive capacity. *Indian Res. J. Ext. Edu.,* **18**(2): 1-6.

SenthilKumar, P. (2012). Impact of climate change and adaptation measures in dairy sector of Sikkim. In Arrawatia, M.L., Tambe, S. (Eds), Climate Change in Sikkim Patterns, Impacts and Initiatives. Information and Public Relations Department, Government of Sikkim, Gangtok.

Sharma, G. and Rai, L.K. (2012). Climate Change and Sustainability of Agro diversity In Traditional Farming Of The Sikkim Himalaya. In Arrawatia, M.L., Tambe, S. (Eds), Climate Change in Sikkim Patterns, Impacts and Initiatives. Information and Public Relations Department, Government of Sikkim, Gangtok.

Sharma, R.K.; and Shrestha, D.G. (2016). Climate perceptions of local communities validated through scientific signals in Sikkim Himalaya, India. *Environmental monitoring and assessment*, **188**: 1-11.

Tambe, S.; Kharel, G.; Arrawatia, M.L.; Kulkarni, H.; Mahamuni, K. and Ganeriwala, A.K. (2012). Reviving Dying Springs: Climate Change Adaptation Experiments from The Sikkim Himalaya.In Arrawatia, M.L., Tambe, S. (Eds), Climate Change in Sikkim Patterns, Impacts and Initiatives. Information and Public Relations Department, Government of Sikkim, Gangtok.

Victoria Devi, M.; Singh, R.J.; Chauhan, J.K. and Marbaniang, E.K. (2022). Farmers' resilience to climate change in the North Eastern hill region of India. *Indian Res. J. Ext. Edu.,* **22**(5): 290-294.

• • • • •