



# Does climate knowledge act as a shield for farm livelihoods? Empirical analysis from the coastal and non-coastal ecosystems of India

Usha Das<sup>1</sup> · M. A. Ansari<sup>1</sup> · Souvik Ghosh<sup>2</sup>

Received: 18 February 2022 / Accepted: 8 September 2022 / Published online: 27 October 2022  
© The Author(s), under exclusive licence to Springer-Verlag GmbH Austria, part of Springer Nature 2022

## Abstract

Developing countries with agrarian economy have been facing challenges arising from climate change events and its consequences. Climate knowledge influences the adaptation and mitigation measures shielding farm households in climatically vulnerable regions. Indian states with climatically vulnerable coastal and non-coastal agro-ecosystems have dominantly an agrarian economy; and small and marginal farmers' livelihoods are under focus through implementation of National Innovations in Climate Resilient Agriculture (NICRA) by the Indian Council of Agricultural Research. The present study was undertaken in one such state, Odisha. Climate knowledge test was developed following appropriate methods and administered to 200 farmers, 100 each in coastal and non-coastal NICRA districts to assess the knowledge level of dominant livelihood groups. Farmers' climate knowledge was higher in coastal district as compared to non-coastal district with overall climate knowledge index values of 53.10 and 43.95, respectively. Farmers who engaged in crop + livestock farming have better climate knowledge as compared to crop farmers and livestock farmers. Multiple regression and path analyses revealed social, economic, communication and psychological attributes of the farmers determining their climate knowledge level. Education level, social participation, participation in community initiatives, annual family income and personal cosmopolite information sources use are few such important determinants of climate knowledge. These dimensions require attention for the policy advocacies to improve climate knowledge so as to shield climatically vulnerable farm households.

## 1 Introduction

Global climate change has its own severity extended to plants, animals, human beings and almost all earth inhabitants across the continents. The severity due to climate extremes is attributable to the projections of net temperature rise by 1–4 °C as well as an annual rainfall rise of 9–16% by 2050s (Kumar et al. 2011). According to the Intergovernmental Panel on Climate Change (IPCC) AR6 report (IPCC 2021), the current 1.1 °C rate of global warming if averaged over the next 20 years, the global temperature rise will exceed 1.5 °C (IPCC 2021). The production of greenhouse gases caused by human activities is increasing at an alarmingly rapid rate, which is having a widespread and

detrimental effect on both natural and man-made systems (IPCC 2021). The potential adversities of climate change now challenge the well-being and food security of everyone (World Food Programme 2011). With the world climate changing visibly in terms of altered seasonality, shifting shorelines, increased greenhouse gases, enhanced sea levels, exacerbated rates of melting of icebergs and so on, it becomes pivotal to look for factors contributing to such phenomena (IPCC 2019; UNFCCC 2010). The change in climate and climatic patterns are governed by a number of factors that are governed by largely diversified natural drivers and man-made (anthropogenic) activities. Some of these factors are so severe that the effects of these factors on climate change if not controlled now will be beyond management intervention (Kanter et al. 2018; ECA 2009).

FAO (2017) reported that agriculture could decline by nearly 2% per decade in this century as a result of rising temperatures, rampant deforestation, and mismanaged agricultural practises; the latter two are responsible for a quarter of global greenhouse gas (GHG) emissions, which are projected to increase by over 30% by 2050. The rate of greenhouse gas emissions has doubled during the past

✉ Usha Das  
udas.240294@gmail.com

<sup>1</sup> Department of Agricultural Extension and Communication, College of Agriculture, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

<sup>2</sup> Institute of Agriculture, Visva-Bharati University, Shantiniketan, West Bengal, India

five decades. Therefore, transition of the agricultural sector toward more climate-resilient, sustainable production systems is necessary, particularly for small-scale farmers in developing nations (Branca et al. 2021).

Vulnerability due to climate change is most pronounced in developing countries in South Asia and Sub-Saharan Africa region (Eckstein et al. 2021; Aryal et al. 2021). Farmers have differential awareness, knowledge and perceptions towards climate change and thus their responses differ to combat climate change impacts (Karki et al. 2020; Ramborun et al. 2020). Climate change adaptation strategies are being formulated in the agriculture sector; however, consistency of those with the farmers' preferences has been the concerns in developing countries (Khanal et al. 2018). Climate change mitigation measures are often hampered by level of farmers' awareness, knowledge and attitude towards climate change and its impact on agriculture and vice versa (Tzemi and Breen 2019).

The climate change process is having global importance with local visibility in the agriculturally driven economies, and India being an agrarian economy greatly experiences the adverse impacts of climate change phenomena like floods, tropical cyclones, landslides, heatwaves, avalanches and the list goes on (Birthal et al. 2014; FAO 2013). India is at seventh position in climate vulnerability as per the Global Climate Risk Index (CRI) (Eckstein et al. 2021). While India's overall rank has improved in environmental performance index (Wendling et al. 2020), it still continues to remain at the bottom in several individual indicators including air quality and climate change, thus concerning indicating local visibility of such a global phenomenon of climate change. The deepest concerns from this kind of scenario in India still remain with the farmers, who are at the receiving end from the climatic disasters. Climate change has arisen as a severe threat to the livelihood of Indian farmers (more than 80% of them are marginal and small farmers), who are ill-informed and unprepared to deal with recent climate changes and its effects on agriculture. Enhancing the need and capacity to manage climate risk, which stands as a core adaptation strategy, demands an increase in the "climate knowledge" of decision-makers so that they become more cognizant of climate impacts on various systems, and of how to use management options to intervene, thus reducing negative impacts and using such opportunities to thrive amidst all adversities (Lemos and Rood 2010; Lemos and Morehouse 2005). Rao et al. (2016) mentioned that adaptation is as important as mitigation, when dealing with climate change. The more farmers are aware of consequences of climate change, the greater is their adaptation measures; therefore, increasing farmers' knowledge and awareness facilitates implementation of climate change adaptation programmes (Khanal et al. 2018). With humans intervening and managing most of the factors contributing to climate change directly or indirectly,

it becomes further crucial to locate what is exactly their knowledge level, how they understand and process the various causes and consequences of climate change; is it alike for everyone and with their given level of knowledge can it act as a shield against climatic vulnerabilities? The present article in further sections unfolds these aspects of consideration in a climatically vulnerable state of India.

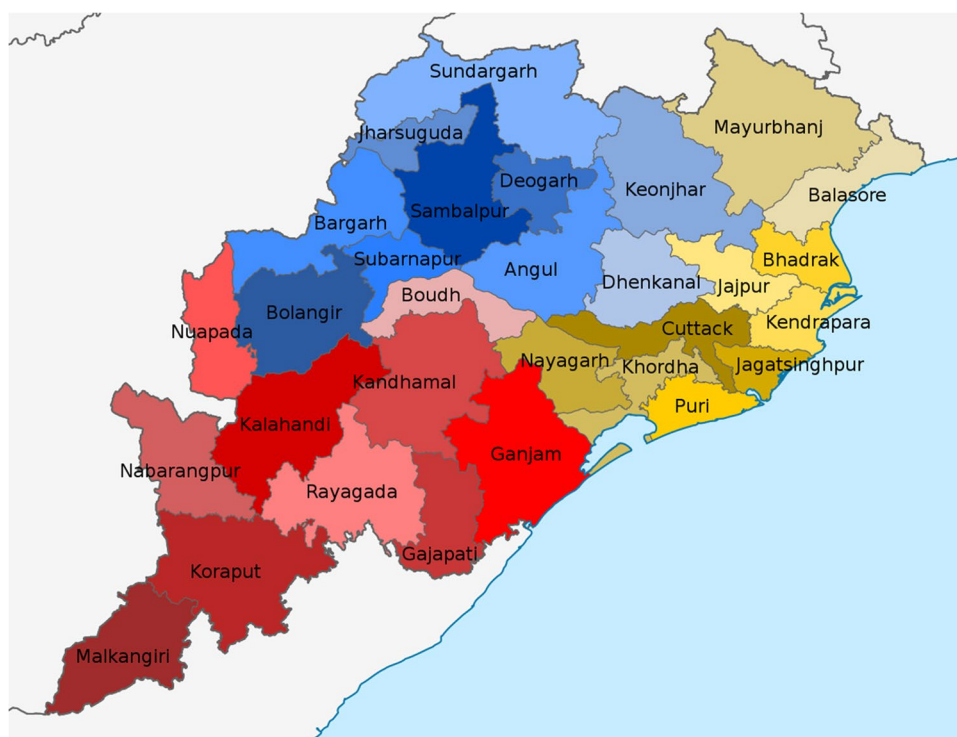
Odisha, the most climatically vulnerable Indian state endowed with resources that are highly exposed to climate change events like floods, tropical cyclones, droughts, heat waves and so on (Mohapatra 2012). The geographical position of Odisha with vulnerable coastal and non-coastal ecosystems (Fig. 1) has made the rural livelihoods susceptible to extreme climatic events. These events are greatly impacted upon by the factors that are inherently linked to the farmers inhabiting the area as well as factors that are consequences of their actions. So, tapping the understanding of farmers is very crucial for creating safety mesh from the climate adversities (Das and Ansari 2021). Studies conducted in Odisha (Narayanan and Sahu 2016; Bahinipati 2014) suggested that frequency and intensity of calamities that hit coastal districts are totally in contrast to the non-coastal districts, and response to these calamities is prerogative of their socio-economic, socio-personal attributes. The calamity years used to experience a dent in the agricultural productivity, and the social and economic status of farmers (Das and Ghosh 2019), thus expressing importance of addressing these calamities either through awareness creation or perceptual interventions mediated via varied communication sources like mass media, personal cosmopolite, personal localite, ICT-driven programmes etc. (Das and Ghosh 2020; Dhanya and Ramachandran 2016; Sarkar and Padaria 2015). Looking into the urgent need to harness the understanding of farmers in the climatically vulnerable state of Odisha, India, the present study was conducted to determine if climate knowledge of vulnerable farm households can shield them against the adverse impacts of climate change events as well as to identify the determinants of climate knowledge in two agro-ecologically different districts of Odisha.

## 2 Methodology

### 2.1 Locale of the study and sampling

Odisha is classified as a highly vulnerable state of India (State of India's Environment 2021) and most districts of the state are placed in the category of highly vulnerable to vulnerable (Bahinipati 2014). So, it was purposively selected for the investigation. The present investigation looks into the cross-section data of farmers from two climatically vulnerable and agro-ecologically varied districts of Odisha. In this investigation, the study is divided into two phases. The first

**Fig. 1** State of Odisha, a climatically vulnerable state in India



phase solicits/grounds for construction of a knowledge tool to determine the level of climate knowledge of the farmers, and the second phase involves administration of the tool to the respondent farmers to evoke their climate knowledge and awareness from two distinctive climatically vulnerable districts from the state of Odisha.

An integrated approach of assessing vulnerability as a function of exposure, sensitivity, and adaptive capacity delineated the vulnerability index values of all 30 districts of Odisha (Bahinipati 2014); according to which the variation in vulnerability level across all the districts is lower. The coastal districts (like Balasore and Kendrapara) have both high exposure and vulnerability values compared to the remaining districts. Eight districts have vulnerability index value  $> 0.5$ ; while 17 and 5 districts have vulnerability index values in between 0.4–0.5 and  $< 0.4$ , respectively. Present study was conducted in coastal district of Kendrapara with vulnerability index value 0.555 (second most vulnerable district after Balasore with index value 0.591) and non-coastal district of Dhenkanal with vulnerability index value 0.403; thus, representing the climatically vulnerable both coastal and non-coastal districts in Odisha. Moreover, climate change issues are also streamlined nationally by the Indian Council of Agricultural Research (ICAR) through implementation of National Innovations in Climate Resilient Agriculture (NICRA) programme, which have been implemented in agro-ecologically and climatically contrasting coastal districts like Kendrapara and non-coastal district like Dhenkanal in Odisha. Thus, these two districts

were purposively selected for our study. Thereafter, the NICRA beneficiary villages (two villages under each district) were purposively selected. Later, following purposive sampling with proportionate allocation, 50 farmer respondents from each village proportionately across three dominant livelihood groups (namely crop farmers, livestock farmers and crop + livestock farmers) were chosen finalizing the total respondents to 200 so as to gather the cross-sectional data on their attributes and climate knowledge level. The ratio followed in Kendrapara and Dhenkanal district were 55:25:20 and 60:20:20 for crop farmers: livestock farmers: crop + livestock farmers, respectively.

## 2.2 Variables and their measurements

### 2.2.1 Farmers' Attributes

The study included 33 independent variables identified under five broad capitals of selected farm households, namely, physical capital (house type, communication devices, electricity connection, conveyance, farm machinery and implements, water source, road connectivity from and to house, sanitation facility, cooking facility), social capital (social recognition, social participation, social cohesiveness, participation in community initiatives, accessibility to common facilities), financial capital (economic status, annual family income, sources of income, annual family expenditure, family savings, credit behavior, insurance), human capital (education level, communication

sources use pattern {mass media, personal cosmopolite and personal localite}, information availability, participation in training and extension activities, family health status {extent of suffering due to climatic hazards}) and natural capital (farm size, cultivated land, irrigated land, livestock holding, water bodies). These variables were measured following DFID (1999) sustainable livelihood framework with the help of a semi-structured interview schedule developed for the same purpose.

## 2.2.2 Climate knowledge

Climate knowledge level was the dependent variable from which climate knowledge index was developed later to make a comparison between coastal and non-coastal districts of Odisha.

**2.2.2.1 Knowledge tool construction** The knowledge tool to test the climate knowledge level of farmers was developed. Climate knowledge of farmers holds paramount importance, for it is decisive along with other factors interplay how vulnerable a farm livelihood group will be on exposure to climatic vagaries. So, it becomes crucial to test the cognitive orientation of farmers to climate change causes and consequences.

Ideally a knowledge test consists of verified, reliable and valid statements pertaining to the context (here climate change causes and consequences). These statements are otherwise referred to as “knowledge items”. These items are administered in the form of questions which had one correct and one incorrect answer. The climate knowledge test construction in the present study began with collection of items from various literature sources, bibliographic databases and also from the climate research experts during pilot studies. Then, it proceeds to item selection where those items that could cognitively arouse a differentiating ability between an ill-informed from a well-informed person were selected. The items selected were examined for judgement at two levels. The first level of judgement was done by judges (those experts were considered to judge the knowledge items who had worked in climate change field of researches for a period of 3 years and more; for the judgement purpose, 66 judges were approached with 61 initial statements/knowledge items) for relevancy rating on a scale of 1 (irrelevant) to 5 (most relevant) using mailed questionnaire technique. Those items with a relevancy rating of greater than or equal to 4 were considered for level two of judgement (30 statements were retained after relevancy rating from level one) that was carried out with non-sample farmers (to avoid the testing effects, these farmers were not a part of final administration of the tool

and they belonged to similar category of socio-economic status and agro-climatic zones). These items were put in dichotomous question form (where yes = correct = 1 and no = incorrect = 0) and were administered using “Computer-Aided Personal Interviews” (CAPI) to 60 non-sample farmers. The maximum possible score was 30 and minimum was 0, and these items were to evaluate difficulty and discrimination level of farmers based on their responses. The CAPI technique was used from the open-source software and application platform called KoBo toolbox. The purpose behind the use of this platform was to monitor real-time data, have ready to use digitized data and ensure contact less data collection during the times of COVID-19 pandemic.

The above-mentioned thirty items were evaluated for difficulty level that indicated the difficulty of respondent non-sample farmers in answering a question correctly which implied that their knowledge level was directly related to the probability of answering a question correctly. The following is the mathematical formula used for calculating difficulty index:

$$P_i = n_i/N_i \times 100$$

where,

$P_i$  difficulty index of the  $i^{\text{th}}$  term (in %)

$n_i$  number of respondents giving correct answer to  $i^{\text{th}}$  term

$N_i$  total number of respondents selected for administering the test

Discrimination level of items indicated the difference between a well-informed and an ill-informed respondent, and it was mathematically calculated using the formula (Mehta 1958):

$$E^{1/3} = (S1 + S2) - (S5 + S6)/(N/3)$$

where,

S1, S2, S5 and S6 are the frequencies of correct answers from group G1, G2, G5, G6, respectively. Farmers were grouped into six groups, each group with 10 farmers, based on their test scores in a descending order.

N total number of respondents administered for testing and item analysis.

The validity of items in this knowledge test was tested for content and construct validity. Content validity indicates the adequate representation of the content (here climate change causes and consequences) and it was judged at the

beginning by the judges in terms of relevancy. The construct validity of items measures the theoretical trait or construct that was tested using point-biserial correlation ( $r_{pbi}$ ). The construct here we are referring to is the knowledge level. The mathematical formula indicating construct validity:

$$r_{pbi} = \frac{(\bar{y}_1 - \bar{y}_2)\sqrt{pq}}{S_y}$$

where,

$r_{pbi}$  point-biserial correlation coefficient

$\bar{y}_1$  conditional mean of the quantitative variable y when nominal score is 1

$\bar{y}_2$  conditional mean of the quantitative variable y when nominal score is 0

p proportion for which nominal value is 1

q proportion for which nominal value is 0 or 1-p

$S_y$  standard deviation of entire set of items

The reliability of this knowledge test was calculated following Richardson-Kuder formula otherwise referred to as “The Reliability Coefficient based upon the Method of Rational Equivalence”, and it is mathematically calculated using the following formula (Kuder and Richardson 1937):

$$\text{Reliability coefficient of the entire test} = \frac{(\text{total number of items in the test})}{(\text{total number of items in the test}) - 1} \times \frac{(\text{standard deviation of the test scores for the entire group})^2 - \sum pq}{(\text{standard deviation of the test scores for the entire group})^2}$$

where,

p the proportion of the group answering a test item correctly

q (1-p)=the proportion of the group answering a test item incorrectly.

The reliability coefficient of the final test items using Richardson-Kuder formula is 0.760 at 1% level of significance. This indicated that the knowledge test is highly reliable (with a reliability of 76%).

Those items having a difficulty index value between 0.15 and 0.85 and discrimination index value of the corresponding items identified within the difficulty index range as above 0.25 were shortlisted. Later, the construct validity of these

items with values between 0.15  $r_{pbi}$  and 0.25  $r_{pbi}$  (0.25  $r_{pbi}$  preferable) was considered for final inclusion into the knowledge tool for administration.

Based on the above criteria mentioned (reliability, difficulty index, discrimination index, validity), 10 items were finalised.

**2.2.2.2 Knowledge tool administration** The standardised knowledge tool was administered to the 200 farmer-respondents across three dominant livelihood groups in two climatically vulnerable districts of Odisha. Each of the 10 knowledge items was measured on 3-point continuum (Fully known=2, partially known=1, and unknown=0); thus, maximum possible score for a respondent was 20 and minimum was 0. Climate Knowledge Index (CKI) for each livelihood group was derived from the total score of each respondent in the group using the following formula:

$$CKI_i = \sum K_{ij} / K_{\max}$$

where,

K is the knowledge score

i is no. of respondents and j is no. of knowledge items (10 for present study)

### 2.2.3 Vulnerability of farm households

The shielding effect of climate knowledge against climatic adversities was worked out for the four predominant calamities (flood, cyclone, drought and heatwaves) based on the perceived vulnerability of farm households. Perceived climatic vulnerability of farm livelihood groups was measured on a six-point continuum (where 0=no effect and 5=very high effect) following which differential perception of vulnerability towards different calamities was recorded (Das and Ghosh 2018).

## 2.3 Test of differential climate knowledge

The study was furthered to determine if the two vulnerable districts had different climate knowledge level with respect to dominant livelihood groups and if given climate knowledge levels has contributed to shield them differently from the adverse impacts of climatic events (for this study particularly flood, cyclone, drought and heatwaves were considered due to frequent exposure to these events in the selected regions), and the extent of differential climate knowledge contrasting across three dominant livelihood groups in two study districts was done following parametric



test statistics like Analysis of Variance (ANOVA) and Post Hoc tests.

## 2.4 Factors influencing climate knowledge

The factors determining climate knowledge of farmers in terms of their attributes were delineated based on degree of association and functional relationships. To identify the relationship between farmers' attributes (33 for this study considered as independent variables) and climate knowledge level of farm households (dependent variable), relational statistical analyses multiple regression analyses (following backward elimination technique), and path analyses (determines direct, indirect and substantial indirect effect of independent variables on dependent variables) were carried out using IBM SPSS version 26.0.

## 3 Results of the study

### 3.1 Climate knowledge of farmers

The climate knowledge of farmers of the coastal district of Kendrapara is presented in Table 1. Ten knowledge items were administered to the farmer respondents where the maximum possible score for each statement is two and minimum is zero. More than 50% of the farmers were fully aware of the contribution of electronic appliances to climate change and the seasonality shift in many crops due

to climate change in the past 10–15 years. Three knowledge items, viz. climate change both natural and man-made, negative impact of stubble burning by farmers on climate, and improper dumping and burning of household and farm waste causing climate change, evoked a response of partially known from more than half of the sampled respondents. It is evident that majority of the respondents were unknown about greenhouse gases (GHGs) causing climate change, and two major sources releasing GHGs. The average overall climate knowledge score was 10.62 with a deviation of 4.87.

Table 2 presents the climate knowledge of farmers of non-coastal district of Dhenkanal. Only knowledge item no. 5 evoked a response of completely known from more than half of the population. While four knowledge items, viz. greenhouse gases causing climate change, two major sources releasing GHGs, increased carbon dioxide catalyzing the process of climate change, and sea level rise due to climate change, evoked a response unknown from more than half of the population, and only three knowledge items, namely, climate change both natural and man-made, improper dumping and burning of household and farm waste causing climate change, and burning of fossil fuels causing climate change, were partially known by more than half of the sample respondents. The average overall climate knowledge score was 8.79 with a deviation of 4.92.

Table 3 and Fig. 2 present the comparative climate knowledge level of major livelihood groups in both the districts. It is evident that overall climate knowledge of Kendrapara (coastal) farmers is higher than farmers of

**Table 1** Farmers' distribution based on their climate knowledge in coastal district of Kendrapara

Sl. no	Knowledge items	Frequency of respondents-farmers (n = 100)			Mean knowledge score
		Fully known	Partially known	Unknown	
1	Is climate change both natural and man-made?	30	62	8	1.22
2	Do you think greenhouse gases cause climate change?	8	26	66	0.42
3	Can you name two major sources that release GHGs?	11	26	63	0.48
4	Is stubble burning by farmers is having negative impact on climate?	28	68	4	1.24
5	Is use of some electronic appliances (e.g., Fridge, Air conditioners) is contributing to climate change?	52	45	3	1.49
6	Does improper dumping and burning of household and farm waste cause climate change?	26	59	15	1.11
7	Are you aware that increased carbon dioxide will catalyse the process of climate change?	25	38	37	0.88
8	Does burning of fossil fuels cause climate change?	38	44	18	1.20
9	Do you think rise in sea level is because of climate change?	24	49	27	0.97
10	Is there any shift in seasonality of many crops due to climate change in past 10–15 years?	62	37	1	1.61
Overall climate knowledge score					10.62 (SD 4.87)

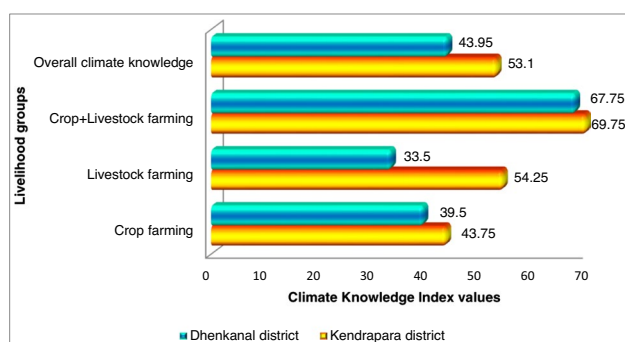
**Table 2** Farmers' distribution based on their climate knowledge in non-coastal district of Dhenkanal

Sl. no	Knowledge items	Frequency of respondents-farmers (n = 100)			Mean knowledge score
		Fully known	Partially known	Unknown	
1	Is climate change both natural and man-made?	38	59	3	1.35
2	Do you think greenhouse gases cause climate change?	9	28	63	0.46
3	Can you name two major sources that release GHGs?	9	26	65	0.44
4	Is stubble burning by farmers is having negative impact on climate?	22	49	29	0.93
5	Is use of some electronic appliances (e.g., Fridge, Air conditioners) is contributing to climate change?	58	41	1	1.57
6	Does improper dumping and burning of household and farm waste cause climate change?	22	51	27	0.95
7	Are you aware that increased carbon dioxide will catalyse the process of climate change?	10	36	54	0.56
8	Does burning of fossil fuels cause climate change?	18	54	28	0.90
9	Do you think rise in sea level is because of climate change?	6	14	80	0.26
10	Is there any shift in seasonality of many crops due to climate change in past 10–15 years?	49	39	12	1.37
Overall climate knowledge score					8.79 (SD 4.92)

**Table 3** Climate knowledge of the farmers in Kendrapara and Dhenkanal districts

Sl. no	Respondents-farmers	Index value		Test statistic
		Kendrapara district	Dhenkanal district	
1	Crop farming	43.75 (n = 55)	39.50 (n = 60)	$z = 1.855^*$
2	Livestock farming	54.25 (n = 25)	33.50 (n = 20)	$t = 2.865^*$
3	Crop + Livestock farming	69.75 (n = 20)	67.75 (n = 20)	$t = 0.290^{NS}$
Overall climate knowledge		53.10 (n = 100)	43.95 (n = 100)	$z = 2.656^{**}$

\*\* Significant at 1% level, \*significant at 5% level

**Fig. 2** Climate knowledge of the farmers in Kendrapara and Dhenkanal districts

Dhenkanal (non-coastal) district. For both the districts, crop + livestock farmers had higher climate knowledge level i.e., 69.75% and 67.75%, respectively. Evidently from respective  $z$  statistic values (in Table 3), the crop farmers of Kendrapara and Dhenkanal districts differed significantly with respect to climate knowledge (CKI). From

the respective  $t$  statistic values, it was implied that there was a significant difference between the livestock farmers of both the districts with respect to climate knowledge (CKI), and there was no significant difference between crop + livestock farmers of the two study districts with respect to climate knowledge.

### 3.2 Differential climate knowledge of farm livelihood groups

The test of significance for comparing climate knowledge of different farmers' groups of Kendrapara and Dhenkanal districts was performed using analysis of variance (ANOVA) in SPSS (version 26). The  $F$  statistics was found to be significant for both the districts between the different livelihood groups. Based on the test of homogeneity of variance (Levene's statistics) and robust test of equality of means (Welch statistic and Brown Forsythe statistic), Scheffe's test was taken up under Post Hoc test to find out significant differences among specific groups of farmers in both districts. The same is presented in Table 4.

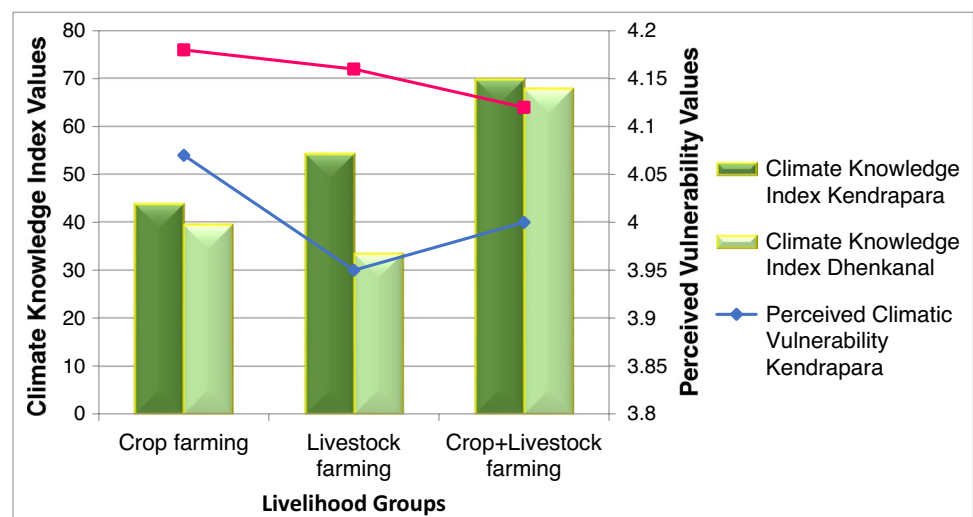
**Table 4** ANOVA and post hoc tests showing significant differences in climate knowledge of different farmers' groups in Kendrapara and Dhenkanal districts

ANOVA						
Climate knowledge index		Sum of squares	df	Mean square	F	Sig. <sup>#</sup>
CKI Kendrapara	Between groups	7530.705	2	3765.352	7.282	.001
	Within groups	50,158.295	97	517.096		
	Total	57,689.000	99			
CKI Dhenkanal	Between groups	14,581.364	2	7290.682	15.652	.000
	Within groups	45,183.386	97	465.808		
	Total	59,764.750	99			
Post hoc tests (Scheffe Test <sup>1</sup> ): multiple comparisons						
Variables				Mean difference (I-J)	Std. error	Sig. <sup>#</sup>
CKI Kendrapara	Crop farmers group	Livestock farmers group		− 5.909	5.48503	.562
		Crop + livestock farmers group		− 22.659*	5.93772	.001
	Livestock farmers group	Crop farmers group		5.909	5.48503	.562
		Crop + livestock farmers group		− 16.750	6.82192	.054
	Crop + livestock farmers group	Crop farmers group		22.659*	5.93772	.001
		Livestock farmers group		16.750	6.82192	.054
CKI Dhenkanal	Crop farmers group	Livestock farmers group		4.946	5.20592	.638
		Crop + livestock farmers group		− 28.205*	5.63557	.000
	Livestock farmers group	Crop farmers group		− 4.946	5.20592	.638
		Crop + livestock farmers group		− 33.150*	6.47478	.000
	Crop + livestock farmers group	Crop farmers group		28.205*	5.63557	.000
		Livestock farmers group		33.150*	6.47478	.000

<sup>1</sup>Applied in case of equal variance as evident from test of homogeneity of variance (Levene Statistic); Robust Tests of Equality of Means indicate significant Welch statistic and Brown-Forsythe statistic values in all cases. \*level of significance at either 1% or 5%. <sup>#</sup>significance values rounded off up to three decimal places

It is evident that various groups of farmers vary with respect to their knowledge level, and they perceived the causes and consequences of climate change differently irrespective of the kind of climatic hazard they were exposed to. It was interesting to observe that livestock farmers of Kendrapara district were having a better knowledge than the crop farmers, and it has no significant difference with

other two livelihood groups, while that of crop + livestock farmers had highest climate knowledge because they had to face consequences of climate change on both the enterprises (crop and livestock), and it has significant difference with crop farmers. Contrastingly, crop + livestock farmers of Dhenkanal district showed significant difference of climate knowledge with both crop farmers and livestock farmers.

**Fig. 3** Contrasting climate knowledge and vulnerability level of different livelihood groups in coastal and non-coastal districts of Odisha



Overall climate knowledge of Kendrapara farmers was better than Dhenkanal farmers indicating that flood and cyclone hit areas make farmers more aware about the local causes and consequences of climatic hazards. This also confirms an inherent factor of their higher exposure to such maladies driving their attitude and perception towards the knowledge items favourably.

### 3.3 Climate knowledge versus climatic vulnerability

The graphical representation in Fig. 3 indicates that the greater the climate knowledge (as in case of coastal district) the lesser is the perceived vulnerability of farm livelihood groups towards natural calamities. It is further crucial to observe that in case of coastal district (Kendrapara), dairy animals or livestock component may be the reason of causing relatively less vulnerability in case of livestock farmers as compared to both crop farmers and crop + livestock farmers. Because crop damage is quite alarming and non-reversible in case of flood and cyclone which hit coastal districts the most, so, due to crop failures experienced by the farmers, they perceived higher level of vulnerability than livestock farmers in coastal district, and because of dual sources of livelihood as in the case of crop + livestock farmers, they bear climate knowledge pertinent to both the enterprises and with a better climate knowledge alongside the assurance that even if crop failures will be there, they still can survive with livestock component, so their perceived climatic vulnerability was lower in comparison to crop farmers. Contrastingly, for non-coastal district, livestock farmers reared mostly small ruminants, which are being considered relatively better drought resistant and are preferred over the dairy animals. They are also less vulnerable than crops in drought-prone areas. However, farmers perceived ill effect of drought and heatwaves on small ruminants were relatively higher than that of flood and cyclone on dairy animals because farmers used to shift their cattle and calves along with themselves

to safer places in the event of flood and cyclone. Thus, rearing of dairy animals in coastal and small ruminants in non-coastal regions are considered as one of the climate change adaptation options and advised to rear along with growing of crops for better climate proofing. So, it is worth concluding that climate knowledge is acting as a shield against the climatic vulnerability of farm households.

### 3.4 Factors influencing climate knowledge

Multiple regression analyses between attributes of farmers and their climate knowledge in Kendrapara district of Odisha were done following backward elimination method in which 23 models were generated eliminating 24 out of 33 attributes. Evidently from Table 5, the last model included nine attributes like communication devices, sanitation facility, social participation, annual family income, household savings, education level, mass media use, information availability and size of water body together explaining 60.80% ( $R^2 = 0.608$ ) variations in knowledge level of farmers on climate change. The regression coefficients are found significant up to 10% level of significance in the model generated through SPSS 26.0 for Windows Version. Regression coefficient of social participation and annual family income was found to be negative. Therefore, it may be attributed to the fact that farmers with better social participation were having better resiliency to climate change and they remained less bothered with the climate change causes and consequences; similarly, farmers with higher annual family income had lower climate knowledge that may be attributed to the fact that the rich farmers have higher resilience so not much affected with climate change impact, causes and consequences on their livelihood.

The multiple regression analyses between attributes of farmers and their climate knowledge in the Dhenkanal district of Odisha were also done following backward elimination method in which 22 out of 33 attributes were eliminated. Table 6 presents model summary that included 11

**Table 5** Regression (backward elimination method) between attributes of farm households and their climate knowledge in Kendrapara district

Model summary	Standard error	Beta coefficient	<i>t</i> -value	Significance
Constant	5.992	− 6.484	− 1.082	0.282
Communication devices	0.087	0.148	1.861	0.066
Sanitation facility	0.097	0.199	2.375	0.020
Social participation	0.108	− 0.201	− 2.033	0.045
Annual family income	0.160	− 0.257	− 1.903	0.060
Household savings	0.103	0.202	1.792	0.076
Education level	0.104	0.455	4.807	0.000
Mass media use	0.130	0.196	1.907	0.060
Information availability	0.113	0.158	1.838	0.069
Size of water body	0.070	0.241	3.250	0.002
<i>n</i> = 100, <i>F</i> value = 15.485**, <i>R</i> value = 0.779, <i>R</i> square value = 0.608				

\*\* Significant at 1% level

**Table 6** Regression (backward elimination method) between attributes of farm households and their climate knowledge in Dhenkanal district

Model summary	Standard error	Beta coefficient	t-value	Significance
Constant	4.655	−7.366	1.583	0.117
Conveyance	0.085	0.136	1.724	0.088
Sanitation facility	0.059	0.163	1.934	0.056
Participation in community initiatives	0.058	0.280	4.242	0.000
Accessibility to common facilities	0.062	−0.125	−1.964	0.053
Annual family income	0.085	−0.250	−2.826	0.006
Sources of income	0.042	0.123	1.798	0.076
Credit behavior	0.095	0.109	1.935	0.056
Education level	0.066	0.628	8.075	0.000
Personal cosmopolite information sources use	0.100	−0.375	−4.065	0.000
Information availability	0.109	0.345	3.724	0.000
Farm size	0.066	0.297	3.779	0.000
$n = 100$ , $F$ value = 25.160**, $R$ value = 0.871, $R$ square value = 0.759				

\*\* Significant at 1% level

attributes like conveyance, sanitation facility, participation in community initiatives, accessibility to common facilities, annual family income, sources of income, credit behaviour, education level, personal cosmopolite information sources use, information availability and farm size, together explaining 75.90% ( $R^2 = 0.759$ ) variations in climate knowledge of farmers. Regression coefficient was negative for accessibility to common facilities, annual family income and personal cosmopolite use. In a group of 11 above-mentioned attribute variables, these three variables were having negative functional relationship, while the rest were having a positive relationship with climate knowledge that indicates well-to-do farmers were relatively less concerned with their knowledge on climate change causes and consequences.

The direct effects of attributes of farmers on climate knowledge were laid using regression analysis. However, the total effect, direct effect, indirect effect as well as substantial indirect effect of independent variables on dependent variables was studied using path analysis. Table 7 presents the path analysis of attributes of farmers of Kendrapara with their climate knowledge. The total effect presents correlation between the attributes of farmers and climate knowledge of the farmer-respondents; 27 attributes were positively and significantly influencing the climate knowledge of the farmers, out of which education level was having the strongest correlation with climate knowledge, thus conclusive that the higher the education level, the better is their climate knowledge. The highest indirect effect on climate knowledge of farmers was exerted by annual family income followed by participation in training and extension. However, maximum substantial indirect effect is mediated through education level of the farmers, followed by information availability and annual family income. These variables were also revealed to have direct effect on the climate knowledge of the farmers (from regression analysis) demanding the utmost attention for future policy advocacy in improving climate knowledge of the farmers.

For Dhenkanal district (Table 8), similar to Kendrapara district, total effect indicates correlation between attributes of farmers and climate knowledge of the farmers; 27 variables were positively and significantly influencing the climate knowledge but not all the 27 variables correlated are similar to that of coastal district, Kendrapara. However, education level was also having the highest correlation with climate knowledge. The highest indirect effect on climate knowledge of farmers was from gross cultivated area (GCA) followed by gross irrigated area (GIA) and personal cosmopolite information sources use. There was a negative indirect effect of gross irrigated area on the climate knowledge of farmers indicating that the farmers having irrigation facilities were less concerned about climate change causes and consequences. It is interesting to note here that total effect (evidently from correlation coefficient value) and direct effect (regression coefficient value) of irrigated area of farm households have positive relationship with climate knowledge; however, it has a negative indirect effect on climate knowledge that may be attributed to the fact that having irrigation facilities influence indirectly to have lesser interest and knowledge of the farmers on climate change causes and consequences as irrigation helps them to overcome detrimental effects of drought, and the maximum substantial indirect effect was mediated by gross irrigated area followed by gross cultivated area and education level. Therefore, these variables demand adequate attention during future policy advocacy to improving climate knowledge of farm households in drought prone regions.

## 4 Discussion

The management and preventive measures must consider the target of climate change processes, i.e., farmers and their associated socio-economic, socio-personal and psychological factors.

**Table 7** Path analysis between attributes of farm households and their climate knowledge in Kendrapara district

Variables	Total effect	Direct effect	Indirect effect	Substantial indirect effect		
				I	II	III
House type (X1)	0.465	−0.006	0.471	0.280 (X22)	0.134 (X8)	−0.132 (X16)
Communication devices (X2)	0.366	0.158	0.208	0.188 (X22)	−0.104 (X16)	−0.084 (X11)
Electricity connection (X3)	0.289	−0.031	0.320	0.242 (X22)	0.091 (X8)	−0.063 (X15)
Conveyance (X4)	0.252	0.08	0.172	0.167 (X22)	−0.121 (X16)	0.097 (X26)
Farm machinery and implements (X5)	0.241	−0.087	0.328	0.206 (X22)	0.121 (X26)	−0.125 (X16)
Water source (X6)	0.138	−0.001	0.139	0.110 (X22)	0.087 (X26)	0.064 (X23)
Road connectivity (X7)	0.093	−0.02	0.113	0.082 (X22)	0.081 (X26)	−0.059 (X16)
Sanitation facility (X8)	0.503	0.234	0.269	0.291 (X22)	−0.106 (X16)	0.101 (X23)
Cooking facility (X9)	0.182	0.04	0.142	0.076 (X26)	0.069 (X22)	0.058 (X23)
Social recognition (X10)	0.463	0.077	0.386	0.291 (X22)	0.138 (X8)	0.124 (X23)
Social participation (X11)	0.346	−0.178	0.524	0.282 (X22)	0.142 (X26)	−0.134 (X16)
Social cohesiveness (X12)	0.321	−0.148	0.469	0.304 (X22)	0.091 (X8)	−0.075 (X11)
Participation in community initiatives (X13)	0.235	0.027	0.208	0.208 (X22)	0.129 (X26)	−0.103 (X11)
Accessibility to common facilities (X14)	0.155	0.019	0.136	0.094 (X22)	0.091 (X26)	−0.082 (X16)
Economic status (X15)	0.419	−0.164	0.583	0.346 (X22)	0.131 (X8)	−0.115 (X16)
Annual family income (X16)	0.453	−0.222	0.675	0.332 (X22)	0.127 (X26)	0.112 (X8)
Sources of income (X17)	0.230	−0.053	0.283	0.176 (X22)	0.128 (X26)	−0.074 (X11)
Annual family expenditure (X18)	0.448	0.047	0.401	0.324 (X22)	−0.178 (X16)	0.109 (X26)
Household savings (X19)	0.375	0.121	0.254	0.245 (X22)	−0.171 (X16)	0.124 (X26)
Credit behaviour (X20)	−0.050	−0.081	0.031	0.029 (X11)	−0.019 (X2)	0.017 (X15)
Insurance facilities (X21)	0.418	0.108	0.310	0.254 (X22)	−0.124 (X16)	0.098 (X23)
Education level (X22)	0.680	0.586	0.094	−0.125 (X16)	0.121 (X23)	0.116 (X8)
Mass media use (X23)	0.599	0.187	0.412	0.380 (X22)	0.127 (X8)	0.124 (X26)
Personal cosmopolite information sources use (X24)	0.431	−0.108	0.539	0.308 (X22)	0.157 (X26)	−0.139 (X16)
Personal localite information sources use (X25)	0.354	−0.012	0.366	0.213 (X22)	0.145 (X26)	0.115 (X23)
Information availability (X26)	0.407	0.25	0.157	0.237 (X22)	−0.112 (X16)	−0.101 (X11)
Participation in training and extension (X27)	0.521	−0.065	0.586	0.341 (X22)	0.178 (X26)	−0.141 (X16)
Extent of suffering (X28)	0.031	0.046	−0.015	0.040 (X22)	−0.039 (X15)	−0.036 (X26)
Farm size (X29)/ GCA (X30)/ GIA (X31)	0.259	0.004	0.255	0.222 (X22)	0.120 (X26)	−0.089 (X16)
Livestock holding (X32)	0.345	0.017	0.328	0.182 (X22)	−0.091 (X16)	0.073 (X23)
Size of water body (X33)	0.298	0.226	0.072	0.110 (X22)	−0.066 (X16)	−0.021 (X15)
Residual	0.358					

These factors greatly affect the attitude, perception and practices of farmers in a way how they act during climate crisis and the way they perceive climate change causes and consequences (Fahim and Sikder 2022). It has been since over a decade that climate change and climate knowledge have been related and studied from many aspects (Lubos and Lubos 2019; Alam et al. 2016; William and Hardison 2013; Crona et al. 2013; Anik and Khan 2012), what has been still nearly under-addressed is the fact that all farmers are not alike (in terms of background, social dynamics, demographics and so on), all of them are not perceiving climate knowledge in similar ways, all of them are not experiencing similar level of climate crisis and above all the factors contributing to their climate knowledge and awareness are not alike (Hesam et al. 2021). Thus, it becomes very crucial to address these dynamic differences.

Studying the relational and functional relationship between dependent and independent variables provides an impetus for capacity building and policy advocacy for the future. In the present context, it has been studied in a varied agro-ecosystem which is exposed to different types of climatic maladies (flood and cyclone prone coastal region and drought prone non-coastal region). The cross-sectional results from the present study suggest that coastal ecosystems have a better climate knowledge level than the non-coastal ecosystems. However, this study provides an additional mile in identifying that not every stratum of farmers is bearing similar level of climate knowledge. Crop + livestock farmers bear the highest climate knowledge even though it is not a dominant livelihood group in both coastal and non-coastal regions. Crop farmers have lower climate knowledge followed by livestock farmers;

**Table 8** Path analysis between attributes of farm households and their climate knowledge in Dhenkanal district

Variables	Total effect	Direct effect	Indirect effect	Substantial indirect effect		
				I	II	III
House type (X1)	0.385	−0.044	0.429	0.523 (X31)	−0.504 (X30)	0.366 (X22)
Communication devices (X2)	0.413	−0.119	0.532	0.587 (X31)	−0.573 (X30)	0.328 (X22)
Electricity connection (X3)	0.111	0.036	0.075	0.240 (X31)	−0.233 (X30)	−0.116 (X16)
Conveyance (X4)	0.522	0.13	0.392	0.830 (X31)	−0.802 (X30)	0.341 (X22)
Farm machinery and implements (X5)	0.635	0.089	0.546	1.186 (X31)	−1.144 (X30)	0.394 (X22)
Water source (X6)	0.423	−0.029	0.452	1.223 (X31)	−1.193 (X30)	0.244 (X22)
Road connectivity (X7)	0.278	0.000	0.278	−0.243 (X30)	0.240 (X31)	0.202 (X22)
Sanitation facility (X8)	0.380	−0.123	0.503	0.700 (X31)	−0.673 (X30)	0.340 (X22)
Cooking facility (X9)	0.024	−0.004	0.028	0.302 (X31)	−0.280 (X30)	−0.102 (X16)
Social recognition (X10)	0.533	0.067	0.466	0.861 (X31)	−0.836 (X30)	0.401 (X22)
Social participation (X11)	0.489	−0.161	0.650	1.043 (X31)	−1.002 (X30)	0.344 (X22)
Social cohesiveness (X12)	0.358	0.086	0.272	0.481 (X31)	−0.474 (X30)	−0.207 (X24)
Participation in community initiatives (X13)	0.534	0.274	0.260	0.517 (X31)	−0.510 (X30)	0.295 (X22)
Accessibility to common facilities (X14)	0.205	−0.121	0.326	0.858 (X31)	−0.823 (X30)	0.241 (X22)
Economic status (X15)	0.320	0.000	0.320	0.481 (X31)	−0.454 (X30)	0.297 (X22)
Annual family income (X16)	0.328	−0.352	0.680	0.834 (X31)	−0.797 (X30)	0.304 (X22)
Sources of income (X17)	0.487	0.142	0.345	0.780 (X31)	−0.748 (X30)	0.302 (X22)
Annual family expenditure (X18)	0.369	0.138	0.231	0.767 (X31)	−0.739 (X30)	0.326 (X22)
Household savings (X19)	0.346	−0.06	0.406	0.741 (X31)	−0.708 (X30)	−0.313 (X16)
Credit behaviour (X20)	0.012	0.067	−0.055	0.085 (X30)	−0.084 (X31)	−0.047 (X13)
Insurance facilities (X21)	0.526	0.068	0.458	1.256 (X31)	−1.210 (X30)	0.407 (X22)
Education level (X22)	0.752	0.623	0.129	0.889 (X31)	−0.867 (X30)	−0.279 (X24)
Mass media use (X23)	0.527	0.194	0.333	0.808 (X31)	−0.787 (X30)	0.386 (X22)
Personal cosmopolite information sources use (X24)	0.467	−0.453	0.920	1.136 (X31)	−1.102 (X30)	0.384 (X22)
Personal localite information sources use (X25)	0.454	−0.048	0.502	1.038 (X31)	−1.008 (X30)	−0.341 (X24)
Information availability (X26)	0.568	0.363	0.205	0.944 (X31)	−0.919 (X30)	0.348 (X22)
Participation in training and extension (X27)	0.588	−0.011	0.599	1.163 (X31)	−1.123 (X30)	0.389 (X22)
Extent of suffering (X28)	−0.168	0.002	−0.170	−0.564 (X31)	0.532 (X30)	0.161 (X16)
Farm size (X29)	0.516	0.207	0.309	1.561 (X31)	−1.506 (X30)	0.327 (X22)
Gross cultivated area (X30)	0.526	−1.566	2.092	1.623 (X31)	0.345 (X22)	−0.319 (X24)
Gross irrigated area (X31)	0.519	1.625	−1.106	−1.564 (X30)	0.341 (X22)	−0.317 (X24)
Livestock holding (X32)	0.046	−0.116	0.162	0.166 (X22)	−0.145 (X16)	0.132 (X30)
Size of water body (X33)	0.076	0.046	0.030	−0.104 (X16)	0.085 (X22)	0.064 (X30)
Residual 0.206						

however, both at below average level. In the highly vulnerable coastal district of Balasore and non-coastal district of Khurda in climatically vulnerable eastern Indian state of Odisha, past research has reported that most of the farmers are aware about climate change issues; however, their climate knowledge is less than average with 46.60% and 45.33%, respectively. In both the districts, relatively higher climate knowledge level is found with respect to irregular and erratic rainfall followed by change in length of season, changes in intensity and frequency of storm, cyclone, etc., increase in temperature, changes in water level, phenomena of heavy flood, occurrence of extreme events like cold wave, heat wave, heavy fog, etc. with mean knowledge score more than the average; the least known

phenomena are found as increased melting down of glacier, increase in sea water level and no awareness about phenomena of reduction of snowfall (Das and Ghosh 2020). Findings of the present study have a similarity with the study implications suggested by Sarkar and Padaria (2015) in the state of Rajasthan (western arid region of India) that reported the farmers are very poorly informed about recent changes in climate and its impacts on agriculture. In another study conducted by the same researchers in Shimla and Kullu districts of Himachal Pradesh, north Indian hilly state, only 22% of the farmers have climate change knowledge in the area, while 43% have knowledge about diverse human-induced causes of climate change. The low knowledge level of the farmers suggests a need of

intensive extension and agro advisories for capacity building and climate information empowerment of the farmers. Similar to the present study in climatically vulnerable eastern Indian state of Odisha, farmers in Tamil Nadu, a South Indian state, have perceived climate variability, and have knowledge on climate change consequences being critical factors of cultivation like increasing temperature, delayed onset of monsoon, intermittent dry spells and decreasing soil moisture (Dhanya and Ramachandran 2016). Farmers may not be having climate knowledge especially with respect to causes of climate change like global warming; however, they are very much knowledgeable about the consequences of climate change like erratic rainfall, fluctuating temperature, shifting of cropping season, increased frequencies of extreme climatic events like cyclones, floods, droughts, heat waves, cold waves, cloud bursts, etc. (Das and Ghosh 2020; Sarkar and Padaria 2015). This differential knowledge of farmers regarding climate change causes and consequences may be attributed to the fact that climate change consequences are observable and directly effecting the farming operations, production and farm livelihoods. It is reported that temperature variation, drought, flood, cyclone and heat waves explain between 15 and 35% of yield variation in wheat, oilseeds, and coarse grains in India (Pathak et al. 2012; Swaminathan 2009). Das et al. (2020a, b) observed that agricultural scenario index values of districts of Odisha are influenced by extreme climatic events; the occurrences of cyclone and flood in coastal districts and drought and heat wave in non-coastal districts in certain years hamper agricultural performances, and the districts having relatively lesser degree of decrease in index values in calamity years indicate better resilience. So, now it becomes further important to look in-depth into the determinants of climate knowledge of the farmers.

The regression and path analyses in the present study identified important determinants of climate knowledge which is contrasting in two different districts. From the findings of the present study, it can be confirmed that farmers differ in their climate knowledge level across different livelihood groups and regions. Even though relatively smaller distance but varied topography, exposure to climate change events, infrastructural development and societal factors have a profound effect on farmers' perception and knowledge about climate change (Hesam et al. 2021). Climate knowledge of the farmers is factored both directly and indirectly by their attributes like education level, information availability, and annual family income in coastal region; while it is directly as well as indirectly influenced by educational level and personal cosmopolite information sources use in non-coastal region. Similar results were reported by Sarkar et al. (2014) in their study, where various social variables like education, perception, social participation and psychological variable like attitude, value and awareness were correlated positively with climate knowledge of farmers of the Rajasthan, arid state of western India; however, age, income, area, pessimism and stress were negatively correlated to their knowledge level. In the

Central Indian state of Madhya Pradesh, education, family type, income, and farming experience have factored farmers' perceptions of climate change (Kawadia and Tiwari 2017). Khanal et al. (2018) reported key socio-economic factors influencing farmers' participation in climate change adaptation programmes in Nepal, namely, farmers' proximity to government extension services, land holding, family labour contribution, farmers' habitat in drought or flood-prone regions and farmer's knowledge on changed climate. Farmers' preferences and willingness to pay for climate-smart agricultural technologies on rice production in Nigeria were significantly predicted by farmers' age, gender, education, social participation, access to credit, farm size, and extension visit (Anugwa et al. 2021). Study by Pandey et al. (2018) confirmed that farmers' perceptions on climate change was not limited to the facts related to climate change, rather it also included their exposure, previous experience and other socio-psychological factors. Thus, social, economic, communication and psychological profile of farmers is important for climate change adaptation and mitigation policy advocacy.

The low knowledge and awareness level of the farmers suggest a need for intensive extension and communication programme for their capacity building and information empowerment. An integrated approach of including mass media along with government and other departments' policy advocacy can help in tackling the issue of lack of awareness and low capacity for facing climate-induced challenges (Guofeng et al. 2018). Weak institutional mechanisms as well as financial and managerial difficulties confronted by farmers in adaptation and coping with climate change impact call for integration of farmers' knowledge and location specific adaptation strategies with national level planning to climate change adaptation (Hameso 2018; Rijal et al. 2021). Similarly, Ferdushi et al. (2019) reported that extending knowledge workshops, adding local institutions and local infomediaries for knowledge and awareness dissemination, access to information and training were some of the basic and key areas to enhance farmers' knowledge, perception and adaptation to climate change. To incorporate climate change awareness into daily practices of farmers transforming them as climate citizens, prevailing farming community norms and values need to be considered by the policy makers; farmers need to be rewarded as well for their adaptive measures (Flemsæter et al. 2018). Thus, for a policy maker, it would be crucial to consider the social, economic, communication and psychology dimensions of farm households for formulation and implementation of climate change adaptation and mitigation strategies.

## 5 Conclusion and recommendations

Climate knowledge has a greater say over the extent of vulnerability and post-threats from any climatic vagary. Overall climate knowledge of coastal farmers was better than



non-coastal farmers indicating flood and cyclone hit areas make farmers more aware about the local causes and consequences of climatic hazards. This also confirms an inherent factor of their higher exposure to such maladies driving their attitude and perception towards the knowledge items favourably. Also, various livelihood groups differed in their climate knowledge level in both the districts. For both the districts, irrespective of type of climatic crisis, education level was having the strongest correlation with climate knowledge, thus conclusive that the higher the educational level, the better is their climate knowledge.

In a coastal ecosystem, attributes like communication devices, sanitation facility, social participation, annual family income, household savings, education level, mass media use, information availability and size of water body largely drive climate knowledge, and from regression and path analysis, it was explicit that annual family income followed by participation in training and extension along with education level of the farmers and information availability variables are revealed to have direct effect and indirect effect on the climate knowledge of the farmers demanding the utmost attention for future policy advocacy in improving climate knowledge of the farmers that will shield them from climate adversities.

In a non-coastal ecosystem attributes like conveyance, sanitation facility, participation in community initiatives, accessibility to common facilities, annual family income, sources of income, credit behavior, education level, personal cosmopolite information sources use, information availability and farm size are driving variations in climate knowledge of farmers, and path analysis unraveled climate knowledge of farmers being affected by gross cultivated area (GCA) followed by gross irrigated area (GIA), personal cosmopolite information sources use and education level. Therefore, these dimensions demand adequate attention during future policy advocacy to improving climate knowledge of farm households in non-coastal climatically vulnerable regions.

The novelty of this research contributes a climate knowledge test that is developed to determine the knowledge level of farmers on the context of climate change causes and consequences, and to the policy advocacies to enhance climate knowledge so as to act as a shield for climatically vulnerable farm households. Climate knowledge test developed may be applied to similar agro-ecosystems by the future researchers as well as extension and agro-advisory providers.

**Author contribution** All authors contributed to the study conception and design. UD wrote the first draft of the manuscript. MAA wrote the discussion part. SG performed the inferential and relational statistical analysis for the present study. All authors provided their valuable insights on previous versions of the manuscript. All authors read and approved the final manuscript.

**Funding** The corresponding author was a fellow of Indian Council of Social Science Research (ICSSR) and this research work was

undertaken as a part of doctoral research work by the corresponding author under the fellowship grant provided by ICSSR which is acknowledged.

**Data availability** The datasets generated during and/or analysed during the current study are not publicly available due to individual privacy but are available from the corresponding author on reasonable request.

## Declarations

**Consent for publication** All the authors have agreed to the present version of manuscript and have no objection for its publication. The authors wish to comply (after acceptance) ONLY for subscription access and NOT open access.

**Competing interests** The authors declare no competing interests.

## References

- Alam GMM, Alam K, Mushtaq S (2016) Influence of institutional access and social capital on adaptation decision: empirical evidence from hazard-prone rural households in Bangladesh. *Ecol Econ* 130:243–251
- Anugwa IQ, Onwubuya EA, Chah JM, Abonyi CC, Nduka EK (2021) Farmers' preferences and willingness to pay for climate-smart agricultural technologies on rice production in Nigeria. *Clim Policy*. <https://doi.org/10.1080/14693062.2021.1953435>
- Anik SI, Khan MASA (2012) Climate change adaptation through local knowledge in the north eastern region of Bangladesh. *Mitig Adapt Strateg Glob Chang* 17(8):879–896
- Aryal JP, Sapkota TB, Rahut DB, Marenja P, Stirling CM (2021) Climate risks and adaptation strategies of farmers in East Africa and South Asia. *Sci Rep* 11(1):1–14. <https://doi.org/10.1038/s41598-021-89391-1>
- Bahinipati CS (2014) Assessment of vulnerability to cyclones and foods in Odisha, India: a district-level analysis. *Curr Sci* 107(12):1997–2007
- Birthal PS, Khan MJ, Negi DS, Agarwal S (2014) Impact of climate change on yields of major food crops in India: implications for food security. *Agric Econ Res Rev* 27:145–155
- Branca G, Arslan A, Paolantonio A, Grever U, Cattaneo A, Cavatassi R, ... Vetter S (2021) Assessing the economic and mitigation benefits of climate-smart agriculture and its implications for political economy: a case study in Southern Africa. *J Clean Prod* 285:125161
- Crona B, Wutich A, Gartin M (2013) Perceptions of climate change: linking local and global perceptions through a cultural knowledge approach. *Clim Chang* 119(2):519–531
- Das U, Ansari MA (2021) The nexus of climate change, sustainable agriculture and farm livelihood: contextualizing climate smart agriculture. *Clim Res* 84:23–40
- Das U, Ghosh S (2018) Livelihood sensitivity matrix: a novel technique for mapping vulnerability of rural households to climate change. *Indian J Ext Educ* 54(4):201–205
- Das U, Ghosh S (2019) Contrasting resilience of agriculture to climate change in coastal and non-coastal districts of Odisha. *Indian J Agric Sci* 89(5):769–774
- Das U, Ghosh S (2020) Factors driving farmers' knowledge on climate change in a climatically vulnerable state of India. *Nat Hazards* 102(3):1419–1434
- Das U, Ansari MA, Kameswari VLV, Bhardwaj N (2020a) Developing knowledge tool using computer aided personal interview technique for assessing the climate knowledge of farmers of Odisha. *J Commun Mobil Sustain Dev* 15(3):661–667

- Das U, Ghosh S, Mondal B (2020b) Resilience of agriculture in a climatically vulnerable state of India. *Theor Appl Climatol* 139:1513–1529
- DFID (1999) Sustainable livelihoods guidance sheets. Department for International Development (DFID), London. [www.ennonline.net/attachments/871/dfid-sustainable-livelihoods-guidance-sheet-section1.pdf](http://www.ennonline.net/attachments/871/dfid-sustainable-livelihoods-guidance-sheet-section1.pdf)
- Dhanya P, Ramachandran A (2016) Farmers' perceptions of climate change and the proposed agriculture adaptation strategies in a semi-arid region of south India. *J Integr Environ Sci* 13(1):1–18
- ECA (2009) Shaping climate-resilient development: a framework for decision-making. Report of the Economics of Climate Adaptation (ECA) Working Group, a partnership of Climate Works Foundation, Global Environment Facility, European Commission, McKinsey & Company, The Rockefeller Foundation, Standard Chartered Bank, and Swiss
- Eckstein D, Künzel V, Schäfer L (2021) Global climate risk index 2020: who suffers most from extreme weather events? Weather-related loss events in 2018 and 1999 to 2018, Germanwatch, Bonn. Retrieved from [https://www.developmentaid.org/api/front-end/cms/file/2021/03/Global-Climate-Risk-Index-2021\\_1.pdf](https://www.developmentaid.org/api/front-end/cms/file/2021/03/Global-Climate-Risk-Index-2021_1.pdf). Accessed 15 Jan 2022.
- Flemsæter F, Bjørkhaug H, Brobak J (2018) Farmers as climate citizens. *J Environ Plan Manag* 61(12):2050–2066
- FAO (2013) Climate-smart agriculture: source book. Food and Agriculture Organization of the United Nations, Rome. <http://www.fao.org/3/a-i3325e.pdf>. Accessed 15 Jan 2022
- FAO (2017) Sustainable Development Goals. Food and Agriculture Organization of the United Nations. Retrieved from: <http://www.fao.org/sustainable-development-goals/goals/goal-13/en/>. Accessed 15 Jan 2022
- Fahim TC, Sikder BB (2022) Exploring farmers' perception of climate-induced events and adaptation practices to protect crop production and livestock farming in the Haor area of north-eastern Bangladesh. *Theor Appl Climatol* 148:441–454. <https://doi.org/10.1007/s00704-021-03907-3>
- Ferdushi KF, Ismail MT, Kamil AA (2019) Perceptions, knowledge and adaptation about climate change: a study on farmers of Haror areas after a flash flood in Bangladesh. *Climate* 7:85
- Guofeng Z, Dahe Q, Jiawen R et al (2018) Assessment of perception and adaptation to climate-related glacier changes in the arid Rivers Basin in northwestern China. *Theor Appl Climatol* 133:243–252. <https://doi.org/10.1007/s00704-017-2181-y>
- Hameso S (2018) Farmers and policy-makers' perceptions of climate change in Ethiopia. *Clim Dev* 10(4):347–359
- Hesam M, Roshan G, Grab SW et al (2021) Comparative assessment of farmers' perceptions on drought impacts: the case of a coastal lowland versus adjoining mountain foreland region of northern Iran. *Theor Appl Climatol* 143:489–503. <https://doi.org/10.1007/s00704-020-03432-9>
- IPCC (2019) Land-climate interactions. In: Shukla PR, Skea J, Buendia EC, Masson-Delmotte V and others (eds) Climate change and land: an IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Summary for Policymakers. IPCC, Geneva
- IPCC (2021) Climate change 2021: the physical science basis. In: Masson-Delmotte V, Zhai P, Pirani A, Connors SL, Péan C, Berger S, Zhou, B. Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change. Cambridge University Press. [https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC\\_AR6\\_WGI\\_SPM\\_final.pdf](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf). Accessed 15 Jan 2022.
- Kanter DR, Musumba M, Wood SLR, Palm C (2018) Evaluating agricultural trade offs in the age of sustainable development. *Agric Syst* 163:73–88
- Karki S, Burton P, Mackey B (2020) The experiences and perceptions of farmers about the impacts of climate change and variability on crop production: a review. *Clim Dev* 12(1):80–95
- Kawadia G, Tiwari E (2017) Farmers' perception of climate change in Madhya Pradesh. *Area Dev Policy* 2(2):192–207
- Khanal U, Wilson C, Lee B, Viet-Ngu H (2018) Smallholder farmers' participation in climate change adaptation programmes: understanding preferences in Nepal. *Clim Policy* 18(7):916–927
- Kuder GF, Richardson MW (1937) The theory of the estimation of test reliability. *Psychometrika* 2(3):151–160
- Kumar KK, Patwardhan SK, Kulkarni A, Kamala K, Rao KK, Jones R (2011) Simulated projections for summer monsoon climate over India by a high-resolution regional climate model (PRECIS). *Curr Sci* 101:312–326
- Lemos MC, Morehouse B (2005) The co-production of science and policy in integrated climate assessments. *Glob Environ Chang* 15:57–68
- Lemos MC, Rood R (2010) Climate projections and their impact on policy and practice. *Wiley Interdiscip Rev Clim Chang* 1:670–682
- Lubos LC, Lubos LC (2019) Knowledge, practices, and action on climate change and environmental awareness of the twenty-two villages along the river banks in Cagayan de Oro City, Philippines: PART II. *Acta Sci Agric* 3(2):114–125
- Mehta P (1958) A study of communication of agricultural information and the extent of distortion occurring from district to village level workers in selected I.A.D.P. Districts. Ph. D. Thesis, The University of Udaipur, Rajasthan
- Mohapatra M (2012) Classification of cyclone hazard prone districts of India. *Nat Hazards* 63(3):1601–1620
- Narayanan K, Sahu SK (2016) Effects of climate change on household economy and adaptive responses among agricultural households in eastern coast of India. *Curr Sci* 110(7):1240–1249
- Pandey R, Kumar P, Archie KM, Gupta AK, Joshi PK, Valente D, Petrosillo I (2018) Climate change adaptation in the western-Himalayas: household level perspectives on impacts and barriers. *Ecol Indic* 84:27–37
- Pathak H, Aggarwal PK, Singh SD (eds) (2012) Climate change impact, adaptation and mitigation in agriculture: methodology for assessment and applications. Indian Agricultural Research Institute, New Delhi
- Ramborun V, Facknath S, Lalljee B (2020) Moving toward sustainable agriculture through a better understanding of farmer perceptions and attitudes to cope with climate change. *J Agric Educ Ext* 26(1):37–57
- Rao CAR, Raju BMK, Rao AVMS, Rao KV, Rao VUM, Ramachandran K, Venkateswarlu B, Sikka AK, Rao MS, Maheswari M, Rao CS (2016) A district level assessment of vulnerability of Indian agriculture to climate change. *Curr Sci* 110(10):1939–1946
- Rijal S, Gentle P, Khanal U, Wilson C, Bhagawat R (2021) A systematic review of Nepalese farmers' climate change adaptation strategies. *Clim Policy*. <https://doi.org/10.1080/14693062.2021.1977600>
- Sarkar S, Padaria RN (2015) Measuring farmers' awareness and knowledge level about climate change and formulating future extension strategies. *Indian Res J Ext Educ* 15(1):107–111
- Sarkar S, Padaria RN, Vijayaragavan K, Burman RR, Pathak H, Kumar P, Jha GK (2014) Assessing the socio-economic impacts of climate change in arid ecosystem of India. *Range Manag Agrofor* 35(2):249–255
- State of India's Environment (2021) In figures. A down to earth annual. <https://www.cseindia.org/state-of-india-s-environment-2021-10694>. Accessed 10 June 2021
- Swaminathan MS (2009) Building climate awareness at the grassroots level. In: United Nations Climate Change Conference, 7 to 18 December, 2009

- Tzemi D, Breen J (2019) Climate change and the agricultural sector in Ireland: examining farmer awareness and willingness to adopt new advisory mitigation tools. *Clim Policy* 19(5):611–622
- United Nations Educational Cultural and Scientific Organization (UNESCO) (2010) The UNESCO climate change initiative: climate change education for sustainable development
- Wendling ZA, Emerson JW, de Sherbinin A, Esty DC (2020) Environmental performance index. Yale Center for Environmental Law & Policy, New Haven. [epi.yale.edu](http://epi.yale.edu)
- Williams T, Hardison P (2013) Culture, law, risk and governance: contexts of traditional knowledge in climate change adaptation. In *Climate Change and Indigenous Peoples in the United States*, Springer, Cham, pp 23–36
- World Food Programme (2011) Climate change and hunger: towards a WFP policy on climate change. WFP, Rome
- Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.
- Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.