Climate and Development

ISSN: 1756-5529 (Print) 1756-5537 (Online) Journal homepage: https://www.tandfonline.com/loi/tcld20

Assessing differential vulnerability of communities in the agrarian context in two districts of Maharashtra, India

Bhavana Rao Kuchimanchi, Divya Nazareth, Ramkumar Bendapudi, Suchita Awasthi & Marcella D'Souza

To cite this article: Bhavana Rao Kuchimanchi, Divya Nazareth, Ramkumar Bendapudi, Suchita Awasthi & Marcella D'Souza (2019) Assessing differential vulnerability of communities in the agrarian context in two districts of Maharashtra, India, Climate and Development, 11:10, 918-929, DOI: 10.1080/17565529.2019.1593815

To link to this article: https://doi.org/10.1080/17565529.2019.1593815

CLIMATE AND DEVELOPMENT
2019, VOL. 11, NO. 10, 918–929
https://doi.org/10.1080/17565529.2019.1593815

Assessing differential vulnerability of communities in the agrarian context in two districts of Maharashtra, India

Bhavana Rao Kuchimanchi, Divya Nazareth, Ramkumar Bendapudi, Suchita Awasthi and Marcella D'Souza

Watershed Organisation Trust, Pune, Maharashtra, India – Partner within ASSAR-CAARIA

ABSTRACT

Climate variability causes multiple difficulties to rural poor. The loss in agriculture production is the most predominant impact among many, especially in drought-prone regions of India. Aggravating this further are the non-climatic risks like depletion of groundwater, land fragmentation, lack of post-harvest structures and disappearing and deteriorating common property resources among many others. Within this context, the current study presents how agrarian livelihoods in rural Maharashtra has been transforming to adapt to both the changing climate and non-climatic drivers. A community engaging vulnerability assessment tool was used to explore the climate risks and vulnerabilities of different social groups. Insights indicate that vulnerability is socially differentiated and across farmer categories and social groups. Caste and social standing play a significant role in access to resources, land ownership, livelihoods choices and approaches – impacting their vulnerability to climate change. The study concludes that vulnerability assessments need to be conducted at lower scales, as climate risks vary even within small clusters of villages. This understanding helps designing programmes and policies that build adaptive capacities of rural poor and thus recommends integrating community engagement into academic research is critical.

ARTICLE HISTORY
Received 4 January 2018
Accepted 28 February 2019

KEYWORDS
Vulnerability assessment; climate risks; Semiarid regions; differential vulnerability; agriculture

1. Introduction

India is one of the most drought-prone regions of the world; about 69 per cent of its geographical area falls under dryland (arid, semi-arid and dry sub-humid), which receives less than 750 mm rainfall (Ajai, Arya, Dhinwa, Pathan, & Ganesh, 2009; Banerjee, 2014). These regions are characterized with a high populace mainly dependent on livelihoods sensitive to climate perturbations and witness to frequent fluctuations in agricultural production and therefore in incomes (Bizikova, Parry, Karami, & Echeverria, 2015; Brown et al., 2018). High dependence on climate-sensitive sectors, limited infrastructure, volatile markets, poor socio-economic and low biophysical status of the habitat makes the rural poor most vulnerable to climate change (Banerjee, 2014; Safriel & Adeel, 2005; Singh et al., 2017).

Adaptation to climate variability and change is not a new phenomenon and can be traced to previous generations owing to natural variability in climate, but adaptive capacities could come under strain due to an accelerated rate of change in local rainfall and temperature regimes (Adger, Huq, & Brown, 2003). There is a consensus in current climate change literature that climate change is only one process among other multi-scalar processes that ultimately determine vulnerability (Sugden et al., 2014). Vulnerability is now understood as a series of causal linkages where changes in the biophysical environment interact with socio-economic factors to cause vulnerability (Huq et al. 2015; Ramprasad, 2018). While vulnerability stems from climate perturbations, it is sustained and aggravated by social stratification inherent particularly in agrarian economies of developing nations. The framing of societal vulnerability is thus located in the context of socio-ecological processes (Crane, Roncoli, & Hoogenboom, 2011; Mikulewicz, 2017). Even within a region experiencing similar characteristics of climate change, the impacts are likely to vary because some ecosystems, sectors and social groups are more vulnerable than other groups (O'Brien et al., 2004). The impacts of climate change are transformed into differentiated outcomes through socio-economic structures defined by social or political identities, age, gender, accessibility to resources and infrastructure and others (Ribot, 2010; Singh et al., 2017). Skewed access to resources would disproportionately affect the degree of vulnerability experienced by various social groups and could further reinforce unequal social relations (Adger et al., 2003). Even within regions where incomes and adaptive capacities are relatively high, certain groups of people can be particularly vulnerable; these are women, children, and the elderly. In India, formal and informal systems and institutions shape the capabilities differently for men and women and of people from the various communities. For example, the stratified caste system influences the individual's rights to access to resources; people from lower castes form 'the weakest economic segment of rural society with limited access to education and financial institutions, and little effective voice' (Jones & Boyd, 2011; Nielsen & Reenberg, 2010; Simmons & Supri, 1997; Sugden et al., 2014). Current adaptation strategies and differential decision making reflect the ownership and access to both private and public resources and are also indicative of

CONTACT Bhavana Rao Kuchimanchi bhavanarln@gmail.com Watershed Organisation Trust, Pune, Maharashtra, India – Partner within ASSAR-CAARIA

an individuals economic status (Kattumuri et al.2015). Studies have analyzed differential decision making in shaping adaptation actions from the point of view of values (O'Brien & Wolf, 2010), geography (Adger, 2016), culture (Adger, Barnett, Brown, Marshall, & Brien, 2012; Nielsen & Reenberg, 2010), social stratification (Sugden et al., 2014), social institutions (Jakimow, 2013) and power relations and politics (Marino & Ribot, 2012; Nightingale, 2017; Taylor, 2013a; Tschakert, van Oort, St. Clair, & LaMadrid, 2013; Tschakert et al., 2016). While the factors underlying the choice of a particular strategy play out in the broader context of dominant local social processes, they are also strongly influenced by culture (Adger et al., 2012). The latter is largely understudied though they shape modes of production, consumption and lifestyle (Adger et al., 2012, Shackleton, Ziervogel, Sallu, Gill, & Tschakert, 2015). Selection of adaptation strategies entails protecting these current production systems to ensure livelihood security and holding onto social identities (Crane et al., 2011).

In India too, vulnerability studies have focused mainly on how adaptation practices to climate change in agriculture were influenced by a wide range of social factors (Dhanya & Ramachandran, 2015; Jain, Naeem, Orlove, Modi, & DeFries, 2015); but how factors like culture, tradition and indigenous knowledge determine livelihood strategies are limited. Studies on different social groups (Blinman, 2008; Crane et al., 2011; Jones & Boyd, 2011; McCabe, Leslie, & DeLuca, 2010) all show how culture influences how options are assessed, valued, responded to and revealed how dominant social groups respond in an attempt to protect social identities and status even though these decisions could make them worse off (Coulthard, 2008; Nielsen & Reenberg, 2010). The studies show that culture provides a crucial reference point to chart livelihood strategies, which shed light on what strategies are feasible, locally relevant, and have the potential to be upscaled. Such knowledge is also relevant as the erosion of these identities could, in turn, transform into enablers and barriers of effective adaptation in the future (Adger et al., 2012). As adaptation is a dynamic and complicated process, it indicates that that vulnerability assessments need to be conducted at lower scales with more participatory approaches so such insights can be captured.

Vulnerability assessments may be used at multiple scales for which, adaptive planning to reduce climate and non- climate stresses is required. To design feasible and sustainable interventions, that emerge from vulnerability assessments, the analysis must consider the needs of local people, their aspirations as well as their socio-economic context (Banerjee, 2014; Ribot, 2010). The concept of differential vulnerability across social groups, in line with human wellbeing, also needs to be incorporated into adaptation and developmental planning. When vulnerability is viewed from a multi-dimensional perspective, it will help to recognize, arrange, plan and channel the resources to improve the capacity to adapt more effectively (Singh, Bantilan, & Byjesh, 2014). In addition to identifying vulnerable groups and the factors inducing stress, vulnerability assessments need to investigate reasons adaptive capacities are lacking or constrained (Ribot, 2014).

However, in the above context, there is still limited research on socially differentiated vulnerability in India particularly in the perspective of the diverse castes and communities that exist. Given this, objectives of the study are to understand socially differentiated vulnerability to climate risks in selected villages in two districts in Maharashtra state and to examine the past and current strategies employed by the respective groups to manage risks along with the enablers and barriers influencing decision making/ strategies of the various social groups.

Table 1. Characteristics of Representative Villages in the study.

Village name	Characteristics	Demographic Profile (%)
Study site –1: Sangamner, Ahmednagar, Maharashtra		
Jawale Baleshwar	Located in the Upper catchment of Mula River, Over exploited groundwater resources, Slight soil erosion, Relatively far from market centre	1027 HH, (FC- 52%; ST- 47%), Landless – 1%, Small and Marginal – 70%, Medium and Large –29%
Khandgedara	Located in Middle catchment of Mula river, Groundwater status safe, Moderate soil erosion, Relatively far from market centre	301, (FC- 70%; ST- 30%), Landless – 9%, Small and Marginal – 41%, Medium and Large –50%
Borban	Located in Lower catchment area of Mula river, Over exploited groundwater resources[a], Severe soil erosion, near market centre (Ghargaon)	812 (OBC- 85%; ST- 15%), Landless – 0%, Small and Marginal –100%, Medium and Large 0%
Study site –2: Aurangabad, Maharashtra		
Kachner Tanda 1	Located in Upper catchment area of the Godavari, Groundwater status is safe, Far from market centre (*Adul* town at a distance of 13 km)	268, (VJNT –100%), Landless – 4%, Small and Marginal – 68%, Medium and Large – 28%
Aurangabad Kachner Tanda 3	Located in Upper catchment area of the Godavari, Groundwater status is safe, Far from market centre (*Adul* town at a distance of 16.5 km)	177; (VJNT - 100%), Landless – 21%, Small and Marginal – 55%, Medium and Large – 24%
Paithan Wanjarwadi	Located in Upper catchment area of the Godavari, Ground water status is safe; Accessibility to Market (4.1 km)	271; (FC- 89%) Landless – 4%, Small and Marginal – 53%, Medium and Large – 44%

Note: HH= Households, FC – Forward Caste, OBC- other backward caste, ST – Schedule Tribe, VJNT- Vimukthi Jathi Nomadic Tribes (*Banjaras*).
[a]Source:Groundwater Surveys Development Agency, Government of Maharashtra.

2. Materials and methods

2.1. The study area

The current study was located in the Sangamner taluka of Ahmednagar district and Aurangabad and Paithan talukas of Aurangabad district, in Maharashtra, India (Figure 1). About a quarter of India's drought-prone districts are in Maharashtra, which has 73% of its geographic area classified as semi-arid and about 84% of the total area under rainfed agriculture (Kalamkar, 2011). Trends indicate that the state could face an increase in rainfall variability, including drought and dry spells, making agriculture particularly vulnerable to climate change (TERI, 2014).

In Sangamner, a cluster of 17 villages covering a contiguous area of 14,604 hectares, inhabited by approximately 3,138

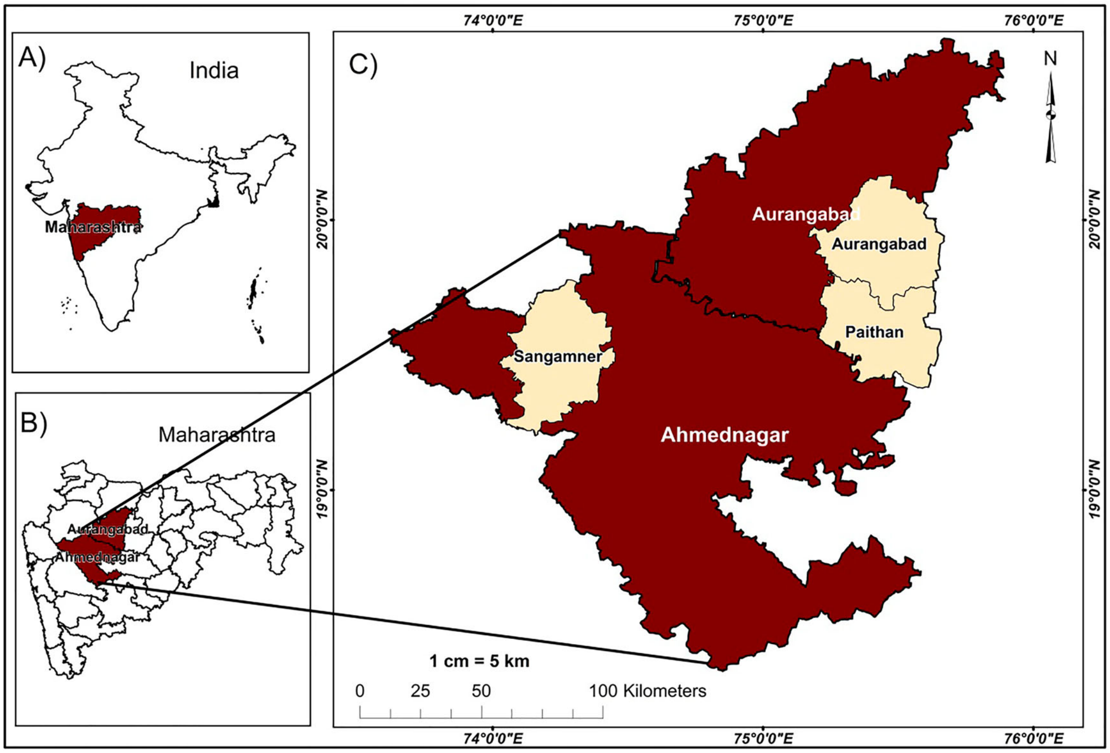

Figure 1. Location of the study.

households was selected for the study. The average annual rainfall in this region is 560.7 mm. Sangamner lies in the rain-shadow belt of Maharashtra, and the selected villages are drought prone with rainfed agriculture. In Aurangabad district, a cluster of 10 villages covering an area of 5,252 hectares having 920 households was selected. These villages are located in the Aurangabad and Paithan talukas, though administratively different, the villages are contiguous having similar conditions. The average annual rainfall in Aurangabad is 725.8 mm.

2.2. Selection of villages

When assessing the vulnerabilities within a landscape, differences in biophysical characteristics of the landscape play a critical function in determining/defining the vulnerability to climate change in a region. Hence, stratified random sampling (based on biophysical characteristics) was used to choose three villages in Ahmednagar and three villages in Aurangabad districts out of a cluster of villages in both locations. The biophysical characteristics include the location of villages within the catchment, topography (slope), soil erosion status, natural vegetation cover, wastelands, water-body spread area, and the groundwater status. In addition to these, accessibility to market though not a biophysical parameter was also considered. In the Sangamner study cluster, the categories differed by the location, i.e. upper, middle and lower catchments of Mula river; while in the Aurangabad-Paitan study cluster, all the villages are located in the upper catchment of Godavari river but differed in the access to markets. Within these two categories, representative villages were randomly selected for assessing their vulnerabilities (Table 1). The villages selected in Sangamner taluka – Jawale Baleshwar Khandgedara and Borban – are located in the upper, middle and lower catchments of river Mula respectively. Borban is nearest to the market centre (3–4 km away) and Jawale Baleshwar farthest (about 32 km away). The subsurface geology of Jawale Baleshwar and Kandgedara villages consists of hard massive basalt lava flow forming an undulating landscape. This limits deepening of existing wells and digging of new wells. It escalates the cost of such activities and is beyond the reach of small and marginal farmers. The main social categories present in the area were Forward Caste category (Maratha), Backward Caste (BC) category (namely, Mali) and a small percentage of Scheduled Tribes (ST) category (Mahadev Koli) in the Sangamner area. In Aurangabad, the social groups were the de-notified tribes called Vimukti Jati Nomadic Tribes (VJNT) category (Banjara) and the Forward Caste category (Rajput).

2.3. Data collection process

The vulnerabilities were assessed using the Community Driven Vulnerability Evaluation –Programme Designer (CoDriVE-PD) tool, which is a participatory tool for assessing vulnerabilities of communities, villages and landscapes to climatic and non-climatic risks for locale-specific adaptation plans. The framework of the tool is based on the following: Driver-Pressure-State-Impact-Response (DPSIR) (EEA, 1999); The UK Department for International Development's Sustainable Livelihoods Framework (DfID, 1999), and the Community Risk Screening Tool: adaptation & livelihoods – CRiSTAL (IISD, 2012).

The application of the tool has four methodological steps (Figure 2). Step 1 builds a vulnerability context to understand changes in the environment and how these changes impact the livelihood of the communities. This step generates information on how livelihoods are changing and identifies the

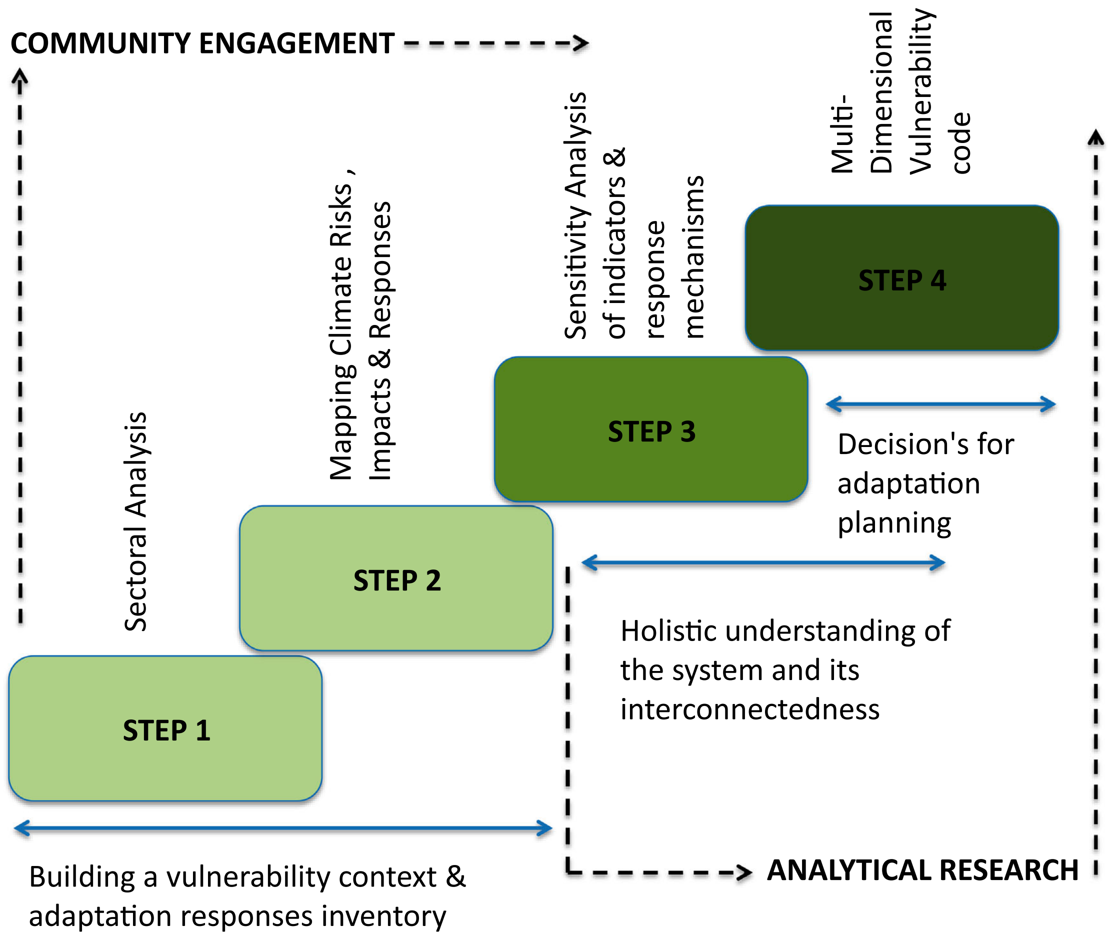

Figure 2. Analytical Framework of CoDriVE-PD Tool.

drivers and pressures that trigger the change. It also identifies the indicators affecting the adaptive capacities of the community. Step 2 maps climate risks, impacts and responses. This involves engaging communities to identify the major climate risks, their impacts and how they respond to the risks the region has been experiencing during the past one decade. The step also involves a contextual understanding of the communities' coping and/or adaptation responses to climatic variability and risks. It helps to identify the responses that reduce or enhance the vulnerabilities of the natural resource base and the community to long-term climatic variations. Step 3 assesses the various indicators that demonstrate the vulnerability of the community. The step involves perception based scoring of the indicators under five livelihood capitals on a scale of 1–5 for all the social categories. The scores are then validated using information from the baseline survey, census data and other secondary sources. The vulnerability scores are very high vulnerability −1, high vulnerability −2, medium vulnerability −3, low vulnerability −4 and very low vulnerability −5. Finally, step 4 generates the vulnerability code. The indicators obtained from step 3 are grouped into five livelihood capitals. These are: the physical capital (e.g. infrastructure, facilities), financial (e.g. incomes, access to credit, subsidies), natural (e.g. land, livestock, forest, water), human (e.g. access to knowledge inclusive of traditional, skills) and social capital (e.g. institutions, groups and networks). The final scores are derived using the simple average of the scores obtained by the indicators listed in a particular capital. The data was collected through Focus Group Discussions (FGD) accompanied with transect walks followed up by in-depth interviews with few secondary stakeholders as relevant. A total number of 23 FGDs were conducted with both homogeneous and heterogeneous groups in all study villages (Table 2). However, information from only 20 FGDs has been presented in this paper as the focus was on the vulnerability of social groups in the agrarian context. Being a dynamic process, each FGD consisted of an average of 20–25 participants belonging to specific social groups and landholding categories and was held for 2–3 h long. As the aim was to assess socially differentiated vulnerability the participants for each FGD were purposively selected using household lists provided by village heads as well as old baseline surveys reports so that adequate representation of all farmer categories and social groups was ensured. In all villages, as a first round both men, women across all farming and social categories were invited to participate in the FGDs after which again separate FGDs were held with women and some social groups and farmers categories to allow them to express their thoughts more comfortably. The timing of the FGDs was important as this made villagers participate more willingly. Meetings were generally held in the evenings after work hours in places convenient to all social groups, e.g. the village school or committee hall. For women, meetings were held in the afternoon once they were free from their household responsibilities and agriculture wage work – in places where they usually hold their SHG

Table 2. Number of focus group discussions with different categories of farmers and social groups.

Categories of farmers	No.of FGDs	Villages	Composition
Large farmers	1	Jawale Baleshwar	Homogeneous groups of Forward Caste category (*Maratha*)
	1	Kandgedara	Homogenous group -Forward Caste category (*Maratha*)
Medium farmers	2	Wanjarwadi,	100% Homogenous group of Forward Caste (*Rajputs*)
	1	Kachner Tanda 1	100% Homogenous group *VJNT Banjaras*
	1	Kachner Tanda 3	100% Homogenous group *VJNT Banjaras*
Small and marginal Farmers	1	Wanjarwadi	100% Homogenous group of Forward Caste (*Rajputs*)
	1	Kachner Tanda 1 & 3	100% Homogenous group *VJNT Banjaras*
	1	Jawale Baleshwar	Heterogenous groups of both Forward Caste category (*Maratha*) and Scheduled Tribe (ST) category (*Mahadev Koli*), approx 50% representation of both social groups
	1	Kandgedara	Heterogenous groups of both Forward Caste category (*Maratha*) and Scheduled Tribe (ST) category (*Mahadev Koli*) but 60% presence of FCs
	1	Borban	Homogenous group of Backward caste category (namely *Mali* community)
Women	8	All 6 villages	All caste groups mixed
Total number of FGDs	19		
Indepth Interviews	2	Aurgangabad	Bank managers – of a local nationalized banks
	1	Aurgangabad	Govt. officers who handle schemes for SC/ST communities and agriculture
	1	Sangamer	Local agriculture officers

*in some villages additional FGDs needed to be conducted again to reconsolidate certain findings

group meetings or at a group leaders houses familiar to them. Each FGD necessarily had a locally experienced facilitator to help facilitate the discussions.

Summary of all the information was recorded and compiled as village wise reports. Each FGD started with an introduction to the research study its need and concepts of vulnerability to climate change. After setting the context, it moved on to discussing information on the various aspects detailed out in steps 1–3 in the CoDriVE-PD tool explained above. While the FGDs were conducted mainly in homogeneous groups, as in India de-notified tribes such as the *Vimukti Jati Nomadic* (VJNT) or the *Mahadev Kolis* usually stay in habitations outside the main villages. However, villages like *Jawale Baleshwar* and *Khandgedara* heterogeneous FGDs were also possible due to the presence of an equal proportion of both social groups in the village. The FGDs were followed by transect walks across the villages with few village volunteers to understand the issues that were discussed in the FGDs as well as understand the biophysical aspects. As a final step in-depth interviews were also conducted with secondary stakeholders such as local government department officials, local branch managers of formal banking institutions to build the bigger picture and also understand the issues of relational vulnerability.

3. Results and Discussion

3.1. Profile of the social groups:

The farmers were categorized into large farmers (> 4 ha), medium farmers (2–4 ha), small and marginal farmers (< 2 ha) and landless based on land ownership. Historically, land ownership was closely associated with the social groups (caste). In India, the officially recognized social categories include Forward Castes (FC), Backward Castes (BC), Scheduled Castes (SC) and Scheduled Tribes (ST) (Williams et al., 2016). In the study areas, the large and medium landowners mainly belong to the forward castes (*Maratha, Rajput*) and a small per cent are of de-notified tribes, VJNT (*Banjara*). Farmers belonging to small and medium landholding categories include all caste groups namely, STs (*Mahadev Koli*), BCs (*Mali*), FCs (*Rajput*) and VJNT (*Banjara*). In both the regions, farmers belonging to large and medium landholding categories practice water-intensive crop cultivation (horticulture and commercial crops) and dairy production. On the other hand, the small and marginal farmers, except the *Mali*, due to lack of irrigation facilities, practice subsistence farming, rear small ruminants, and depend mainly on wage labour work for sustenance.

In Sangamner, the FC (*Maratha*), BC (*Mali*), ST (*Mahadev Koli*) are the dominant social groups. Farming practices and patterns were similar for all the farmer categories, irrespective of the castes they belonged to, in the past (20–30 years earlier). Agriculture was entirely rain-fed with subsistence crops grown. However, since the last couple of decades, there has been a significant change in the farming system. Agricultural practices among large and medium farmers have become resource intensive with shifts according to crop preferences (horticulture and commercial crops) and dairy production with crossbreds. The BC (*Mali*), owing to their small land holdings have been categorized here as small and medium farmers, stand out distinctly as they have been cultivating pomegranate as a large-scale mono-crop. Livestock ownership among them is negligible. The ST communities (*Mahadev Koli*) too were agriculturists with large landholdings in the past. However, over the years they have become marginal farmers or landless with a majority of them depending on wage labour for a livelihood. They prefer to rear goats over cattle as a support livelihood option.

In Aurangabad, the dominant social groups are the VJNT (*Banjara*) and FC (*Rajput*). The VJNT (*Banjara*) were earlier nomadic, but over three decades, they have settled into agriculture and allied activities. Being a nomadic pastoral tribe, they reared large herds of cattle and goats in the past. They possess good traditional knowledge of animal husbandry. The FC (*Rajput*) community in Aurangabad, on the other hand, is similar to the Maratha of Sangamner regarding farming (focus on cash crops) as well as social status. Bt cotton is currently the most popular commercial crop grown by all farmer groups of Aurangabad in the Marathwada region of Maharashtra, which is an important cotton-producing belt. While the medium farmers cultivate cotton, the small and marginal farmers, particularly the VJNT (*Banjara*) now practice rainfed agriculture, growing food cum fodder crops majorly. The livestock holding among all farmers groups except the *Banjara* have reduced significantly due to declining water resources.

Table 3. Climate risks and responses by different farmer categories/Social groups

Climatic Risks	General responses	Specific Responses –Large and Medium farmers	Specific Responses –Small and Marginal farmers
Rainfall related: Unseasonal, Reduced monsoon rainfall and Prolonged dry spells, Delayed onset of monsoon, High Intensity Rainfall, Reduction in total monsoon	• Increased use of pesticides and fertilizers • Dependence on Government scheme • Increased visits to hospitals • Re-sowing, • Higher seed rates /acre	• Increased expenditure on health care for dairy cattle • Unsustainable abstraction of water (bore wells) • Use improved crop production technologies • Access Schemes to support high value crops • Increased focus on milk production	• Dependence on Markets and Public Distribution System for food needs • Preventive on health care for small ruminants (*VJNT-Banjaras*) • Depend on unskilled wage work • Use of drip irrigation (Large farmers- *BC-Malis*) • Deepening of wells (*VJNT-Banjaras)* • Shift to food cum fodder crops (*VJNT -Banjaras*)
Temperature related: Warmer winters, reducing number of cold days in winter, Increasing temperature in summer	• Use seeds from different seed companies • Depend on middle men • Increased dependence on markets to meet food shortages • Increased expenses on human heath care • Purchasing drinking water	• Choose other commercial crops (Aurangabad only) • Early harvest of cotton • Change crop production practices • Increased usage of fertilizers to ensure productivity. • Reduction in number of dairy cattle (*Rajputs /Banjaras*) • Purchased fodder from market • Investing in new wells and and drip irrigation	• Sell sick animals at lower prices • Seek out to non farm livelihoods • Use of farm yard manure (*VJNT – Banjaras)* • Reduction in dairy cattle (Rajputs/ Banjaras only) • Increased semi intensive goat husbandry (*VJNT-Banjaras)* • Integrating crop and livestock farming, (*VJNT-Banjaras)* • Shift from commercial crops to food crops; • Leave agricultural lands fallow • temporary migration • Building drinking water troughs for livestock (*VJNT-Banjaras)* • retained bullocks to support agriculture (*VJNT-Banjaras)*

3.2. Climate risks, the impact and responses of communities in the study sites

This section summarizes the perception of various climate risks, the impact and responses taken by the communities as discussed during the focus group discussions (Table 3) in both study sites. While all communities identified similar climate risks and impact on them and the environment, the responses (which can also be seen as livelihood choices) to manage these impacts differed among both farmer categories and social (caste) groups they belonged to.

The major climate risks identified by the communities were unseasonal rainfall, reduced monsoon rainfall, increased dry spells during the cropping seasons, delayed onset of monsoons, high-intensity rainfall, warmer winters/ reducing number of cold days in winter and increasing summer temperatures. For the rainfall-related risks, the major impact reported were damage to agriculture crops at different stages (germination, crop harvest stage), drying of the vegetation on common and private lands, reduced water availability in wells (for about 9 months a year or less), fodder shortages, scarcity of drinking water for humans and livestock, breakage of water harvesting structures and houses built of mud/ haystacks. Additionally, during high-intensity rainfall, water stagnation led to a decay of crops in the fields. Unseasonal rainfall, on the other hand, resulted in spoilage of stored grains, morbidity in livestock due to increased humidity levels, and the increased incidence of pest and diseases in crops. In the context of human health, increase in vector-borne diseases including health problems caused by the consumption of spoiled grain and contaminated stored drinking water were reported.

Temperature-related risks were linked to a loss in crop productivity. Communities reported that all crops (wheat, coarse cereals, pomegranate, cotton, onion) are affected in one way or another leading to a decline in production. The otherwise robust sorghum and pearl millet crops also showed reduced productivity and increased pest attacks. The warmer winters also affected the flowering of pomegranate and quality of the onion crop in Sangamner region. Excessive heating up of the soil was also reported to impact the reduction in seed viability and germination. Increasing summer temperature was another important climate risk reported by communities. While excessive heat also caused many of the impacts mentioned above, symptoms of heat stress in humans (Banerjee, 2014) and livestock (reduction in milk production) was also reported to cause several issues. It was more explicit in Aurangabad as compared to Sangamner and more among the small and marginal farmer category, children and the elderly. Increase in indoor temperatures was also stated and could be attributed to the tin roofing, which significantly increases indoor temperature and human health problems (Pradyumna, Bendapudi, Zade, & D'Souza, 2018a; Pradyumna, Bendapudi, Zade, D'Souza, & Tasgaonkar, 2018b).

To manage the impact faced by the climate risks identified, communities adopted several responses. These responses, however, varied among the different farmer categories and social groups indicating their adaptive capacity and vulnerability in context to the five livelihood capitals. The general responses adopted by all farmer categories to both rainfall and temperature related risks in context to crop production were increased use of pesticides and fertilizers, increased seed rates per acre over time, sowing crop multiple times, experiment with different seed companies (particularly in the case of the cotton crop). These measures were primarily to ensure some amount of harvest from the crops sown. To manage the sale of lowered quality of the produce and yields all farmer categories opted to sell to intermediaries to save on transportation costs and cash flow issues. Dependence on government schemes for crop insurance and loan waiver was also reported. Food, fodder and drinking water shortages were managed by depending on markets, and health issues were managed by repeated visit to hospitals.

The differential responses, in context to crop and livestock production, in the case of large and medium farmers in the Sangamner region were shift to milk production, high investments in livestock health care, unsustainable abstraction of water for irrigating crops, application of excessive amounts of fertilizers, accessing schemes to support high value crop production, and improved crop production technologies in vegetable crops. In Aurangabad, though many responses by farmers were similar, some distinct responses were improvising crop management practices in cotton (replacing wheat with cotton in the *rabi* season, harvesting earlier, increasing the crop rotation lengths, adoption of line sowing technique) and reduction in dairy cattle.

The small and marginal farmers on the other had responded differently to the same risks. Food shortages were handled through the governments' public distribution system (PDS) as well as markets for some items. In times of crop failure, skilled and unskilled wage work in others farms were resorted to. To manage water scarcity some resorted to using drip irrigation while others opted for well deepening due to inadequate water to use micro-irrigation. In contrast to the large and medium farmers, this category reduced cultivation of commercial crops and shifted to dual-purpose crops like millets and sorghum to meet their food and fodder needs. In context to livestock rearing, dairy cattle were reduced, small ruminant rearing was enhanced, and bullocks were retained for farming purpose. This strategy was seen more in the VJNT-*Banjaras* compared to the *Rajputs* and also more predominant in Aurangabad compared to Sangamner. In times of distress, morbid goats were sold at lower prices, and croplands would be left fallow temporarily. To manage water scarcity issues for livestock, drinking water troughs were built near municipal water taps to store water for livestock specifically by the VJNT-*Banjaras*.

3.3. Non- climatic risk

In addition to climate stressors, a range of non-climatic factors were identified that were increasing the degree of vulnerability to climate change further.

The first risk was the depletion of groundwater, aggravated by increased groundwater draft due to water-intensive cropping, amid drought-like conditions. Groundwater in recent years has become the primary source of irrigation in both regions. The share of wells in net irrigated area is very high in Sangamner at 92% in 2011–12 (Government of Maharashtra, 2013). According to the Groundwater Survey Development Agency, the status of groundwater in Sangamner has been stated as 'over exploited' (CGWB, 2014) while the Aurangabad district it is relatively moderate to good groundwater potential (CGWB, 2013). In both Sangamner and Aurangabad, large and medium farmers (usually upper caste groups), cultivate water intensive horticulture and vegetable crops along with dairying (only Sangamner) that are sensitive to water stress and variations in temperature. The typical response of this category of farmers, to manage drought-like conditions, was to increase investments in irrigation facilities. This was possible due to their capacity to invest as they had better access to formal credit institutions as well as government schemes that enhance irrigation. The small and marginal farmers, usually lower caste groups, in this context are highly disadvantaged as increased groundwater draft by large and medium farmers, amid climate change and declining productivity has exposed them to a higher degree of vulnerability (Thomas & Duraisamy, 2016).

Additionally, the small and marginal farmers could not invest or benefit from government schemes due to lower landholdings, inability to mobilize funds for own contribution or even own wells in many cases. Most often, they depended on informal credit (private money lenders), which made them even more vulnerable under conditions of repeated crop failures and increasing debts (Datta, Tiwari, & Shylajan, 2018). While farmer suicides were not reported, the situation in the study sites was grave as Taylor (2013b) indicated that farmer suicides in India are directly correlated to failure of borewells (30% of suicides) and medium-term build up of agricultural debts, including irrigation expenses from drilling wells or buying groundwater (about 40% of suicides).

The second risk found impacting the communities in the area was land fragmentation, impacting crop yields and income as it influenced cropping patterns and crop management practices. Fragmentation of land is widespread in India and plays a major role in explaining low levels of agricultural productivity. Average profit efficiencies are higher for unfragmented farms, large farms, or farms with a diversified cropping pattern as compared with their counterparts (Manjunatha, Anik, Speelman, & Nuppenau, 2013). Smallholdings also face new challenges on integration of value chains, globalization effects, market volatility as well as vulnerability and adaptation to climate change (Dev, 2014). In both study sites, farmers from all categories have shifted to mono-crop cultivation with higher crop densities, which makes the farmers vulnerable to increased risks as high plant densities also lead to increased incidence of pest attacks causing widespread crop loss (Schroth, Krauss, Gasparotto, Duart-Aguilar, & Vohland, 2000).

The third risk was the lack of post-harvest infrastructure at both household and community level, which forced farmers especially the small and marginal, to sell their produce immediately at low prices due to the subsequent market saturation. In Aurangabad, all farmers categories across all social groups relied on intermediaries for sale of produce to avoid risks from low yields and poor quality due to land fragmentation. Presence of intermediaries was a win-win option in this case as they not only helped marginal and small farmers sell their produce but saved on transportation costs and delayed payments, which otherwise happen if they sold directly in bigger government markets. As Kumar (2014) articulated that power in agrarian markets (in the case of Soybean) was shaped by a variety of factors that governed the relationship between farmers and intermediaries who purchased their crop; and the very expectation of disintermediation is misleading since it was essential for the value chain to succeed, which was also the case in cotton trade in Aurangabad. Findings also revealed that marginal and small farmers (usually lower caste groups) face the brunt of price oscillations in Indian markets, particularly in the case of perishable products (Ramaswami, Ravi, & Chopra, 2003). The tomato farmers (especially marginal and small farmers) in Sangamner were reported to be worst hit due to market saturation despite Ahmednagar district being the leading producer of horticulture produce mainly, due to lack of post-harvest infrastructure. Since high-value agricultural commodities are perishable and their markets are fragmented, there is high volatility in their prices, and thus highly risky (Thapa, 2009).

The deterioration and loss of Common Property Resources (CPRs) was the fourth risk. CPRs play a vital role in the economic, cultural and social activities of poor rural women and men (Beck & Nesmith, 2001). According to Menon and Vadivelu (2006) about 58 per cent of households with 0.50–1.0 ha landholdings, about 49 per cent of households with 0–0.20 ha landholdings and 62.3 per cent of the landless households depend on CPRs for fuelwood. As Narain and Vij (2016) report the erosion of CPRs in India is not a new phenomenon, and in the recent past, the nature of threats to the commons has changed. Some of these threats are the result of conscious state policy for urban expansion, increased area under cultivation, allocation of protected areas for wildlife while others are the result of illegal encroachments; some of which a relevant to the study area. An important indicator of the reduced productivity of CPRs is the greater time and longer distances required to collect the same quantity, or lesser quantities of CPR products today as compared to the past (Jodha, 1990; Pasha, 1992; Jodha, 1995; Rao, Manikandan, & Filho, 2005), which was the situation in the study sites. All farmer categories in both Sangamner and Aurangabad study areas depended heavily on CPRs for fuelwood, fodder, non-timber forest produce (NTFP) in the past. However, major factors such as the ban on grazing in forests due to the Government Order (GO) issued after the 1972 drought, various development programmes, conversion of grazing lands into reserve forests, expansion of croplands had impacted the magnitude of CPRs both in terms of percentage of geographical area and per capita availability. In response to the lack of grazing resources, the large and medium farmers belonging to upper caste groups reduced rearing indigenous cattle and shifted to dairy cattle under a stall-fed system (Kuchimanchi & Mathur, 2012). The small and marginal farmer categories, on the other hand, reduced their livestock holdings and shifted into a rainfed or mixed crop-livestock system, which, was more subsistence-oriented (predominant with the *Banjaras* and *Mahadev Kohlis*). In the context of fuelwood, in areas where cotton was grown fuelwood was not an issue as the cotton crop residue was used as fuelwood (Aurangabad). In Sangamner scarcity of fuelwood was an issue-affecting women of poorer households significantly. Lack of NTFPs, medicinal plants or other forest-based livelihood options also affected poorer households (particularly women, landless and ST groups) in both regions in the form of loss of food and supplementary income sources. To overcome these situations, communities now depend more on daily wage labour work (both skilled, unskilled, farm and off-farm) for making a livelihood. However, farm-based wage work, being climate sensitive, is also limited in availability increasing their vulnerability further.

3.4. Enablers and barriers

The transforming structures and processes within the sustainable livelihood framework, such as organizations, policies, laws and incentives do shape people's livelihood options. In this section, some transforming processes that have influenced the livelihood capitals are discussed. The key enablers and barriers, found to influence vulnerability or make communities resilient in the study sites were access to credit, soil and water conservation measures, Government subsidies for agriculture & Welfare measures for SC/ST communities, and the Public distribution system (PDS).

A major constraint in the achievement of profitable agriculture is the lack of access to finance by farmers (Bharati, 2018). Concerning access to credit, government crop loans, other specialized schemes financed through nationalized and regional banks were available and accessible to meet the credit needs of farmers. While formal and informal credit facilities were available for all the farmer categories, the large and medium farmers accessed more credit from the banks while the small and marginal farmers relied on the informal credit system (Banerjee, Kamanda, Bantilan, & Singh, 2013); as farmers with larger acreage of land and assured irrigation facilities were perceived positively by lenders while disbursing loans (Pal & Laha, 2014). In both study sites, large and medium farmers (mostly upper caste groups) accessed most of the loans, incidents of non-repayment by some farmers, due to crop loss coupled with crop loan waivers by the government, rendered banks unable to sanction loans to small and marginal farmers. The study brought out the fact that a relational vulnerability exists where it manifests itself particularly in the case of credit access or debt as social relationships (class, caste and gender) consolidate these inequities either allowing certain social groups to shield or profit from the vulnerability of others (Taylor, 2013a). Villages that had good communication (transport) infrastructure had easier access to banks and availed of the services, while those located far off, often resorted to informal credit systems. Furthermore, Datta et al. (2018) found that incidence of indebtedness among marginal and small farmers is the highest (falling in the range of 80–90 per cent) with non-institutional sources being the major lenders. As Sarap (1990) summaries lower bargaining strength, bureaucratic and procedural formalities, the asset-based lending policies, smaller landholdings, illiteracy and lower caste status all work adversely against the rural poor and marginal and small farmers in the context of access to formal credit institutions.

The soil and water conservation measures, taken up as part of watershed development activities by NGOs, increased the groundwater levels and its availability, reducing the impacts of drought like situations. However, in the study area, only where the participatory processes were well implemented all social groups and farmer categories benefitted from the programme. While government subsidies for agriculture & Welfare measures for SC/ST communities were available, only a few small and marginal farmers and SC/ST households have been able to avail of these subsidies due to the governance challenges, demanding terms, conditions and procedures (Banerjee et al., 2013). The Public distribution system, which is a state food supply programme, was a key enabler particularly in the context of small and marginal farmer households. In the study area, community members stated that at present they had access to the timely supply of average quality food grains (wheat and rice) through the system. Villages located far off from the market largely depended on the PDS. In times of scarcity and crop loss, dependence on the PDS increased. The food grains provided were mainly cereals, which did not meet their nutritional needs. The PDS has also suffered from several other limitations, such as leakage, wastage due to inadequate storage facilities, the inclusion of the better-off, corruption at different levels, high administrative costs, poor monitoring systems, lack of accountability and poor beneficiary participation (Gaidhane, 2015; Mane, 2006).

3.5. Assessment of the five capitals and vulnerability to climate and non-climate risks

This section illustrates the vulnerability and adaptive capacity of the different social groups identified, based on the status of the five capitals and in relation to their exposure to climate and non-climatic risks, their responses to manage the risks, enablers and barriers discussed above.

3.5.1. Small and marginal farmers – the vulnerability context

This section provides the vulnerability status at a glance of small and marginal farmers belonging to different social groups. Among the four social groups namely, BC – *Mali*, ST – *Mahadev Koli*, FC – *Rajputs,* and *VJNT* – *Banjaras*, found in this farmer category, the BC (*Mali*) farmers from Borban village are found to be most progressive and very rich as compared to others but also vulnerable at the same time. Even though they owned small parcels of land, having good access to water directly from the river Mula, made them more sucessful. While they had low natural, human and social capitals having high physical and financial capitals compared to the others seemed to be the only factors in making them less vulnerable over others. Having low human capital such as the lack of knowledge on climate compatible farming methods; practicing high external input agriculture; extensive monocropping of pomegranate and lack of alternative livelihood skills puts them at risk to climate change raising questions about future vulnerability and long-term sustainability. The small and marginal farmers from other villages, in contrast to the OBC (*Mali*) of Borban, are not as resourceful in obtaining physical infrastructure and subsidies. Crop production methods adopted by the ST (*Mahadev Koli*) and FC (*Rajput*) and VJNT (*Banjara*) farmers are mainly rainfed. They own lesser physical capital such as irrigation sources, micro-irrigation, farm equipment and post-harvest structures. Their main livelihood sources were subsistence agriculture and wage labour. Most of them reared goats and backyard poultry to supplement their household needs. However, in the given context, the VJNT – *Banjaras*, appeared the least vulnerable, as they managed well under rainfed conditions having innovated on their traditional knowledge of livestock management (semi-intensive goat rearing) and rainfed farming of food and fodder crops. While the small farmers of the *Rajput* community also practiced rainfed agriculture, they cultivate high external input Bt –cotton, also reared small ruminants on an extensive mode and had relatively better access to credit than the *Banjaras*, which may be attributed to being a forward caste group. Additionally, the *Rajputs* had skills for taking up non–farm work, which was an essential alternative livelihood source. Hence, the above findings place the small and marginal *Rajput* farmers slightly high on the vulnerability scale for all five capitals compared to the other social groups (*Banjaras* and *Malis*) in the same farmer category. The *Mahadev Kolis,* however were the most vulberable. Though they practised rainfed subsistence agriculture too, with goat rearing being a secondary source of income and mostly earned from agricultural wage labour as seasonal migrants which has increased in recent years – they had the lowest livelihood capitals. Although there are several developmental programmes to support lower social groups, the benefits are inaccessible due to various procedural bottlenecks furthering their vulnerability.

3.5.2. Large and medium farmers – the vulnerability context

This section gives a picture of the vulnerability status of the three social groups under large and medium farmer categories. The large farmers in Sangamner are almost exclusively from the forward caste (*Maratha*) community, and the medium farmers are from the *Rajput* (FC) and *Banjara* (VJNT) communities in the Aurangabad site. These farmer categories have better access to land and water resources as well as to the markets and information on schemes and subsidies. All farmers of this category own wells and/or bore-wells, but micro-irrigation practices are followed more in Sangamner when compared to Aurangabad due to groundwater availability. Concerning physical capital, the *Marathas* seemed better indicating medium vulnerability compared to the other two, which could be attributed to the use of micro-irrigation and more post-harvest structures. Regarding the financial capital, all three social groups indicated high vulnerability despite having assets and limited cash flow problems. This is because all three social groups in this category practiced high external input market-driven agriculture (use of high yielding seed varieties, chemical inputs, mechanization) with a focus predominantly on commercial crops. The climate and non-climate risks have led them to excessively exploit the natural resources – groundwater and soil health rendering them highly vulnerable. With regard to the natural capital, the VJNT-*Banjaras* were the least vulnerable followed by the *Marathas* and *Rajputs*. This was because the *Maratha* farmers reared crossbred dairy cows and cultivated more commercial crops except for some coarse cereals for home consumption. The *Rajputs*, on the other hand, mainly grew Bt -cotton and depended on the markets for both food and fodder and had very less livestock. While the *Banjaras* grew dual purpose crops (food and fodder) besides small quantities of cotton and managed their livestock using traditional knowledge practices. With respect to social capital, the cohesiveness among *Marathas* was visible in their self-organization for learning modern agriculture practices, accessing subsidies as well as the active functioning of the women's SHGs and hence scored better than the other two groups. The *Rajputs* also had better political connectedness, in comparison to the *Banjaras*. In Aurangabad, the SHGs were active during a watershed project implemented in the past when several assets were created, however, they later became inactive because of several reasons such as the migration of some households in response to drought-like conditions; search of other livelihoods due to aspirations of educated youth and increasing risk in agriculture; and the inability of many households to repay the loans taken from banks and SHGs. In terms of the human capital, the large and medium farmers (all communities) had more market information and knowledge of agriculture practices for commercial and horticulture crops and dairy farming; however, they had little knowledge of climate smart and sustainable farming methods except the *Banjaras* to some extent. While the *Marathas* were proactive learners, entirely depending on commercial crop and dairy production as a means of livelihood indicated higher vulnerability. Here the *Banjaras* scored better than the other two social groups as their traditional knowledge and crop and livestock production practices were more climate compatible giving them an advantage over others.

4. Conclusions

The study indicated that communities do identify various climate risks associated with changes in climate which in turn influence their decisions in livelihood choices and thus their vulnerability too. The non-climatic risks were found to further induce this vulnerability. While several enablers existed several barriers continue to be there. While, farmers from all categories demonstrated a high sensitivity to both climate and non-climatic risks, differential vulnerabilities across the farmer categories, as well as among social groups within a farmer category were found.

In general, access to water resources made a difference in the livelihoods of farmers across different categories. Irrespective of the category of farmers, investment in irrigation infrastructure improved their income and their ability to increase production. However, the shift to high external input and water intensive production, the overall trend in the in the region, indicated a higher vulnerability to the current and future climate risks predicted and being witnessed in the region. The findings also indicate that access irrigation does not necessarily reduce vulnerability or that rainfed farming increases vulnerability. This was clearly seen in the cases of the small and marginal *Mali* community farmers and the *Banjaras,* that indicates there are differences in types of skills and inherent knowledge among the different social groups that may be attributed to respective cultures which inturn influences their vulnerability.

Important lacunae are identified, which if addressed will enhance resilience of all social groups e.g access to climate compatible agriculture technologies, climate information services, etc. Caste and social standing still plays a major role in access to resources and subsidies, despite special subsidies and programmes for lower caste communities due to various implementation reasons.

The experiences from this study underscore the importance of using participatory tools that could complement the survey-based research. Vulnerability assessments need to be conducted at smaller scales as climate risks vary even within the cluster of villages as observed in the study sites; advocating the need for a cluster-based, participatory approach for assessing vulnerability to climate change.

Acknowledgements

The authors are grateful to Ms. Anjali Waghe and Mr. Pradeep Ghagre for facilitating the FGDs and other stakeholder interactions in the study sites. Mr. Yash Kadam is also acknowledged for his support in fieldwork and data analysis for the Sangamner region. This series is based on work funded by Canada's International Development Research Centre (IDRC) and the UK's Department for International Development (DFID) through the **Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA)**. CARIAA aims to build the resilience of vulnerable populations and their livelihoods in three climate change hot spots in Africa and Asia. The programme supports collaborative research to inform adaptation policy and practice.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by International Development Research Centre.

Notes on contributors

Bhavana Rao Kuchimanchi is the Regional Manager and a Senior Researcher at Watershed Organisation Trust.

Divya Nazareth is a Researcher at Watershed Organisation Trust.

Ramkumar Bendapudi is a Research Lead at Watershed Organisation Trust within ASSAR – CAARIA.

Suchita Awasthi is a Researcher at Watershed Organisation Trust.

Marcella D'Souza is the Executive Director of the Watershed Organisation Trust.

References

Adger, W. N. (2016). Place, well-being, and fairness shape priorities for adaptation to climate change. *Global Environmental Change*, *38*, A1–A3. doi:10.1016/j.gloenvcha.2016.03.009

Adger, W. N., Barnett, J., Brown, K., Marshall, N., & Brien, K. O. (2012). Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change*, *3*(2), 112–117. doi:10.1038/nclimate1666

Adger, W. N., Huq, S., & Brown, K. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies*, *3*, 179–195. doi:10.1191/1464993403ps060oa

Ajai, R. R., Arya, A. S., Dhinwa, P. S., Pathan, S. K., & Ganesh, R. K. (2009). Desertification/land degradation status mapping of India. *Current Science*, *97*(10), 1478–1483. doi:10.5194/isprsarchives-XXXVIII-8-W20-170-2011

Banerjee, R. (2014). Farmers' perception of climate change, impact and adaptation strategies: A case study of four villages in the semi-arid regions of India. *Natural Hazards*, *75*(3), 2829–2845. doi:10.1007/s11069-014-1466-z

Banerjee, R., Kamanda, J., Bantilan, C., & Singh, N. P. (2013). Exploring the relationship between local institutions in SAT India and adaptation to climate variability. *Natural Hazards*, *65*(3), 1443–1464. doi:10.1007/s11069-012-0417-9

Beck, T., & Nesmith, C. (2001). Building on poor people's capacities: The case of common property resources in India and West Africa. *World Development*, *29*(1), 119–133.

Bharati, N. (2018). Evolution of agriculture finance in India: A historical perspective. *Agricultural Finance Review*, *78*(3), 376–392. doi:10.1108/AFR-05-2017-0035

Bizikova, L., Parry, J. E., Karami, J., & Echeverria, D. (2015). Review of key initiatives and approaches to adaptation planning at the national level in semi-arid areas. *Regional Environmental Change*, *15*(5), 837–850. doi:10.1007/s10113-014-0710-0.

Blinman, E. (2008). 2000 years of cultural adaptation to climate change in the Southwestern United States. *AMBIO: A Journal of the Human Environment*, *37*(sp14), 489–497. doi:10.1579/0044-7447-37.sp14.489

Brown, P. R., Afroz, S., Chialue, L., Chiranjeevi, T., El, S., Grünbühel, C. M., … Williams, L. J. (2018). Constraints to the capacity of smallholder farming households to adapt to climate change in South and Southeast Asia. *Climate and Development*, 1–18. doi:10.1080/17565529.2018.1442798

Central Ground Water Board. (2013). Ground water information, Aurangabad district Maharashtra, Government of India ministry of water resources. Retrieved from http://www.cgwb.gov.in/District_Profile/Maharashtra/Aurangabad.pdf

Central Ground Water Board. (2014). Groundwater information, Ahmednagar district, Maharashtra. Ministry of Water Resources, Government of India. Retrieved from http://cgwb.gov.in/District_Profile/Maharashtra/Ahmadnagar.pdf

Coulthard, S. (2008). Adapting to environmental change in artisanal fisheries —insights from a South Indian Lagoon. *Global Environmental Change*, *18*, 479–489. doi:10.1016/j.gloenvcha.2008.04.003

Crane, T. A., Roncoli, C., & Hoogenboom, G. (2011). Adaptation to climate change and climate variability: The importance of understanding agriculture as performance. *NJAS - Wageningen Journal of Life Sciences*, *57*(3–4), 179–185. doi:10.1016/j.njas.2010.11.002

Datta, S., Tiwari, A. K., & Shylajan, C. S. (2018). An empirical analysis of nature, magnitude and determinants of farmers' indebtedness in India. *International Journal of Social Economics*, *45*(6), 888–908.

Dev, M. S. (2014). *Small farmers in India: Challenges and opportunities*. Mumbai: Indira Gandhi Institute of Development Research. Retrieved from http://www.igidr.ac.in/pdf /publication/WP-2012-014.pdf

DfID. (1999). *Sustainable livelihood Guidance Sheets*. London: Department for International Development. Retrieved from http://www.eldis.org/vfile/upload/1/document/0901/section2.pdf

Dhanya, P., & Ramachandran, A. (2015). Farmers' perceptions of climate change and the proposed agriculture adaptation strategies in a semi arid region of south India. *Journal of Integrative Environmental Sciences*, *13*(1), 1–18. doi:10.1080/1943815x.2015.1062031

EEA. (1999). Environmental Indicators: Typology and Overview. Tech. Report 25. Retrieved from https://www.eea.europa.eu/data-and-maps/indicators/progress-in-management-of-contaminated-sites-3/european-environment-agency-1999-environmental

Gaidhane, A. (2015). Understanding the Linkage between poverty, hunger and food security in India: Role of Public distribution system as a 'development input' for poverty alleviation –problems and Prospects of PDS. *Journal of Humanities And Social Science*, *20*(4), 56–65. doi:10.9790/0837-20415665

Government of Maharashtra. (2013). District Socio-economic review-2013. Directorate of Economics and Statistics, Maharashtra. Retrieved from https://mahades.maharashtra.gov.in/files/publication/esm_2013-14_eng.pdf

Huq, N., Hugé, J., Boon, E., & Gain, A. K. (2015). Climate change impacts in agricultural communities in rural areas of Coastal Bangladesh: A Tale of many Stories. *Sustainability*, *7*(7), 8437–8460. doi:10.3390/su7078437

IISD. (2012). CRiSTAL - Community-based Risk Screening Tool – Adaptation and Livelihoods, International Institute for Sustainable Development, Canada. Retrieved from https://www.iisd.org/cristaltool/

Jain, M., Naeem, S., Orlove, B., Modi, V., & DeFries, R. S. (2015). Understanding the causes and consequences of differential decision-making in adaptation research: Adapting to a delayed monsoon onset in Gujarat, India. *Global Environmental Change*, *31*, 98–109. doi:10.1016/j.gloenvcha.2014.12.008

Jakimow, T. (2013). Unlocking the Black Box of institutions in livelihoods analysis: Case study from Andhra Pradesh. India. *Oxford Development Studies*, *41*(4), 493–516. doi:10.1080/13600818.2013.847078

Jodha, N. S. (1990). Rural common property resources: Contributions and Crisis. *Economic and Political Weekly*, *25*(26), 65–78.

Jodha, N. S. (1995). Common property resources and the environmental context: Role of biophysical versus social stresses. *Economic and Political Weekly*, *30*(51), 3278–3283.

Jones, L., & Boyd, E. (2011). Exploring social barriers to adaptation : insights from Western Nepal. *Global Environmental Change*, *21*(4), 1262–1274. doi:10.1016/j.gloenvcha.2011.06.002

Kalamkar, S. S. (2011). *Agricultural Growth and productivity in Maharashtra: Trends and Determinants*. New Delhi: Allied Publishers Pvt. Ltd.

Kattumuri, R., Ravindranath, D., & Esteves, T. (2015). Local adaptation strategies in semi-arid regions: Study of two villages in Karnataka. India. *Climate and Development*, *9*(1), 36–49. doi:10.1080/17565529.2015.1067179

Kuchimanchi, B. R., & Mathur, M. (2012). Watershed Development and Livestock Rearing - Experiences and Learning from the Watershed Organisation Trust, Maharashtra, India. Retrieved from http://sapplpp.org/files-repository/goodpractices/Watershed Development and Livestock Rearing.pdf/at_download/file

Kumar, R. (2014). Elusive Empowerment : price information and disintermediation in Soybean markets in Malwa, India. *Development and Change*, *45*(6), 1332–1360.

Mane, R. P. (2006). Targeting the poor or poor Targeting A case for Strengthening the Public distribution system of India. *Journal of Asian and African Studies*, *41*(4), 299–317. doi:10.1177/0021909606065788

Manjunatha, A. V., Anik, A. R., Speelman, S., & Nuppenau, E. A. (2013). Impact of land fragmentation, farm size, land ownership and crop diversity on profit and efficiency of irrigated farms in India. *Land Use Policy*, *31*, 397–405. doi:10.1016/j.landusepol.2012.08.005

Marino, E., & Ribot, J. (2012). Special issue introduction: Adding insult to injury: Climate change and the inequities of climate intervention. *Global Environmental Change*, *22*(2), 323–328. doi:10.1016/j.gloenvcha.2012.03.001

McCabe, J. T., Leslie, P. W., & DeLuca, L. (2010). Adopting cultivation to Remain Pastoralists: The Diversification of Maasai livelihoods in Northern Tanzania. *Human Ecology*, *38*(3), 321–334. doi:10.1007/s10745-010-9312-8

Menon, A., &Vadivelu, G. A. (2006). Common property resources in different agro-climatic landscapes in India source. *Conservation and Society*, *4*(1), 132–154. Published by: Ashoka Trust for Research in Ecology and the Environment and Wolters Kluwer India Pvt. Ltd. Stable URL: https://www.jstor.org/stable/26396651. Retrieved October 15, 2018.

Mikulewicz, M. (2017). Politicizing vulnerability and adaptation: On the need to democratize local responses to climate impacts in developing countries. *Climate and Development*. doi:10.1080/17565529.2017.1304887

Narain, V., & Vij, S. (2016). Where have all the commons gone ? *Geoforum; Journal of Physical, Human, and Regional Geosciences*, *68*, 21–24. doi:10.1016/j.geoforum.2015.11.009

Nielsen, JØ, & Reenberg, A. (2010). Cultural barriers to climate change adaptation : A case study from Northern Burkina Faso. *Global Environmental Change*, *20*, 142–152. doi:10.1016/j.gloenvcha.2009.10.002.

Nightingale, A. J. (2017). Geoforum power and politics in climate change adaptation e ff orts : Struggles over authority and recognition in the context of political instability. *Geoforum; Journal of Physical, Human, and Regional Geosciences*, *84*(June 2016), 11–20. doi:10.1016/j.geoforum.2017.05.011

O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., … West, J. (2004). Mapping vulnerability to multiple stressors: Climate change and globalization in India. *Global Environmental Change*, *14*(4), 303–313. doi:10.1016/j.gloenvcha.2004.01.001

O'Brien, K. L., & Wolf, J. (2010). A values-based approach to vulnerability and adaptation to climate change. *Wiley Interdisciplinary Reviews: Climate Change*, *1*(2), 232–242. doi:10.1002/wcc.30

Pal, D., & Laha, A. K. (2014). Credit off-take from formal financial institutions in rural India : quantile regression results. *Agriculture and*

Food Economics, *2*(9), Retrieved from http://www.agrifoodecon.com/content/2/1/9
Pasha, S. A. (1992). CPRs and rural poor: A micro level analysis. *Economic and Political Weekly*, *27*, 2499–2503.
Pradyumna, A., Bendapudi, R., Zade, D., & D'Souza, M. (2018a). Heat Stress –Vulnerability, health impacts, and coping strategies in rural communities in the semi-arid region of Maharashtra, India. CARIAA-ASSAR Working Paper. International Development Research Centre, Ottawa, Canada and UK Aid, London, United Kingdom. Retrieved from www.assar.uct.ac.za
Pradyumna, A., Bendapudi, R., Zade, D., D'Souza, M., & Tasgaonkar, P. (2018b). Managing the increasing heat stress in rural areas. In W. L. In Filho (Ed.), *Handbook of climate change resilience* (pp. 1–22). Springer International Publishing. doi:10.1007/978-3-319-71025-9_46-1
Ramaswami, R., Ravi, S., & Chopra, S. (2003). Risk management in agriculture. (Discussion draft), Retrieved from http://www.isid.ac.in/~pu/dispapers/dp03-08.pdf
Ramprasad, V. (2018). Debt and vulnerability : indebtedness, institutions and smallholder agriculture in South India. *The Journal of Peasant Studies*, 1–22. doi:10.1080/03066150.2018.1460597
Rao, K. R. M., Manikandan, M. S., & Filho, W. L. (2005). An overview of the impacts of changes in common property resources management in the context of globalisation: A case study of India. *International Journal of Sustainable Development & World Ecology*, *12*(4), 471–477. doi:10.1080/13504500509469655
Ribot, J. (2010). Vulnerability does not fall from the sky: Toward multi-scale, pro-poor climate policy. *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World*, 47–74.
Ribot, J. (2014). Cause and response: Vulnerability and climate in the Anthropocene. *The Journal of Peasant Studies*, *41*(5), 667–705. doi:10.1080/03066150.2014.894911.
Safriel, U., & Adeel, Z. (2005). Dryland systems, Chapter 22, pp. In R. Hassan, R. Scholes & N. Ash (Eds.), *Ecosystems and human well-being: Current state and trends. The millennium ecosystem assessment, Vol. 1* (pp. 623–662). Washington: Island Press. Retrieved from http://www.maweb.org/documents/document.291.aspx.pdf
Sarap, K. (1990). Factors affecting small farmers ' access to institutional credit in rural Orissa, India. *Development and Change*, *21*, 281–307.
Schroth, G., Krauss, U., Gasparotto, L., Duart-Aguilar, J. A., & Vohland, K. (2000). Pests and diseases in agroforestry systems of the humid tropics. *Agroforestry Systems*, *50*(3), 199–241.
Shackleton, S., Ziervogel, G., Sallu, S., Gill, T., & Tschakert, P. (2015). Why is socially-just climate change adaptation in sub-Saharan Africa so challenging? A review of barriers identified from empirical cases. *Wiley Interdisciplinary Reviews: Climate Change*, *6*(3), 321–344.
Simmons, C., & Supri, S. (1997). Rural development, employment, and off farm activities: A study of rural households in Rurka Kalan Development Block, north-west India'. *Journal of Rural Studies*, *13*(3), 305–318.
Singh, C., Daron, J., Bazaz, A., Ziervogel, G., Spear, D., Krishnaswamy, J., … Kituyi, E. (2017). The utility of weather and climate information for adaptation decision-making: Current uses and future prospects in Africa and India. *Climate and Development*. doi:10.1080/17565529.2017.1318744
Singh, N. P., Bantilan, C., & Byjesh, K. (2014). Vulnerability and policy relevance to drought in the semi-arid tropics of Asia – A retrospective analysis. *Weather and Climate Extremes*, *3*, 54–61. doi:10.1016/j.wace.2014.02.002i
Sugden, F., Maskey, N., Clement, F., Ramesh, V., Philip, A., & Rai, A. (2014). Agrarian stress and climate change in the Eastern Gangetic Plains : Gendered vulnerability in a stratified social formation. *Global Environmental Change*, *29*, 258–269. doi:10.1016/j.gloenvcha.2014.10.008
Taylor, M. (2013a). Climate change relational vulnerability and human security rethinking sustainable adaptation in agrarian environments.pdf. *Climate and Development*, *5*, 318–327. doi:10.1080/17565529.2013.830954
Taylor, M. (2013b). Liquid debts : credit, groundwater and the social ecology of agrarian distress in Andhra Pradesh. *Third World Quarterly*, *34*(4), 691–709. Retrieved from www.tandfonline.com/doi/abs/10.1080/01436597.2013.786291
TERI. (2014). Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change (MSAAPC). Retrieved from http://www.moef.gov.in/sites/default/files/Maharashtra%20Climate%20Change%20Final%20Report.pdf
Thapa, G. (2009). *Smallholder farming in transforming economies of Asia and the Pacific: Challenges and opportunities*. Rome: IFAD. Retrieved from https://www.ifad.org/documents/10180/a194177c-54b7-43d0-a82e-9bad64b76e82
Thomas, R., & Duraisamy, V. (2016). Hydrogeological delineation of groundwater vulnerability to droughts in semi-arid areas of western Ahmednagar district. *Egyptian Journal of Remote Sensing and Space Science*. doi:10.1016/j.ejrs.2016.11.008
Tschakert, P., Das, P. J., Shrestha Pradhan, N., Machado, M., Lamadrid, A., Buragohain, M., & Hazarika, M. A. (2016). Micropolitics in collective learning spaces for adaptive decision making. *Global Environmental Change*, *40*, 182–194. doi:10.1016/j.gloenvcha.2016.07.004
Tschakert, P., van Oort, B., St. Clair, A. L., & LaMadrid, A. (2013). Inequality and transformation analyses: A complementary lens for addressing vulnerability to climate change. *Climate and Development*, *5*(4), 340–350. doi:10.1080/17565529.2013.828583
Williams, L. J., Afroz, S., Brown, P. R., Chialue, L., Grünbühel, C. M., Jakimow, T., … Roth, C. H. (2016). Household types as a tool to understand adaptive capacity: Case studies from Cambodia, Lao PDR, Bangladesh and India. *Climate and Development*, *8*(5), 423–434.