ASSAR

ADAPTATION AT SCALE IN SEMI-ARID REGIONS

2014–2018

PUTTING **PEOPLE** AT THE CENTRE TO ENABLE EFFECTIVE **CLIMATE ADAPTATION** IN SEMI-ARID REGIONS

INSIGHTS FROM KARNATAKA, INDIA

iihs™
INDIAN INSTITUTE FOR
HUMAN SETTLEMENTS

atree

WOTR
water gives life

VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE IN SEMI-ARID KARNATAKA, INDIA

ASSAR'S FOCUS IN KARNATAKA, INDIA

India consists of a diverse set of ecosystems with a range of risks, climatic and non-climatic exposures, differential vulnerability profiles, and various institutional regimes. The country is complex, with multi-hazard environments and climate-change hotspots. Negative impacts on key rural production systems like agriculture and forestry are already evident, and a range of losses and impacts across agricultural, water, and forest-based systems is projected for the future. Major livelihood transitions are expected to take place along the rural-urban continuum, coupled with increasing urbanisation. A significant proportion of the population lives in extreme poverty and is highly vulnerable to both everyday risks and the impacts of extreme events.

The country also faces serious institutional and governance challenges, compounded by contested growth dynamics, rural-urban migration, and fluxes in the historically-established formal and informal sectors. These dynamics will combine to create pockets of risk where concentrations of historical and emergent challenges are amplified by climatic variability.

From 2014-2018, ASSAR's Indian Institute for Human Settlements (IIHS) team worked in urban, rural and peri-urban study sites in the Bengaluru district, and rural sites in Gulbarga (north Karnataka) and Kolar (in close proximity to Bengaluru) to better understand their existing climate and development challenges. Made up of a team of senior researchers, early career researchers, and post doctoral fellows from IIHS, and scientists from the Indian Institute of Tropical Meteorology (IITM), Pune, we worked with stakeholders across all levels: state, non-state, household, and community to understand what makes people vulnerable to climate change, what the barriers to adaptation are, and what could enable more effective, sustained and widespread adaptation to climate change.

Key insights

- To deal with differential vulnerability across the rural-urban continuum, development policies and climate change adaptation interventions need to respond to the needs and dynamic aspirations of the most vulnerable. Urban development policies require a deeper understanding of informal settlements, including dimensions of differential vulnerability, particularly across the multitude of social categories present, the various actors involved, and the roles of social networks, local associations, and social cohesion. Additionally, viable employment options in rural areas should be developed through the strengthening of rural livelihoods and/or the natural resource base upon which these livelihoods depend.

- Migration drivers, processes, and outcomes are complex, differentiated, and span the rural-urban continuum. Migration does not necessarily lead to improved wellbeing, and might have trade-offs for some members of the household. The increasing volumes of migration mean that policy makers need to reimagine adaptation as beyond-local, and develop strategies that can, on one end, make agriculture more viable, and on the other end, provide safer and more inclusive conditions for migrants in urban areas.

- Urban and regional governance in India is fragmented and weak, and there is little engagement with climate policy. Local governments lack personnel and technical capacity, and have not sufficiently leveraged the presence of a range of domestic and international non-state actors. The relationship between state and city government remains top-down, with decision-making occurring at the state level, and local agencies responsible for implementation. The largest challenge, however, is to build support for climate action within state and local government officials.

- For decision makers and practitioners in semi-arid regions to make robust and informed decisions it is imperative that they take into account the available, legitimate and reliable knowledge that supports fine-scaled, contextualised, and robust adaptation responses. To facilitate knowledge transfer and local-level adaptation, knowledge brokers should be recognised and formally supported, and the effectiveness of extension services should be improved.

- Preserving functioning ecosystem services within the urban fabric is crucial for climate resilience planning. However in Bengaluru, these ecosystem services are being challenged by unplanned, haphazard urbanisation. Promoting ecosystem-service-based stormwater-management practices, and exploring alternative strategies that can enable stormwater attenuation or retention are necessary.

ABOUT THE RESEARCH

Research priorities

Our research priorities were guided by an evolving national and sub-national context that is characterised by incremental and unplanned urbanisation, skewed structural transformation, and stressed rural production systems. These characteristics are compounded by huge dependency, particularly in semi-arid regions, on the Indian summer monsoon. Our research was further guided by ASSAR's overarching research framework that was designed to examine climate adaptation challenges through research streams of social differentiation and gender, governance, dynamics of ecosystem services, and knowledge systems.

Our research for the Karnataka semi-arid region focused on: (1) understanding the drivers of differential vulnerability to better address its root causes; (2) understanding current and future climate variability, non-climatic risks, and their interactive impacts; (3) understanding the local and sub-regional institutional imbalances that intensify existing inequity in accessing public services, natural resources, knowledge and power; and (4) understanding the dynamics of livelihoods, and migration as an adaptive strategy along the rural-urban continuum. Our broader aim was to influence balanced regional development, and mainstream climate change into development planning.

Case study sites

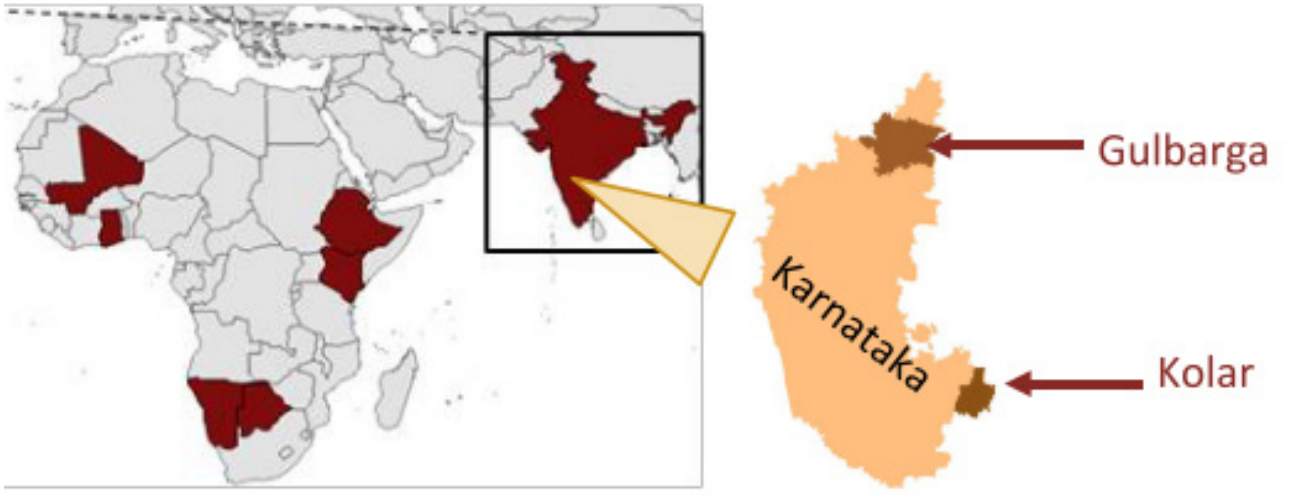
Karnataka is a predominantly semi-arid state in South India. Within Karnataka, we studied two districts – Kolar and Gulbarga – which are among the least developed districts in the state, and face severe water scarcity, recurrent droughts, and increasing natural resource degradation. Kolar falls in the southern part of the state and is relatively more developed on account of its proximity to the state capital, Bengaluru, while Gulbarga, part of North Karnataka, is recognised as a 'backward district', and performs poorly on most human-development indicators.

We also studied distinct urban, rural, and peri-urban areas in the Bengaluru region, which is characterised by rapid urbanisation and unplanned growth. We observe increasing population trends here due to in-migration, since Bengaluru acts as a magnet for livelihood opportunities for people in surrounding areas and regions. In addition, large-scale infrastructure and development projects are shaping the spatial, economic, and cultural landscape of Bengaluru. We also find an increasing trend in informal settlements in the city; these settlements are particularly vulnerable due to their location, and lack of access to basic services such as water supply and sanitation. There is also an increased dependency on marginal work within the informal economy. The natural resource base is limited and fast depleting, and structural gender-based inequalities exist. A multiplicity of city planning agencies, and fragmented governance processes complicate development and climate response, and skewed public policy (inadequate structural transformation) does not adequately address multidimensional poverty and both climate and non-climate induced vulnerabilities.

The ASSAR India study areas at IIHS are regionally spread across the Bengaluru sub-region in Karnataka (which includes Kolar and Gulbarga districts in Karnataka).

Approach

Our research in Karnataka was guided by ASSAR's overarching research framework (that enabled comparative regional and cross-regional research). Within that, we used a mixed methods approach to collect data, which included a structured household survey, participatory focus group discussions (FGDs), multi-stakeholder key informant interviews, and in-depth life histories. The main driver of our research was to have a meaningful impact in the realm of climate policy and practice in the region, particularly in the context of the most marginalised population. It was, therefore, imperative for us to get buy-in from all key stakeholders (state, non-state, and the most marginalised population) regarding key challenges in the region, so as to orient our research agenda towards those challenges. The methods helped us explore risk and response portfolios at three scales: settlement-level, household-scale, and intra-household scale.



Our mixed method, multi-scalar approach allowed us to deliberate on the circumstantial drivers of vulnerability at the local scale, going beyond the immediate, observable impacts to more structural drivers of vulnerability. We also emphasised a gendered approach to the planning and practice of data collection and analysis, and paid special attention to issues of marginalisation, intersectionality, and the many forms of social differentiation. We supplemented our research methods with detailed literature reviews, and analysis of relevant grey and policy literature.

We constantly endeavoured to orient our research to the needs of the policy makers and the vulnerable communities, as guided by ASSAR's Theory of Change. To do this, while formulating our research design and setting up relevant research processes, we did numerous scoping visits to sites of relevance, and conducted interviews and held dialogues with key informants. We subsequently held iterative processes to get thematic and location-specific feedback from peers and experts. We also gave regular research updates to policy makers through our structured, theme-based IIHS policy dialogues, and – where appropriate – adjusted our work plans in response to their feedback. We also consciously engaged with grassroots organisation (MYRADA Gulbarga and MYRADA Kolar) to be co-participants in our research in the rural sites of Karnataka, in order to facilitate local research, and leverage on long-standing regional relationships.

We also used participatory processes such as Transformative Scenario Planning (TSP) to bring together diverse stakeholders such as government officials, lake-citizen groups, and NGO representatives to facilitate initial dialogue and enable further collaborations. As an offshoot of this process, we investigated if TSP can be used as a precursor for developing adaptation pathways.

Capacity building was an important element in IIHS ASSAR research. We focused on building interdisciplinary research capacity amongst early-career researchers (within IIHS) coming from varied disciplines through participation in several short courses on gender, and climate information for adaptation, and by using various opportunities within ASSAR (e.g., Small Opportunities Grants). We were also able to build external capacities through multiple platforms, channels and engagement processes (e.g., ASSAR's Grants for Local Adaptation Support, TSP, IIHS institutional engagement processes, project stakeholder consultations, and strategic partnerships). We were also able to use our research process and findings to build capacity to mainstream climate concerns in development planning, either through training courses (e.g., IIHS course on vulnerability assessments), or through dialogues with strategic partners like IITM, to integrate climate science with vulnerability and adaptation planning. While internal capacity building processes enabled rigour in our research, these external processes were a constant source of validation of our research, and presented opportunities to influence policy processes.

Finally, we also produced and disseminated multiple research products such as information and policy briefs, and used our partnerships with key policy and science-based stakeholders like IITM to help us engage closely with the science-based policy process in India.

FINDINGS AND RECOMMENDATIONS

ADAPTATION INTERVENTIONS NEED TO RESPOND TO THE NEEDS AND DYNAMIC ASPIRATIONS OF THE MOST VULNERABLE

a. In the rural context of the semi-arid regions of Karnataka, risks from environmental change, climate change, and increased climate variability are crucial but are mediated through existing structural conditions such as poor market linkages, inadequate credit, low asset bases, and caste- and gender-based differences.

Vulnerability in semi-arid regions is characterised by a range of interacting social, economic, political, and environmental changes, which impact agricultural and non-agricultural livelihoods. This vulnerability is exacerbated by inherently low agricultural productivity, rapid and increasing natural resource degradation, inadequate governance responses to aid livelihood diversification and adaptation processes, and an overall poor performance on development indicators due to economic marginalisation. Climate change is projected to exacerbate these problems, pushing semi-arid systems to cross biophysical thresholds, with long-term implications on local livelihoods and agricultural sustainability. Extant vulnerability and adaptation research has typically focussed on a static, location-specific understanding of risk and response; yet risk management strategies traverse multiple locations through, for example, higher human mobility and changing social norms.

In this context, we attempted to understand the dynamic reality of risks and responses in the context of climate change, by examining livelihood responses and their outcomes at household, community, and sub-national scales in rural Karnataka. We aimed to unpack household risk portfolios and assess their long-term implications on household wellbeing and systemic sustainability.

We found that people are responding to multiple risks, of which environmental changes are a significant part. However, these responses are not necessarily climate change adaptation strategies. Further, although many interventions are helping build generic capacity to deal with non-climatic risks and alleviate development deficits, they may not be building specific adaptive capacity to climate change. In some cases, in fact, interventions can be maladaptive in nature.

Furthermore, risk accumulates over time with recurrent drought, natural resource degradation, and deteriorating common pool resources being significant drivers of biophysical vulnerability. The nature of risks also changes over time with increasing reports of drought incidence and dry spells. When seen through a livelihoods lens, these environmental risks interact with institutional risks (e.g., pervasive agricultural policies favouring irrigation-based farming), financial risks (e.g., reliance on moneylenders in the absence of adequate credit facilities), and social risks (e.g., women unable to travel long distances for work) to shape household vulnerability.

Responses to risks are also multi-scalar in nature: policy shifts such as diesel subsidies or promotion of organic farming at the state level, percolate into household response strategies, with negative or positive outcomes. Across time, some responses (e.g., digging farm ponds, shifting to water-intensive cash crops) are highlighted as having potentially maladaptive outcomes. This calls for growing awareness about trade-offs that a particular intervention entails, and a careful pre-project exploration of potential maladaptive outcomes becomes necessary and desirable.

Some responses are changing either in type (shifting away from farm livelihoods) or in nature (migrating farther away, into non-agriculture wage labour), demonstrating how livelihood portfolios are increasingly dynamic and complex. Critically, these changes in responses also signal changing aspirations, especially among rural youth.

b. Climate action and priorities in Indian cities is a function of city development trajectories, their governance and political contexts (at city, state, and national levels), and their emerging patterns of socioeconomic inequality. A better understanding of how structural vulnerability and climatic impacts intersect would lead to better responses and climate-resilient outcomes.

The impacts associated with climate change differ significantly among different social groups, falling disproportionately on the working classes and the marginalised, and reflecting highly nonlinear relationships between climate change and its outcomes. Understanding the causality and structure of vulnerability helps to focus on the larger social, political-economic, and structural variables that shape capacity and underpin livelihood security. Within cities, the processes of urbanisation produce several forms of social, political and economic inequality, and contribute to creating multiple forms of vulnerability.

It has been argued that climate change is not just impacting the city but is produced through the city, exacerbating uneven patterns of development and urban inequality.

We found that the drivers of vulnerability are different in rural, urban and peri-urban areas, and moving away from rural areas does not necessarily make people less vulnerable. In fact, people enter new risks in urban settings. These risks are usually different for inter- and intra-state migrants, and climate-related vulnerability directly impacts their material and subjective wellbeing. For example, in urban areas, localised flooding, poor access to basic services, and insecure livelihoods are key risks. In addition to climate drivers, structural drivers of vulnerability directly impact people's wellbeing. These drivers are partly driven by historical marginalisation, the political economy of development pathways, and poor planning.

Recommendations

- Strengthening institutions to support household-level autonomous responses such as crop diversification, or using water-saving technologies, is critical. We see some examples of early successes such as subsidising drip irrigation in Kolar, or providing drought-tolerant seed varieties. However, these interventions need to be sustained, inclusive, and focused on building upon local, tested solutions instead of replacing them.

- While climatic risks are important, and increasingly perceived as crucial for rural livelihoods, they are experienced in conjunction with non-climatic risks. Thus, a focus on perceived risks (e.g., increasingly-erratic rainfall, higher daytime temperatures), is a critical starting point for adaptation interventions.

- Additionally, risks change over time and space. Current vulnerability assessments – the basis on which adaptation interventions are built – and adaptation interventions, tend to overlook or inadequately account for this dynamic nature of risk. Therefore, we need assessments that acknowledge and incorporate the messy, dynamic nature of vulnerability, tracking risks and responses over time, to understand how they shape household and system-level pathways. In our work, we use life history interviews and participatory timeline mapping in gender-differentiated groups as ways to capture this temporality.

- Building both generic and climate-specific capacities and considering spatio-temporal scales can result in better risk management. Interventions to build specific capacity would involve: forward-looking actions such as using climate information to shape appropriate cropping regimes; incentivising mixed crop-livestock systems to spread risk (as opposed to mono-cultivation of cash crops); institutional reform where local governance structures are flexible in the face of increasing climate vulnerability; and the provision of safety nets for responses spanning the rural and urban, such as migration.

MIGRATION DRIVERS, PROCESSES AND OUTCOMES ARE COMPLEX, DIFFERENTIATED, AND SPAN THE RURAL-URBAN CONTINUUM

Migration does not necessarily lead to improved wellbeing, and might have trade-offs for some members of the household. The increasing volumes of migrants mean that policy makers need to reimagine adaptation as beyond-local, and develop strategies that can, on one end, make agriculture more viable, and on the other end, provide safer and more inclusive conditions for migrants in urban areas.

Our study of migrants in multiple contexts — urban, rural and peri-urban — offered a unique opportunity to understand different forms and patterns of human mobility, as well as the drivers and outcomes of migration across different contexts and different social groups. By considering migration into urban Bengaluru, land-use change and migration patterns in peri-urban Bengaluru, and migration and commuting from rural Kolar and Gulbarga, we were able to explore how migration shapes adaptive capacity at household and intra-household levels across the rural-urban continuum.

Within Karnataka, migration is a key livelihood and response strategy. Its drivers are primarily economic, but reinforced by climatic risks that have disrupted traditional farm-based livelihoods. The prospect of better livelihoods, driven partly by aspirational changes and partly by a lack of opportunity in rural areas, is the major driver to outward migration from the rural areas. The nature of migration depends on the social location of gender, land-holding size,

caste, religion, and accessibility of villages to urban centres. Short-term, seasonal, and long-term migration patterns differ across gender and social groups. Women's mobility for work is restricted, while members of disadvantaged groups are more likely to migrate out due to their lower endowment of landholding.

Although the wellbeing and adaptation outcomes of migration vary due to specific circumstances, permanent migrants with an endowment of human and social capital are able to attain a better standard of living over the long run. However, in the short term, migrants face considerable challenges in urban areas, primarily due to the difficulty of accessing critical infrastructure and public services. Due to the precarious nature of their habitations and settlements, migrants are also prone to various environmental hazards.

Migrant households fare worse in terms of asset ownership. They are therefore likely to report lower quality of life and poorer adaptive capacity to deal with disruptions to their livelihoods. However, there is no significant difference between the income of migrants and non-migrants. The differences in wellbeing outcomes are primarily due to migrants' inability to access infrastructure services at the destination.

Due to the lack of recognition of their domicile status, migrants often lack access to critical social security services and entitlement, most significantly, the Public Distribution System that offers access to food grains at subsidised prices. Migrants also score low on indicators of subjective wellbeing. Migrant wellbeing can vary from surviving, erosive coping, positive coping, and possibly adaptive.

Recommendations

- When considering response strategies for climate-induced risks, a continuum approach allows for a systems perspective that connects rural, peri-urban and urban areas. In rural areas, key issues to address are changing aspirations and climatic stressors interacting with social marginalisation, while in urban areas it is poor planning and inadequate safety nets for the most vulnerable. In the peri-urban, overlapping and unclear jurisdiction, and rapid land-use-change interactions are critical. Overall, actions on these aspects must be taken simultaneously to enable sustainable and just adaptation. In some cases, however (e.g., in peri-urban Bengaluru) we see examples of changing gender norms demonstrating how moving along the continuum can change norms and, consequently, change household response strategies.

- In addition to focusing on structural drivers of vulnerability such as caste or gender-based differences, and their related outcomes, climate-induced risks and their interactions with non-climatic risks must be addressed. For urban development policies to be effective and inclusive, they require a deeper understanding of the nature of informal settlements — dimensions of differential vulnerability, particularly across a multitude of social categories, the various actors involved, and the roles of social networks, local associations and social cohesion.

- Migration remains a key livelihood strategy in semi-arid regions, either due to intensification of climate signals or through changing aspirations, and this must be recognised within state policies. It appears that strengthening of adjacent city public services and improving accessibility to social security services and their entitlement would be able to improve wellbeing outcomes for all kinds of migrants.

BUILDING CLIMATE RESILIENCE AND ENHANCING ADAPTIVE CAPACITIES REQUIRES GOVERNANCE COORDINATION AT MULTIPLE LEVELS

Urban and regional governance in India is fragmented and weak, and there is little engagement with climate policy. Local governments lack personnel and technical capacity, and have not sufficiently leveraged the presence of a range of domestic and international non-state actors. The relationship between state and city government remains top-down, with decision-making occurring at the state level, and local agencies responsible for implementation. The largest challenge, however, is to build support for climate action within state and local government officials.

Urban regions across the world are emerging as critical actors in dealing with climate change. As India prepares for a large-scale urban transition, with the urban population projected to almost double by 2030 as compared to 2010, current and future urban populations will become increasingly vulnerable to climate change. While growing interest in climate policy and its resulting initiatives are welcome, the larger challenge in the Indian context is perhaps the creation of an institutional architecture to enable the adoption and implementation of the adaptation and mitigation strategies that are being developed at the national scale. Focusing on Bengaluru, and Chennai — and using institutional mapping, stakeholder interviews, and literature reviews — we were particularly interested in understanding how a variety of urban stakeholders (state and non-state) participate in, and influence, climate governance across scales and sectors in India.

While there are a range of efforts across multiple scales and sectors underway to tackle climate and other environmental challenges, these are often piecemeal and not coordinated. Regional governance is fragmented, as institutional structures do not translate/replicate across government levels (national to sub-national, state/regional), with sub-optimal outcomes. The governance challenge is more acute in the context of climate-specific governance, as climate is a subsidiary of existing structures, processes and mechanisms, and does not get the attention needed to allow it to be mainstreamed or respond efficiently. Furthermore, potential opportunities for multi-level governance across state/non-state actors, and different levels of government do exist, but these are not leveraged.

There is also no systematic approach at the urban or regional scale to specifically address questions of adaptation or mitigation. Instead most environmental policy is broadly framed and addresses questions of sustainable development rather than focusing specifically on climate change. In the absence of an adequate institutional governance framework, the long-term sustainability of climate action in the Indian context is called into question.

Recommendations

- There remains a perception within state and city agencies that climate change is beyond their mandate. This is an issue that needs to be resolved by national governments. However — in the absence of city or state government agencies taking on a coordinating role for climate action across different scales of government and different sectors — this role is increasingly being taken on by non-state actors such as donor agencies or community-based groups. The challenge with this is that their influence is limited, and often very focused on a particular problem or sector. We recommend a stronger coordinating agency within the sub-regional administrative structures which could help coordinate climate action and provide convergence across multiple sectors and actions. Needless to indicate, such an agency should have a political, financial, and legislative mandate.

- Urban governments and their agencies have the potential to play an important role in mobilising climate action at the city-scale. There are isolated examples of Indian cities and individual champions that are beginning to take action on climate-related issues (e.g., Surat), but these remain few and far between. There are also opportunities to engage with several non-state actors such as local academics, community organisations, and private sector entities to help fill the technical and knowledge deficit within government, and to help mobilise effective climate governance.

EFFECTIVE ADAPTATION IS UNDERPINNED BY THE EFFICIENT PRODUCTION, INTEGRATION, TRANSFER, AND USE OF RELEVANT KNOWLEDGE

For decision makers and practitioners in semi-arid regions to make robust and informed decisions it is imperative that they take into account the available, legitimate, and reliable knowledge that supports fine-scaled, contextualised, and robust adaptation responses. To facilitate knowledge transfer and local-level adaptation, knowledge brokers should be recognised and formally supported, and the effectiveness of extension services should be improved.

A key barrier to managing current and future climate risks relates to the availability of accessible, reliable and relevant weather and climate information. Despite advances in science, and the increasing availability of climate information, examples of long-term climate information being used in decision making are hard to find. While weather advisories and seasonal forecasts are used to plan for and manage short-term risks, long-term information predominantly serves only a steering function. The difficulty of integrating long-term climate information into decision-making and policy processes is largely due to the uncertainty of the information, the mismatch of fine-scale information needs and coarse-scale climate projections, mistrust in the mode of information delivery, and a lack of institutional capacity to deal with long-term climate risks. However, not considering long-term climate information in present actions can have long-term and potentially maladaptive implications.

One way of better integrating available climate information into local-level practice is through knowledge brokers. Through our research on four knowledge brokers (Tarun Bharat Sangh in Alwar, Rajasthan; North East Network in Phek, Nagaland; Timbaktu Collective in Anantapur, Andhra Pradesh; and Foundation for Ecological Security in Anand, Gujarat) we found that by transferring knowledge horizontally (among locals) and vertically (among research institutions and extension offices), knowledge brokers (be they individuals, groups or organisations) can help address weak links that persist between local and supra-national levels. They can promote local practices that are culturally and socially relevant, and can help to integrate these practices with modern/formal knowledge. They can also facilitate interactions and engagement among varied stakeholders, including local communities, scientific institutions, and extension offices, and can use these networks to foster social learning, and advocate for appropriate policy changes. In doing so they can also facilitate the evolution of decentralised institutions, and the inclusion of local actors in local resource governance. Finally, they can create local awareness about entitlements, and help to regulate access to available state schemes and benefits.

Agricultural extension services are also a crucial means of transferring knowledge to local levels, particularly small and marginal farmers. However, in rural Karnataka we found low or inadequate visibility of extension institutions, and the devolution of extension services at the village level. Even though the institutional landscape of extension services has undergone a drastic change from a more top-down to a group-based approach that employs information and communication technology (ICT), the penetration of public extension remains poor. It is beset by differential access based on socio-economic status, with upper and dominant landed castes, villages close to district headquarters, and farmers with higher education levels having far better accessibility to services than marginalised communities.

Women have far more limited access to extension services than men due to their not traditionally being seen as a beneficiary group for technical information, and their non-ownership of mobile phones. There are also structural challenges with extension services, including staff shortages, lack of village-level deployment of functionaries, regional disparities, and operational inconsistencies within the extension programme. As a result, the current extension framework does not address the objectives of knowledge transfer and effective decentralisation, especially in remote villages.

Recommendations

- Combining short- and long-term climate information can aid decision making across spatial and temporal scales, and can help systems to become more resilient to both current and future climate risks. Setting up processes, institutions, and infrastructure that align short-term and long-term action, coupled with improvements in knowledge, will help improve the utility of climate information for decision making.

- Tailored climate products and information (agro-advisory services provided by the Watershed Organization Trust (WOTR), in coordination with the India Meteorology Department) – that are scaled to local contexts and realities, and delivered in appropriate formats at appropriate times – are being increasingly recognised as important for enabling climate-resilient decision making in different sectors. Achieving this requires a collaborative effort between multi-level institutions in order to develop forecast systems, maintain and strengthen observation networks, and engage with different communities to co-develop relevant information.

- The important role played by knowledge brokers should be recognised by formal governance structures and better supported. For example, knowledge brokers could be used to help integrate local practices with state development policies and programs, and subsequently these processes could be institutionalised.

- Dealing with the layered inadequacies of extension services, particularly in the context of small and marginal farmers, requires using a mix of approaches, and state and non-state interventions. More specifically this means:

    - Having the right mix of face-to-face engagement and ICT for outreach. Further, in areas where mobile ownership is still exclusively male-dominated, continued efforts should be made to tap into women's networking potential by holding separate training sessions by dedicated state institutions.

    - Incorporating a systemic reform of extension services, including additional fiscal support and investment in manpower, and considering the active involvement of non-state actors or processes to help bridge information gaps, particularly in areas where the reach of public extension is limited by structural and other barriers.

FUNCTIONING ECOSYSTEM SERVICES CAN ENHANCE CLIMATE RESILIENCE IN CITIES

Preserving functioning ecosystem services within the urban fabric is crucial for climate resilience planning. However in Bengaluru, these ecosystem services are being challenged by unplanned, haphazard urbanisation. Promoting ecosystem-service-based stormwater-management practices, and exploring alternative strategies that can enable stormwater attenuation or retention is necessary.

Urbanisation, especially in developing countries, is often accompanied by degradation of the surrounding environment and overall loss of biodiversity. When urbanisation is rapid (due to increased economic activity), institutional capacities are often found lacking, and unplanned development occurs. The result is the degradation and loss of crucial ecosystem services such as water provision, disaster protection, water treatment, and healthy environments. A changing climate will exacerbate and compound these urbanisation issues while the decline in ecosystem services is likely to make cities less resilient in the future.

Bengaluru is the fastest growing city in India. This growth is fueled by a sharp rise in economic activity, which inadvertently has had a major impact on ecosystems and biodiversity. While historically, the city attracted people for its pleasant climate provided by the large expanses of green cover and water bodies, the subsequent influx of growth has led to a reduction in green cover due to the disproportionate increase in impervious surfaces, along with the encroachment and degradation of water bodies.

Furthermore, due to weak governance and haphazard planning, the city has grown in an inequitable fashion where the peripheries have seen rapid urbanisation along with a high degree of fragmentation of processes and services.

Peri-urban growth in Bengaluru has had implications on the integrity of the watersheds that define the northern edge of the city. The management of water in a city, both for anthropocentric uses, and for those that cater to the health of the environment, should be critical components of planning practices. It is with this lens that we conducted geospatial analyses on a sub-watershed which is a part of the larger Yale Mallappa Shetty Kere (YMSK) watershed.

We found that changing rainfall regimes are increasing water extraction patterns. In addition, changes in land use and land cover, and reduced infiltration caused by rapid urbanisation, have led to a decline in groundwater levels. Encroachment of previously green and open spaces coincides with regions that have reported floods in the last few monsoon seasons. Land-use changes – typically in the form of an increase in impervious area, reduction in local water retention in lakes, a decrease in vegetation cover, and alteration in drainage patterns – have led to enhanced threats of flooding, and water shortages in the city. Stormwater, often mixed with sewage flowing through the urban landscape, has also led to widespread contamination of water bodies, causing degradation of ecosystem services attached to these water bodies.

Recommendations

- Ecosystem-service-based stormwater-management practices should be promoted to better conserve stormwater as a resource, while in the process providing additional ecosystem service benefits including hydrological services, climate regulation, and flood mitigation.

- There is a need for exploring alternative strategies that enable stormwater attenuation or retention within urban environments. Low Impact Development (LID) is one such suggested approach. Green Infrastructure-based development (such as LID) is intended to mimic the pre-urbanisation hydrology of the location or city, thereby providing a valuable ecological service. It is possible to identify potentially viable spaces within urban catchments and to map them at a high resolution with the intention of rejuvenating hydrological flows in cities. This is technically feasible for Bengaluru, but the social implications of doing so need to be extensively studied first.

WORKING WITH STAKEHOLDERS TO IMPROVE ADAPTATION AT MULTIPLE SCALES

IIHS has been involved in various processes of climate policy discussions at the local, national and international levels. We were significantly present in the IPCC process with Aromar Revi being the Coordinating Lead Author on the IPCC Special Report on 1.5 degrees. Chandni Singh and Amir Bazaz were Contributing Authors to this report. Aromar Revi is also a Coordinating Lead Author in the next cycle of IPCC's Assessment Report 6 on Chapter 18 "Climate resilient development pathways", and Chandni Singh is a Lead Author (Working Group II, AR6) on Chapter 10 "Asia". We have and will continue to influence climate policy through the IPCC engagement, with the bulk of our policy influencing work being guided by ASSAR research. We were also able to present research findings from ASSAR, especially on 'Assessing Sensitivity and Vulnerability to Climate Change', at a UNFCCC process: Nairobi Work Programme called the 11th Focal Point Forum. We will continue to engage with this forum and other related ones so as to influence climate policy processes.

At the national level, IIHS, along with representatives from DECCMA and HI-AWARE created a Country Engagement Group and produced three national level policy briefs: on Hotspots, Migration, and Adaptation Policy. These were launched in an event attended by national level policy makers, and disseminated widely to policy and decision makers. We hope that the findings presented will build significant external decision-making capacities. We will continue, through this network, to engage with policy process at multiple levels.

ASSAR's findings were frequently discussed during the flagship IIHS annual event, Urban Policy Dialogues (UPD), with a range of audiences including policy makers, practitioners and researchers. Through UPD and the National Consultations on Climate Change (which were a regular feature during ASSAR), IIHS has been able to create a network of governmental and non-governmental professionals, and has been continuously building their capacities while also benefiting from their experience in and knowledge of other contexts and sectors.

Our Transformative Scenario Planning (TSP) process on water security in Bengaluru was an imaginative exercise that helped bring together multiple stakeholders. While the objectives of the process were to engage stakeholders in a scenario planning exercise, it also enabled the creation of a cohort of institutions and actors that regularly engaged on other issues in the city. The trust, mutual respect, understanding of alternate language, and knowledge exchange mechanisms developed through this process have enabled IIHS to maintain a sustained dialogue within the group, which has been leveraged to create responses to multiple other challenges facing Bengaluru.

Responding to the needs identified on the ground, IIHS co-organised a Capacity Development Workshop on Integrating Climate in Development Projects funded through ASSAR's Grants for Local Adaptation Support (GLAS). This was aimed to build frontline capacities of local NGOs, especially from Mysore Resettlement and Development Agency (MYRADA) in both Kolar and Gulbarga. MYRADA was our local partner through multiple phases of our research, and we consciously aimed to ensure that they benefited from this partnership.

We also aimed to build capacities of organisations like MYRADA in order to encourage reflexive and critical thinking about their work at the interface of development and climate change/variability, which in turn will directly impact vulnerable communities that they work with on the ground. Finally, we used these collaborations as opportunities to influence MYRADA's research methods and to facilitate knowledge exchange for bringing in climate concerns into development planning efforts.

NEXT STEPS FOR RESEARCH, POLICY AND PRACTICE

Climate change and its impacts are being progressively, albeit at a slow place, recognised as an important challenge in the Indian context. Most of the state responses have been largely project-driven or in mission mode, with no systematic understanding of how climate change intersects with social and economic development trajectories in various regions. Governance structures, processes, and mechanisms are also inappropriate for managing climate stresses, with extreme discontinuities across administrative and policy boundaries. These challenges could be addressed in the following ways:

- Sustained external capacity building efforts are desirable and these should be institutionalised. Research evidence, across multiple scales and contexts, needs to be organised into appropriate learning material for policy makers. For example, IIHS has been actively engaged, using various institutional avenues, in offering electives such as Sustainable Cities and Climate Change and Human Settlements as part of the institutional Urban Fellowship Program, a nine month urban fellowship. In addition, IIHS is also involved in developing a MOOC on Cities and Climate Change that uses ASSAR research as teaching cases and is aimed at practitioners, policy makers, researchers, and citizens across the world.

- It is important that a clear, unambiguous message goes to policy makers that current adaptation is largely autonomous, and short-term and multiple barriers (technical, institutional, social, economic, cultural) interact to shape effectiveness and sustainability of local adaptation. There is an urgent need to build climate-specific capacities, and to carefully analyse the long-term impacts of climate on people and systems. Adaptation planning and implementation should be expanded from a narrow, reactive perspective, towards a regional agenda that incorporates longer-term changes.

- Current planning based on five-year-plans is unable to address entrenched structural vulnerabilities (determined by who you are, and where you live). Climate change is not explicitly considered in planning because the focus tends to remain on immediate risk management or poverty reduction. Although this focus has yielded reasonable results in the short-term, it is unable to prepare vulnerable groups for future climate risks. Deeper, sustained transformation would require an imagination that merges structural vulnerability concerns with proximate and long-term climate risks, and articulates a policy pathway that is regionally designed (across the dynamics of the rural-urban continuum), with wellbeing of the most vulnerable at the core. Transformational actions that include deep, systemic changes are thus essential to deal with structural vulnerabilities as well as projected climatic risks.

- Inter- and transdisciplinary research is necessary for identifying appropriate policy interventions, for which structured engagements across the science, policy and practice community is essential. For example, climate projections need to be integrated with adaptation prospects and local vulnerability assessments to be able to inform policy makers about the limits of adaptation planning.

- Systematic assessment, recognition, and institutionalisation of varied sources of knowledge systems is necessary. It appears that local knowledge is helping build resilient communities but needs to be recognised and used for large-scale, long-term systemic change. It also appears that access to knowledge, and knowledge translation would be critical in managing climate-induced risks, but access mechanisms need to be carefully structured.

- Serious inconsistencies exist between national and regional development pathways. Largely motivated by political economy concerns, there are huge disparities across development pathways at scale and with incoherent objectives and aims. These are largely due to unclear incentives and accountability mechanisms which themselves are outcomes of rigid institutional structures, discontinuities across governance regimes, and unclear responses to emerging stresses like climate change.

- There is a need for new institutions and governance structures. Many of the climate commitments remain as plans, and with insufficient and inappropriate implementation. Incumbent institutions and governance structures are inadequately equipped to manage climate-induced transitions, which are happening simultaneously with complex structural transformations. There is a need to re-imagine new institutional regimes to manage this complex structural transformation, with climate action and development concerns going hand-in-hand.

AUTHORS

Amir Bazaz* (abazaz@iihs.ac.in),
Indian Institute for Human Settlements
Brendon Bosworth (brendon.bosworth@mailbox.org),
University of Cape Town
Tali Hoffman (tali.s.hoffman@gmail.com),
University of Cape Town
Lucia Scodanibbio (scolucia@gmail.com),
University of Cape Town

ADDITIONAL RESOURCES

ASSAR. 2015. *ASSAR's animated climate messages for India*. [Video]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2015. *ASSAR Theory of Change.* [Video]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2015. *Planning for climate change in the semi-arid regions of India*. [Information brief]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2015. *South Asia regional diagnostic study: Report summary.* [Information brief]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2016. *Climate change in the semi-arid regions of India - Warli animation*. [Video]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2016. *Key findings from ASSAR's regional diagnostic study & initial research: Bangalore sub-region, Karnataka*. [Information brief]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2017. *Does climate information help people address current and future climate risks?* [Video]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2017. *Insight: Out of mind.* [Video]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2017. *Life in Hebbal Settlement, Bangalore, India: A reality sketch.* [Video]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2017. *Preparing for Transformative Scenario Planning (TSP) in India.* [Video]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2017. *The impact of drought in Gulbarga Region, Karnataka, India*. [Video]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2018. *Climate knowledge brokering in Nagaland, India.* [Video]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2018. *Climate knowledge brokering in Rajasthan, India.* [Video]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2018. *Dreaming of a better life: Let's recognise and value people's changing aspirations.* [Infographic]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2018. *Gender is one of many factors that influence how we are impacted by and respond to climate change.* [Infographic]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2018. *Household relationships help determine whether and how we can – or can't – respond to pressures.* [Infographic]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2018. *In semi-arid regions, women are not necessarily victims or powerless: They are often diversifying their livelihoods and increasing their agency*. [Infographic]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2018. *Sometimes our interventions can lead to unintended consequences: A well does not always lead to wellbeing*. [Infographic]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

ASSAR. 2019. *A focus on wellbeing can link adaptation to outcomes that matter to people*. [Information brief]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Basu, R. and Bazaz, A. 2016. *Assessing climate change risks and contextual vulnerability in urban areas of semi-arid India: The case of Bangalore.* CARIAA-ASSAR Working Paper. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Basu, R. and Morchain, D. 2017. *On a road trip to find common ground: Can the goals of the private sector be compatible with sustainable development?* [Comic]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Bendapudi, R., Kumbhar, N., Gaikwad, P. and Lobo, C. 2019. Agro-met services and farmer responsiveness to advisories: Implications for climate-smart agriculture. In: W. L. Filho (ed.) *Handbook of climate change resilience.* Cham: Springer. Link to book. Link to chapter. Link to poster.

CARIAA. 2018. *Climate adaptation policy*. [Information brief]. Collaborative Adaptation Research in Africa and Asia (CARIAA). Link.

CARIAA. 2018. *Understanding migration in India.* [Information brief]. Collaborative Adaptation Research in Africa and Asia (CARIAA). Link.

CARIAA. 2018. *Understanding vulnerabilities using a hotspot approach*. [Information brief]. Collaborative Adaptation Research in Africa and Asia (CARIAA). Link.

Chaturvedi, R., Bazaz, A., Shashikala, V., Krishnaswamy, J., Badiger, S., Bunyan, M., Sanjay, J. and Mujumdar, M. 2018. *Regional climate messages for South Asia.* CARIAA-ASSAR Working Paper. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Davies, J., Singh, C., Tebboth, M. G. L., Spear, D., Mensah, A. and Ansah, P. 2018. *Conducting life history interviews: A how-to guide*. [Manual]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Deshpande, T., and Michael, K. 2017. *Living on the edge: A case study of Bangalore's migrant waste pickers.* [Photo essay]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Deshpande, T., Michael, K. and Bhaskara, K., 2018. Barriers and enablers of local adaptive measures: A case study of Bengaluru's informal settlement dwellers. *Local Environment*. DOI: 10.1080/13549839.2018.1555578. Link to information brief.

Few, R., Morchain, D., Spear, D., Mensah, A. and Bendapudi, R. 2017. Transformation, adaptation and development: Relating concepts to practice. *Palgrave Communications*, 3: 17092. DOI: 10.1057/palcomms.2017.92. Link to summary.

Few, R., Singh, C., Spear, D., Davies, J., Tebboth, M. G. L., Sidibe, A, Mensah, A. and Thompson-Hall, M. 2018. *When adaptation barriers and enablers intersect: Key considerations for adaptation planning drawn from ASSAR's findings.* [Information brief]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Gajjar, S. P. 2016. *Life and Water at Rachenahalli Lake.* [Photo essay]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Gajjar, S. P., Jain, G., Michael, K. and Singh, C. In press. Entrenched vulnerabilities: Evaluating climate justice across development and adaptation responses in Southern India. In: K.K. Bhavnani, J. Foran, P.A. Kurian and D. Munshi (eds.) *Climate Futures: Re-imagining Global Climate Justice*. ZED Books. Link to book.

Gajjar, S. P., Singh, C. and Deshpande, T. 2018. Tracing back to move ahead: A review of development pathways that constrain adaptation features. *Climate and Development*. DOI: 10.1080/17565529.2018.1442793. Link to summary

Hegde, G., Singh, C. and Kaur, H. 2018. *Adaptation as innovation: Lessons from smallholder farmers in rainfed Karnataka.* [Information Booklet]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link to English version. Link to Kannada version.

Hegde, G., Sasidharan, S. and Bazaz, A. In prep. Traditional knowledge systems and the role of knowledge brokers, in India. Link to poster.

Kaur, H., Bazaz, A. and Srinivas, A. In prep. Understanding access to knowledge systems and rural perspectives from Karnataka.

Krishnaswamy, J., Bunyan, M., New, M., Bazaz, A., Wolski, P. and Daron, J. In prep. Are semi-arid regions in Africa and Asia climate-change hotspots?

Mascarenhas, K., Bhargava, V. and Bazaz, A. In prep. Advocating green infrastructure based development for resilience planning: Bengaluru case study.

Michael, K., Singh, C., Deshpande, T. and Bazaz, A. 2017. *Dimensions of vulnerability in rural and urban areas: A case of migrants in Karnataka.* [Information brief]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Michael, K., Deshpande, T. and Ziervogel, G. 2018. Examining vulnerability in a dynamic urban setting: The case of Bangalore's interstate migrant waste pickers. *Climate and Development*. DOI: 10.1080/17565529.2018.1531745. Link to summary. Link to information brief.

Michael, K., Deshpande, T. and Bhaskara, K. In prep. The political economy of climate change and vulnerability in a neo-liberal city: A case of Bengaluru's informal settlements. Link to summary.

Perez, T. In prep. Thinking differently about planning processes to enable climate change adaptation in Namibia and India. Link to summary.

Poonacha, P. and Koduganti, M. 2017. *Thinking critically about the future of water security in Bengaluru, India using Transformative Scenario Planning.* Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Poonacha, P. and Koduganti, M. 2018. *Using Transformative Scenario Planning to think critically about the future of water security in Bangalore.* Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Rahman, A., Basu, R. and Singh C. In prep. Exploring the interface between climate change and migration: Evidence from India.

Rahman, A., Singh, C. and Bazaz A. In prep. Climate change in urban areas: Differential vulnerability and adaptive actions in Bangalore.

Rahman, A., Singh, C. and Srinivas, A. In prep. Mobility along the rural-urban continuum around a large Indian metropolis: Implications for climate adaptation.

Ramarao, M. V. S., Sanjay, J., Krishnan, R., Mujumdar, M., Bazaz, A. and Revi, A. 2018. On observed aridity changes over the semiarid regions of India in a warming climate. *Theoretical and Applied Climatology.* DOI: 10.1007/s00704-018-2513-6. Link to summary.

Ramarao, M. V. S., Sanjay, J., Krishnan, R., Mujumdar, M., Bazaz, A. and Revi, A. In prep. Projected changes in aridity over India using high resolution CORDEX South Asia climate simulations.

Rao, N., Singh, C., Solomon, D., Camfield, L., Alare, R., Angula, M., Poonacha P., Sidibe, A. and Lawson, E. In prep. Managing risk, changing aspirations and household dynamics: Implications for wellbeing and adaptation in semi-arid Africa and India. Link to summary. Link to presentation.

Rao, N., Mishra, A., Prakash, A., Singh, C., Qaisrani, A., Poonacha, P., Vincent, K. and Bedelian, C. In prep. Women's agency and adaptive capacity in climate change hotspots: A qualitative comparative analysis from Asia and Africa.

Revi, A., Bazaz, A., Krishnaswamy, J., Bendapudi, R., D'Souza, M. and Pahwa Gajjar, S. 2015. *Vulnerability and adaptation to climate change in semi-arid areas in India.* CARIAA-ASSAR Working Paper. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Sami, N. 2017. Multi-level climate change planning: Scale, capacity and the ability for local action. In: S. Moloney, H. Fuenfgeld and M. Granberg (eds.) *Local Action on Climate Change*. London, UK: Routledge, pp. 92-110. Link to book. Link to chapter.

Sami, N. 2018. Localising environmental governance in India: Mapping urban institutional structures. In A. Luque-Ayala, H. A. Bulkeley and S. Marvin (eds.) *Rethinking Urban Transitions: Politics in the Low Carbon City*. London, UK: Routledge. Link to book. Link to chapter.

Shenai, N. and Bhaskara, K. 2017. *Mind the Gap.* [Photo essay]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Singh, C. 2015. What farmers really need - And it isn't 'skilling' Or relief Packages. [Web article]. *Huffington Post*. 16 October 2015. Link.

Singh, C. 2017. Using life histories to understand temporal vulnerability to climate change in highly dynamic contexts. *SAGE Research Methods Cases*. DOI: 10.4135/9781526440358. Link to summary. Link to manual.

Singh, C. 2019. Migration as a driver of changing household structures: Implications for household livelihoods and adaptation. *Migration and Development.* DOI: 10.1080/21632324.2019.1589073. Link to summary.

Singh, C . In press. Of borewells and bicycles: The gendered nature of water access in Kolar, Karnataka and its implications on local adaptive capacity. In: A. Hans, N. Rao and A. Prakash (eds.) *En-gendering Climate Change: Learnings from South Asia*. New Delhi, India: Routledge.

Singh, C. and Basu, R. In prep. Moving in and out of vulnerability: Interrogating migration as an adaptation strategy along a rural urban continuum in India. Link to summary.

Singh, C. and Gautam, M. 2015. *Urban dualities: A photo essay of Bangalore city, India.* [Photo essay]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Singh, C., Basu, R. and Srinivas, A. 2016. *Livelihood vulnerability and adaptation in Kolar District, Karnataka, India: Mapping risks and responses.* Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Singh, C., Daron, J., Bazaz, A., Ziervogel, G., Spear, D., Krishnaswamy, J., Zaroug, M. and Kituyi, E. 2018. The utility of weather and climate information for adaptation decision-making: Current uses and future prospects in Africa and India. *Climate and Development,* 10(5): 389-405. DOI: 10.1080/17565529.2017.1318744. Link to summary. Link to video.

Singh, C., Deshpande, T. and Basu, R. 2017. How do we assess vulnerability to climate change in India? A systematic review of literature. *Regional Environmental Change*, 17(2): 527-538. DOI: 10.1007/s10113-016-1043-y. Link to summary.

Singh, C., Gajjar, S. P. and Deshpande, T. 2016. *Policies, projects and people: Exploring the adaptation-development spectrum in India*. CARIAA-ASSAR Working Paper. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Singh, C., Urquhart, P. and Kituyi, E. 2016. *From pilots to systems: Barriers and enablers to scaling up the use of climate information services in smallholder farming communities*. CARIAA Working Paper. Collaborative Adaptation Research in Africa and Asia (CARIAA). Link.

Singh, C., Michael, K. and Bazaz, A. 2017. *Barriers and enablers to climate adaptation: Evidence from rural and urban India.* [Information brief]. Adaptation at Scale in Semi-Arid Regions (ASSAR). Link.

Singh, C., Tebboth, M. G. L., Spear, D., Ansah, P. and Mensah, A. In prep. Opening up the methodological toolkit on climate change vulnerability and adaptation research: Reflections from using life history approaches.

Singh, C., Solomon, D., Bendapudi, R., Kuchimanchi, B., Iyer, S. and Bazaz, A. 2019. What shapes vulnerability and risk management in semi-arid India? Moving towards an agenda of sustainable adaptation. *Environmental Development*. DOI: 10.1016/j.envdev.2019.04.007. Link to summary.

Singh, C., Solomon, D., Bendapudi, R., Kuchimanchi, B., Iyer, S. and Bazaz, A. In prep. Examining barriers and enablers to adaptation in semi-arid India.

Singh, C., Rahman, A., Srinivas, A. and Bazaz, A. 2018. Risks and responses in rural India: Implications for local climate change adaptation action. *Climate Risk Management,* 21: 52-68. DOI: 10.1016/j.crm.2018.06.001. Link to summary. Link to information brief.

Spear, D. and Singh, C. 2017. How to help farmers prepare for climate change. [Web article]. *The Conversation*. 21 September 2017. Link.

Thomas, R. and Mascarenhas, K. In prep. Changing groundwater regimes and geosystem services of Nagawara catchment, Bengaluru district.

Ziervogel, G., Satyal, P., Basu, R., Mensah, A. and Singh, C. In prep. Vertical integration for climate change adaptation in the water sector: Lessons from decentralisation in Africa and India.

Photographs in this section: Hanna Smith, Indian Institute for Human Settlements, Sumetee Gajjar

ASSAR
Adaptation at Scale in Semi-Arid Regions

iihs™
INDIAN INSTITUTE FOR
HUMAN SETTLEMENTS

WOTR
water gives life

atree

CARIAA
Collaborative Adaptation Research
Initiative in Africa and Asia

UKaid
from the British people

IDRC
International Development
Research Centre

CRDI
Centre de recherches pour le
développement international

This work was carried out
under the Collaborative
Adaptation Research Initiative
in Africa and Asia (CARIAA),
with financial support from the
UK Government's Department for
International Development (DfID) and the
International Development Research Centre
(IDRC), Canada. The views expressed in this
work are those of the creators and do not
necessarily represent those of DfID
and IDRC or its Board of Governors.

Design and layout:
Rothko Brand Partners
www.rothko.co.za