Evaluating the resilience of forest dependent communities in Central India by combining the sustainable livelihoods framework and the cross scale resilience analysis

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Resilience has moved from being a peripheral ecological concept to a central goal, in the development discourse. While the concept has become popular, operationalizing resilience has been difficult. Many frameworks have been proposed to operationalize resilience but no common framework has been agreed upon. The present article demonstrates a step by step method to operationalize livelihood resilience analysis, for communities that are affected by climate change by taking the case of rural household livelihoods in villages around Ratapani Wildlife Sanctuary in Central India. The article combines the Sustainable Livelihood Framework (SLF) with the Cross Scale Resilience Analysis (CSRA), as a way to operationalize resilience. The CSRA is found to be simple, systematic and applicable in diverse contexts. The systematic and holistic asset, process and institution-based analysis under the SLF, supports the CSRA by defining the system and identifying associated important shocks that affect the system. Through the analysis, it was realized that the impact of shifts in government policies on rural livelihoods is much greater than the impacts of climate change. The livelihood is worst affected when the shift in government policies coincides with impacts of climate change. The article argues that combining the SLF with the CSRA can provide a standardized method for livelihood resilience analysis of poor natural-resource dependent communities in developing countries. Handling the dynamic nature of these complex adaptive social-ecological systems in the resilience analysis should be the next goal to tackle.

Keywords: Adaptation, central India, climate change, resilience, rural livelihood.

Introduction

CLIMATE change is predicted to have severe implications on natural and social sectors[1], and there are merits in both mitigation and adaptation strategies to address it[2,3]. The resilience approach has been proposed to prioritize the vulnerable areas for focused adaptation efforts around the world. However, resilience also proves difficult to measure, a characteristic which limits its utility in the implementation of adaptation programming[4–6]. To address this challenge, the present article offers a novel framework for measuring the resilience of local livelihoods.

Climate change will affect the attainment of poverty eradication and environmental sustainability, two Millennium Development Goals (MDGs) which are also anticipated to play a role in the Sustainable Development Goals (SDGs). The Sustainable Livelihood Framework (SLF) has been proposed to understand the linkages between livelihoods and the environment[7–10]; however, it has been criticized for its inability to address large scale issues such as global warming and environmental degradation[11].

The use of resilience in the current context has gained momentum in the climate change debate, although it has been in existence since 1973. Operationalizing the concepts of resilience would greatly benefit the development sector. Of the many frameworks proposed[4–6,12,13], four-step cross scale resilience analysis[14,15] provides a simple and systematic method to operationalize resilience. Meanwhile, the SLF is a familiar tool to development organizations, having been used since the 1990's[7,10,11]. It provides a clear and comprehensive method to describe a local livelihood system, its processes, and the shocks that can affect it. Combining the strengths of the SLF and resilience concepts will greatly benefit the development sector in tackling the joint challenges of poverty and climate change.

This study pilots a systematic method to operationalize resilience analysis by integrating two generic frameworks, i.e. Cross Scale Resilience Analysis (CSRA)[14] and improved SLF[7,10,16]. The methodology is evaluated by taking the case of household livelihoods of a rural village panchayat in central India.

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Resilience and the sustainable livelihood framework

The concept of resilience has moved from being a peripheral concept in the field of ecology to being proposed as a central goal in the fields of sustainability, disaster-risk reduction and adaptation[1,4,12,17–20]. There are many definitions of resilience that are available and used by different organizations. We incorporate the definition of social-ecological resilience from the Resilience Alliance[21] as: (i) the amount of change the system can undergo and still retain the same controls on function and structure, or still be in the same state, within the same domain of attraction; (ii) the degree to which the system is capable of self-organization; and (iii) The ability to build and increase the capacity for learning. Frameworks for on-the-ground and policy-relevant resilience research and management have been proposed by multiple authors[22–31]. However, due to a diversity of sectors and issues in which the concept of resilience is being applied, a common operational framework is still not agreed upon[26]. The current article presents a novel framework for integrating CSRA and SLF as useful methods for livelihood resilience analysis.

Resilience analysis

Resilience analysis tools can be categorized into forward-looking and retrospective frameworks[32]. Studies based on retrospective frameworks[33–39] look for evidence that past community-based natural resource management systems have (or have not) increased their ability to absorb change, self-organize, innovate, experiment and learn. Such frameworks describe and explain past process of adaptation and transformation. They draw upon concepts from social learning, social networks, adaptive management and adaptive governance in social-ecological systems.

Meanwhile, forward-looking frameworks are focused on predicting or increasing the buffering capacity of the social-ecological system to absorb change in the future. Studies based on such frameworks[4,5,14,15,22,29–31,40–42] have their roots in engineering and ecology and are focused on defining and modelling natural resource management systems in quantitative terms, developing measurable indicators of resilience, and contributing to management plans.

Sustainable livelihood framework

Households (HHs) show the potential to bridge the micro-level individualistic behaviour with the macro-level political economy of development[43]. The focus on livelihood comes from the recognition (both in policy and research), that a majority of HHs and especially poor HHs, do not depend upon single income generating activities for their sustenance[44,45]. A commonly quoted definition for 'livelihood' is: '*A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base.*'[46]

It has been argued[45] that HHs have access to a portfolio of tangible and intangible assets and make decisions on the use of this portfolio based on their livelihood goals, which could be as diverse as improving their diets to building social support networks. The strategy that the HH implements depends upon its use of the portfolio of options available, and the HH's capacity to find livelihood opportunities. This further depends on number of characteristics internal to HH, including HH composition, as well as external social-ecological and economic variables[7,46,47].

In recognition of the fact that HHs construct their livelihoods based on a number of complex socio-political and ecological factors, various development organizations have tried to develop simplified frameworks to better understand them. The livelihood framework is a tool to conduct livelihood analysis[48]. It defines the scope and provides the foundation for analysis, identifies objectives and appropriate interventions to support livelihoods, and becomes the shared point of reference for all who are concerned with supporting livelihoods, thus enabling complementarity of interventions and tradeoffs between outcomes to be assessed.

While the livelihoods framework is a widely accepted tool for development research and intervention, it also has limitations. It has been pointed out that livelihood approaches have been unable to incorporate global economic, political and environmental changes[11]. SLF provides a comprehensive snapshot of the variables and associated dynamics of a given person's, household's, or community's livelihood in a particular region, at a particular time. While the snapshot provides a good understanding of various livelihood options used by a local HH, the framework is unable to recognize the dynamics of factors that work in tandem and influence each other over time. Limited understanding of the dynamic nature of livelihood and the factors that influence it, reduces the ability to bring more effective solutions that can withstand the test of time.

Given these shortcomings, subsequent studies[16,49–51] have proposed newer frameworks that include power, politics and governance. It is further argued that, moving forward, the livelihood framework should incorporate the issues of knowledge, politics, scale and dynamics between various actors[11]. Incorporation of these would allow a better understanding of how local livelihoods are impacted by dynamic changes over a given period of time, as well as, how local communities manage and adapt to changes.

While knowledge can be incorporated as an element of 'human assets' measured by the currently existing sustainable livelihoods framework, the issues of scale and dynamics are more challenging to integrate into the current framework, and require a different approach. The use of complex system modelling techniques can allow researchers to analyse both concrete livelihood assets and larger issues of scale, dynamics and governance. Although such an analysis is outside the scope of this article, the framework reported here is the first step towards our larger project of applying system dynamics modelling to the analysis of household vulnerability and resilience to climate change[52].

Conceptual and operational framework

Both the livelihood framework[11] and resilience analysis[53] are important and well-known approaches for analysing complex social-ecological systems. In the context of climate change adaptation, where there is a need to analyse the impact of climate stress on poor communities around the world, there are valuable insights that one can gain from working with both the approaches simultaneously. While the livelihood framework takes a holistic approach to recognize the multiplicity of actors, strategies and outcomes[11] in a given system, the resilience framework comfortably handles the issues of multi-scale and actor dynamics. The detailed, multi-actor, strategy- and outcome-conscious livelihood approach, focused on complex rural systems can be strengthened by the resilience of social-ecological approach that recognizes feedbacks, multi-scale, multi-actor and temporal dynamics. Thus, the resilience approach can essentially provide the next step to a more thorough and holistic livelihood analysis. Similarly, SLF can provide a structured way to carry out resilience analysis by providing a holistic method that accounts for a variety of assets, policy and institutions that govern them, local processes, the seasonality of activities, and the various livelihood strategies that define the survivability of local communities.

The present research focuses on the forward-looking resilience analysis approach. The research will use CSRA[14] which is an improvement over the 4-step resilience analysis[15]. The modified forward-looking framework is simple, systematic and broad enough to engage with a variety of systems and interests in the development sector. The framework also allows for incorporation of a variety of techniques that might suit the needs of different studies.

CSRA is supported by an improved SLF framework[16] that incorporates the asset of power in the overall analysis. Addressing these challenges[11], the study argues that knowledge can be incorporated in the human capital element of the SLF, whereas the issues of power, politics and governance can be engaged with the incorporation of political capital. The issues can also be dealt in some part through the institutions and processes within the SLF. The following sections describe the conceptual integration of sustainable livelihood framework with four steps of CSRA.

Step 1: Resilience of what: Step 1 of resilience analysis begins with defining the social-ecological system of interest. It defines the boundaries of the system and the scales of influence that affect the system. This is also the step to understand the major dynamics between various actors that are present in and affect the system. Using local, traditional knowledge and historical analysis, we can understand how the system arrived to its current state. We can thus determine the main drivers of past and present social and ecological dynamics.

SLF is well placed to describe and define the state of a system by looking at the past and present states of various system assets. It allows for a systematic appreciation of local conditions, and of the small- and large-scale drivers that affect them. The framework also allows for a systematic understanding of the policies, institutions and processes that influence the system. Finally the framework allows for both a qualitative and quantitative understanding of how communities and households construct and understand their livelihoods.

Step 2: Resilience to what: Step 2 focuses on identifying the key unpredictable and uncontrollable drivers of system behaviour, as well as, stakeholders' vision for the future, and possible future contrasting public policies. Thus, the step comes up with 3–5 plausible future scenarios through stakeholder participation, and identifies cross-scale issues that might contribute to unpredictability.

With its focus on assets, seasonal variabilities, policies, and institutions, SLF provides a systematic way of analysing the shocks that affect or can possibly affect local communities. It also allows understanding of the interconnections between various assets, policies and institutions and how communities utilize these interconnections to sustain themselves. Through these approaches, SLF offers an opportunity to aggregate and analyse complex sets of information about sources of uncertainty, in a manageable and comprehensible way.

Through this systematic analysis, major shocks affecting the system can be easily identified and prioritized based on their frequency, severity, extent, and the level of threat perceived by local communities. The identification and analysis of these uncontrollable and unpredictable shocks (as per the community's perceptions), is important for understanding community resilience.

Step 3: Resilience analysis: Resilience analysis is conducted on the identified shocks and stressors. Based on the most important shocks and stressors identified in the

system, the analysis is done by creating 3–5 scenarios that are considered to be most likely. Each developed scenario is a combination of important shocks and stressors in a particular state (favourable/unfavourable). These scenarios are developed based on interactions with local stakeholders, policy makers and subject experts to arrive to the most inclusive and realistic understanding of challenges the system faces at its level. The scenarios thus developed, allow for identification of the most plausible conditions under which a system should be tested for its resilience.

The social-ecological system of interest can then be analysed to understand its ability to handle such scenarios. For the purpose of this study, we evaluate resilience as the extent of impact of a shock on livelihoods, and the ability of village households to recover from such an impact. Such an analysis can be done both quantitatively and qualitatively. The ability of SLF to organize the complexity of information in a systematic way, also allows for a step-by-step and careful analysis of the ability of a system to respond to scenarios.

Step 4: Resilience management: Resilience management involves stakeholders' evaluation of the process of resilience analysis, as well as the policy and management outcomes that such analysis generates. Step 4 requires on-the-ground consultation for policy implementation. Due to the scope of the project reported here, this research article is limited to demonstrating the complementarity of CSRA and SLF for operationalizing resilience analysis.

Methodology: Operationalizing resilience analysis in central India

This study seeks to understand the extent to which livelihoods of communities will be affected in different future scenarios and whether rural households can maintain current livelihoods for their sustenance. For the purpose of this analysis, a village panchayat system (social-ecological system) that was far from cities (to reduce the influence of urban effects) and close to the forested areas (to ascertain stronger ecological dependence) was sought. The village panchayat of Pipaliya Goli, located in the central Indian state of Madhya Pradesh, was chosen because it is situated at the boundary of a protected forest area. It is two hours away from the nearest city and is significantly dependent on forest resources for its sustenance.

As discussed above, we used CSRA as the guiding framework for resilience analysis. The first two steps of CSRA, as described above, are strengthened by using SLF (Figures 1 and 2). SLF provides an opportunity for systematic analysis of the complex livelihood landscape for Step 1 of the CSRA and helps identify major risks associated to assets, policies, institutions and seasonalities for Step 2 of the CSRA. The third step of CSRA calls for resilience analysis. For the third step, major risks identified during Step 2 by SLF analysis are prioritized through stakeholder consultations. The combinations of these risks are then developed for scenario analysis. Through scenario analysis, we examined the level and extent of exposure of various livelihood activities, to the combined impacts of different risks, ascertained through scenarios. This further determined vulnerability of the overall system, and provided a clear picture of its resilience.

Data was collected using both qualitative and quantitative techniques. Qualitative techniques like focus-group discussions, participatory rural appraisals and semi-structured interviews, were conducted with various stakeholders, such as government officials, political leaders, businessmen, village members, elders and local NGO representatives, to ascertain important livelihood drivers. Oral histories were also collected from village elders to get a historical perspective. Finally, quantitative household socio-economic data was collected through census of 319 households within 6 villages in the village panchayat, for four consecutive years, i.e. 2009–2012. The survey data were analysed to evaluate the percentage contribution of various livelihood activities to an average household's income.

For scenario analysis, major shocks (high likelihood and high impact) that can affect livelihoods (associated to various assets, institutions and process), were identified and ranked through the Strength Weakness Opportunity and Threat (SWOT) analysis, conducted under focus-group discussions. The top three most likely shocks were then combined, to create likely scenarios through interviews with various stakeholders and resident experts. The percentage of income (data collected through survey), exposed to combined risks under different scenarios, was then considered to be vulnerable, suggesting vulnerability of local households under various scenarios.

Operationalizing resilience analysis: the case of Village Panchayat Pipaliya Goli

Study area

The Panchayat, or village-level administrative and governance unit, of Pipaliya Goli is one of the 72 panchayats that come under the Obaidullaganj Development Block, a government-designated development unit, in the state of Madhya Pradesh in India. The village panchayat is located about 55 km south of the state capital, Bhopal. The panchayat belongs to Raisen District, which is 60 km from the district headquarters in Raisen. The nearest urban location, Goharganj Tehsil is 20 km from the village panchayat, and acts as a market and administrative center (Figure 3).

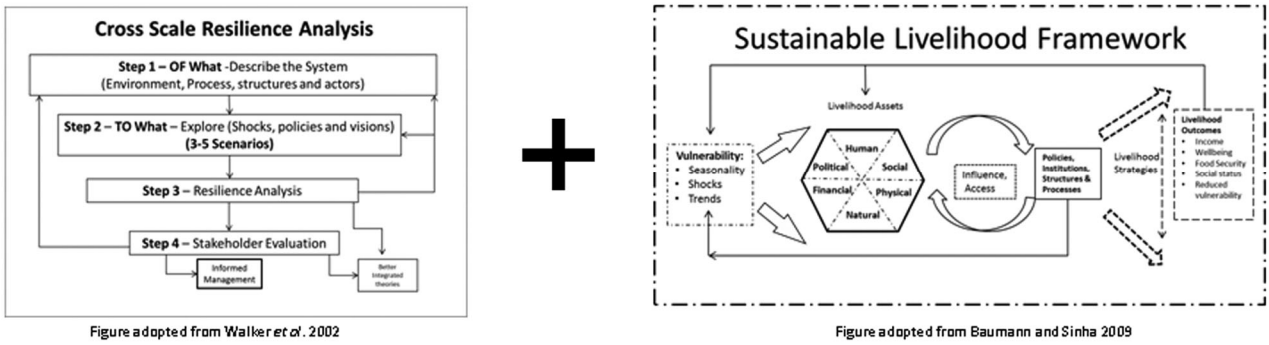

Figure 1. Four step resilience analysis and the sustainable livelihood framework.

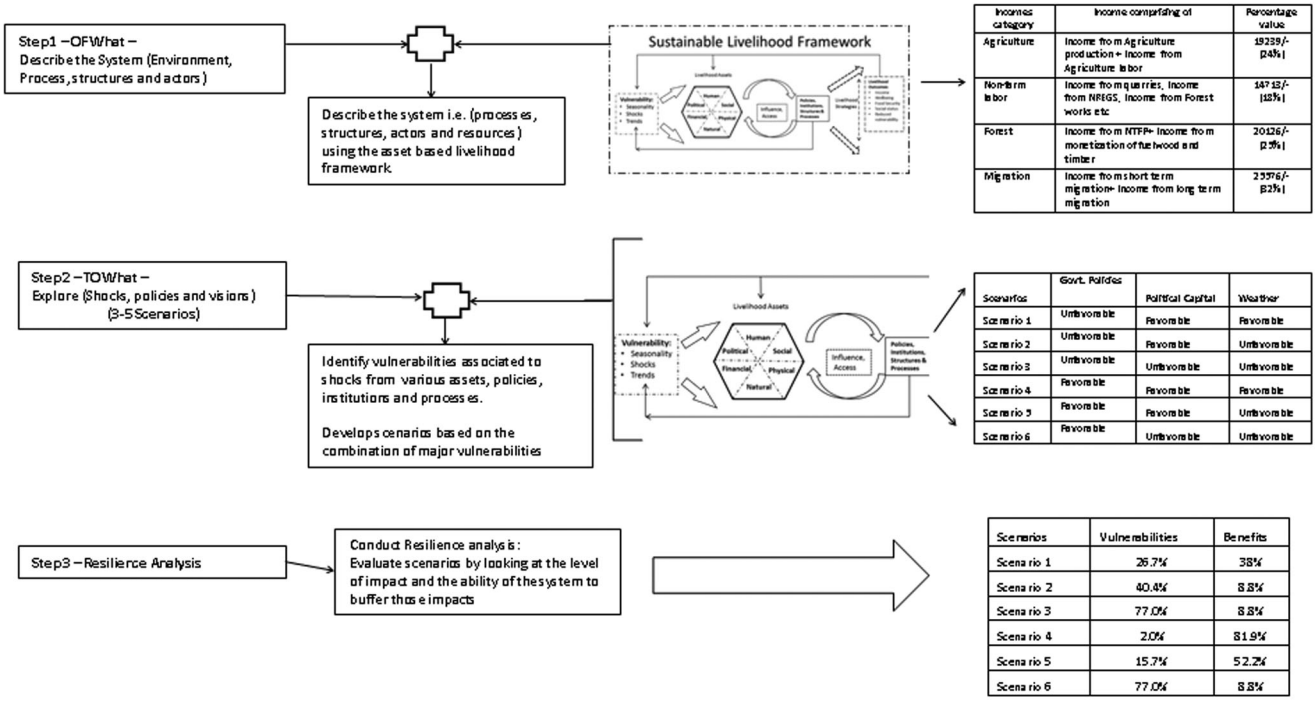

Figure 2. Conceptual diagram to merge the CSRA with the SLF.

The panchayat falls into the Agro-climatic zone of Vindhyan Plateau (MP-5); Central Highlands (Malwa and Bundelkhand), hot sub-humid, (dry) Ecoregion (10.1)[54]. The current rainfall patterns have lately been erratic (as residents confirmed in focus-group discussions) in the panchayat and have led to significant loss of agricultural crop production.

The Panchayat of Pipaliya Goli has six villages in its constituency. These villages are Pipaliya Goli, Panjher, Khodra, Karakwani, Barhakheda and Bandarchuha. The dominant tribe in the region is the Gond tribe followed by Bhils and Banjaras. Many of these villages are remote and have only recently been connected with all-weather roads. The panchayat is situated just outside Ratapani Wildlife Sanctuary (RWLS) area. The sanctuary is in the process to be upgraded to become a national park. A significant population within the region lives below poverty line and subsists with a combination of rain-fed agriculture, manual labour, and extraction and utilization of forest-based resources. Recently many households have started temporarily migrating to nearby urban areas, in search of employment and mostly work as manual labourers in the construction industry.

Assets and livelihood strategy through SLF

Assets: Assets can generally be described as material and social resources that a household can use to make a meaningful living and/or achieve desirable goals[43,55]. These assets can then be used in multiple flexible ways and tradeoffs to achieve a desired outcome. Assets under

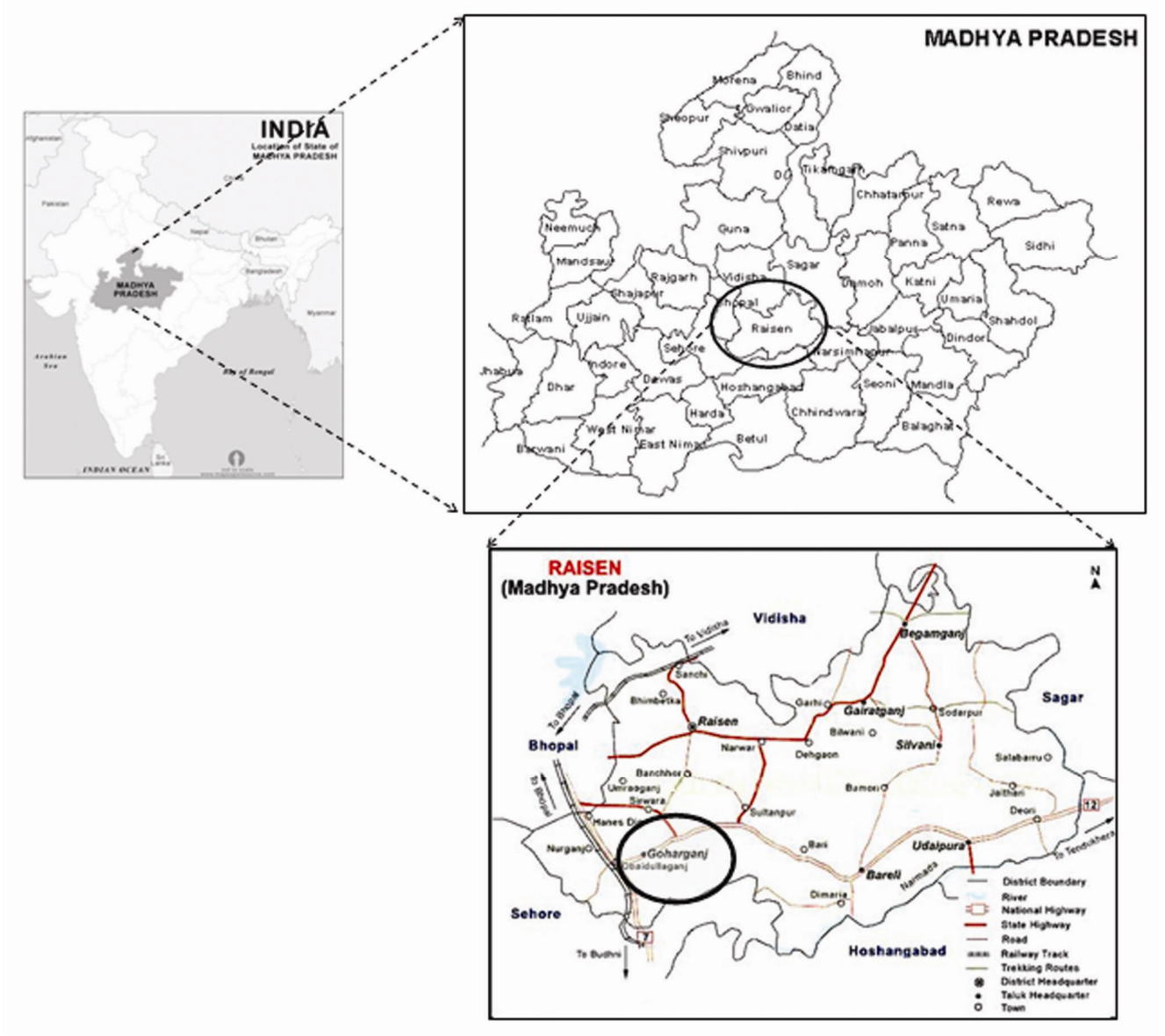

Figure 3. Map of Obaidullaganj development block and Goharganj Tehsil in Raisen district.

the six capitals (social, political, physical, natural, financial and human) can be considered as building blocks and can be substituted or converted into each other[16]. Participatory observation, focus-group discussion, literature review and secondary data, were used to evaluate the six capitals of panchayats. A brief description of the six capitals in Pipaliya Goli is as follows.

Physical assets: The village panchayat has recently been connected with all-weather roads. It has been provided with a Higher Secondary school and now boasts of two primary government and two private medical centres. Recently a small irrigation dam has also been constructed. Electric connections while available, do not provide continuous electricity. Overall, the physical assets of the panchayat have increased significantly over the last decade, compared to other panchayats in the region. However, the conditions of roads have deteriorated due to lack of maintenance.

Social assets: Many villages in the panchayat are ethnically homogeneous. Gond tribes dominate the village panchayat followed by Bhilalas and Banjaaras. Although ethnic conflict is uncommon, conflicts do occur during local panchayat elections, in which Gond tribes are seen by other groups to be dominating. Kinship plays a major role in social organization within the panchayat. Most of the village panchayat members (especially in the Gond tribe) consider themselves relatives of one another both within the village and across the panchayat. This is true for the

Table 1. Average income per ha of agriculture land in the panchayat (Rs/ha)

Year	Bandarchuha	Barhakheda	Karakwani	Khodra	Panjher	Pipaliya Goli
2009	5666	18075	11331	11971	19214	7760
2010	7163	20153	12515	12794	17227	7181
2011	6449	20045	11399	12521	19399	8666
2012	4545	19331	9530	9424	17619	10089
Average	5956	19401	11194	11678	19214	8424

Bhil and the Banjara tribes as well. The village panchayat also boasts of strong personal relations to the members of ruling political party in the state.

Financial assets: Government programmes, like 'farmers' credit cards', provide loans at reduced interest to farmers in the region. However, not many farmers have land and hence are unable to access loans. The ones who have land but have not used it, have reported using this service minimally. Micro-credit was initially available through Self-Help Groups (SHGs), but has recently been unavailable as the NGOs running SHGs have moved out of the region. Other government-sponsored pension schemes are available to households in the panchayat, but are not sufficient to assure household sustenance.

Human assets: The health indicators for the panchayat are fairly low. The sex ratio (females to 1000 males) of children under five years is very poor (773/1000) as compared to the state average of 936/1000. The district infant mortality rate (129/1000 babies) is very high as compared to the national average of 55/1000 babies[56,57]. Malnutrition and health care are also problems in this region. The body mass index in the region (18.43 ± 1.94) is fairly low compared to state with the highest of 19.33 ± 2.16 (ref. 58). However, literacy rates in the village panchayat are rising with the establishment of the new high school and proposal for a higher secondary school in the offing.

Natural assets

Agriculture: As compared to the neighbouring districts (Hoshangabad, Rs 25,269/ha and Bhopal, Rs 21,219/ha), the economic productivity of agricultural land in Raisen (Rs 14,230/ha) is low[59]. Comparatively, productivity of village agricultural lands in the panchayat (Table 1) is also low, ranging from 5956 to 19,214 per ha. Only 25% of land is irrigated in the panchayat. Moreover, 40% of households in the panchayat are landless. The average farm size in the panchayat is 1.98 ha which is smaller than the state average of 2.2 ha. The panchayat does not have water for irrigation for the entire year, but recent damming of the river will provide benefit to some farmers in this region. Since 75% of agriculture is rainfed, variations in weather patterns make this area significantly vulnerable. Increased soil and moisture conservation work, through government supported National Rural Employment Guarantee Scheme (NREGS) is considered to improve productivity of the region as well. Some work on soil and moisture conservation has been done in agricultural fields of few villages.

Quarries: Six open-cast stone quarries are operating in and around the village panchayat, that provide employment to more than 80% of the households in the region. However, these quarries will come under the threat of closure since most of them are operating close to protected areas[60].

Forests: The forest around the Panchayat is classified (according to Champion and Seth) as 5A/C 1b-Southern Tropical Dry Deciduous Teak Forest and 5A/C 3 – Southern Tropical Dry Deciduous Mixed Forest. Most of the forest in the region is of IVb quality (poor), and most of the trees in the region are of younger age class[61]. Due to high species richness, the area has been designated as a national park[62]. The village panchayat benefits significantly by extracting from forest resources. Species like Tendu (*Diasporos melanoxylon*), Achar (*Buchnannia lanzan*), Mahua (*Madhuca indica*) are important sources of non-timber forest products (NTFP). The fruits collected from these species and the firewood collected from the forest, constitute roughly 25% of their overall livelihood income. However, due to such extractions and grazing, the region is under heavy biotic pressure with significantly low regeneration rates.

Political assets: We define political assets as the level of direct connection to the ruling political party. It is mostly defined by how close is the ruling political party to village households. The panchayat has a very strong connection to the current ruling party of the state, and villagers consider party leadership to be connected to their families. Ruling parties in the state and in the village panchayat are also aligned. This alignment has facilitated significant material and non-material benefits to the panchayat in recent years. Approval of a high school, completion of an irrigation dam, development of village roads, and other developments can be attributed to smooth government functions, which are assisted by harmonious political interest and oversight. Thus, the village

Table 2. Average total income of a household in the village panchayat

	2009	2010	2011	2012	Average	Income (%)
Agriculture crops	12,010	12,963	13,333	13,289	12899 ± 615	16
Ag labour	5,980	6,313	6,458	6,608	6340 ± 268	8
Non-farm labour	13,772	14,679	15,655	14,745	14713 ± 769	18
Short-migration	3,747	3,957	4,527	6,702	4733 ± 1353	6
Long-migration	16,525	18,354	17,132	31,362	20843 ± 7054	26
NTFP	5,808	5,864	4,792	4,953	5354 ± 561	7
Wood	14,771	14,771	14,771	14,771	14771	18
Loans	409	670	1,959	1,801	1210 ± 784	1
Total	73,022	77,572	78,628	94,231	80863 ± 9238	100

panchayat has a high political capital. While political connections are here to stay, the five-year local (Panchayat) and state wide elections, can shift these connections and reduce opportunities for the panchayat.

Livelihood strategy: The livelihood opportunities that are available to HHs are based on the assets detailed above, in combination with policies, processes and institutions. Describing all the policies is outside the scope of this article, but more information on policies that influence these villages is available[52]. Here, we focus on locally relevant processes and institutions.

There are six villages of the Pipaliya Goli Panchayat. Factors such as caste configuration, relative closeness to the roads, closeness to the forest and protected area boundary, and finally, respective settlement period, contribute and dictate household livelihood opportunities. The most common livelihood opportunities availed by households are agriculture, non-farm labour, short and long-term migration, collection of NTFPs, and rearing livestock. Households also receive financial support from the government, but most of this support is limited in its ability to sustain a household. The majority of households have similar livelihood opportunities. However, the difference lies in the relative weight of contribution of these activities in overall household livelihood strategy.

Most of the HHs practice rain-fed agriculture, including growing soybean or rice during monsoon season and wheat, grams (chickpeas) during winters. Once members of a HH complete sowing/harvesting of their own field, they provide labour assistance to other HHs, either as labour exchange or for wages. The more capable HHs rent agriculture field from other landholders to increase their agriculture production. Post agriculture season, HHs engage in collecting NTFP through the forest and prepare it for sale, the other members of the HH search for labour in and around the village.

HHs that have access to outside information and opportunities, often migrate to provide services as wage labour in industrial town and other labour markets. In summer, HHs wait for government-assisted labour work that is supported under the national rural employment guarantee scheme, where they work as wage labourers for various construction and maintenance works. Some HHs have members who are educated and are able to get employment through NGO's and other panchayat related information collection work. In limited cases, members with higher education migrate to bigger cities or study further. However, many return to help their families during sowing season.

Most self-sustaining livelihood activities are time-sensitive, and do not occupy the whole year. With all the livelihood activities combined, households are able to work roughly for 6–8 months. Remaining time is spent working non-farm, non-forest labour, either in nearby industrial towns or in quarries close to the village. Non-farm labour becomes an important source of income for most households in the panchayat.

The average household income over the last 4 years, is roughly Rs 80,863/year (Table 2). Household income can be grouped into four large categories: income from agriculture, non-farm labour, income from forest and income from migration. Income from agriculture and forest roughly constitutes about 24% and 25% of total household income respectively, while income from non-farm labour and migration constitutes 18% and 32% respectively (Table 3).

Identifying major shocks

The vulnerability of livelihoods can be analysed by studying shocks, trends and exogenous variables, that can disrupt access to capital or disrupt continuation of services that are employed for creating livelihood opportunities. In order to study vulnerability, it has been argued that resilience of these assets should be studied[7].

Major shocks were identified through the SWOT analysis based on interviews and focus-group discussions, with panchayat households, government officials, and subject and local experts. A detailed description of major shocks and their impact on local livelihoods is available[52]. Based on risk perception and ranking, shifts in the following factors was considered to have a higher

Table 3. Income categories for the household

Incomes category	Income comprising of	Percentage value
Agriculture	Income from agriculture production + income from agriculture labour	19,239 (24%)
Non-farm labour	Income from quarries, NREGS, forest works, etc.	14,713 (18%)
Forest	Income from NTFP + income from monetization of fuelwood and timber	20,126 (25%)
Migration	Income from short term migration + income from long-term migration	25,576 (32%)

Table 4. Scenarios

	Govt policies	Political capital	Weather
Scenario 1	Unfavourable	Favourable	Favourable
Scenario 2	Unfavourable	Favourable	Unfavourable
Scenario 3	Unfavourable	Unfavourable	Unfavourable
Scenario 4	Favourable	Favourable	Favourable
Scenario 5	Favourable	Favourable	Unfavourable
Scenario 6	Favourable	Unfavourable	Unfavourable

likelihood of impact on household livelihoods: change in political capital in terms of political leadership at state level; changes in political leadership at the panchayat level (nature and character of leadership); health of household members; condition of roads and irrigation infrastructure; agriculture productivity (productivity of land); availability of non-farming jobs for households; shift in weather patterns – impacting agriculture and NTFP production; and government policies implementation of national park guidelines.

Scenarios – analysis

Building scenarios is an important way of incorporating possible risks and associated impacts that can happen in future. This allows resilience analysis to help reduce complexity, by focusing on futures that are most probable and important for the studied system. Based on likelihood of occurrence and severity of impact, we can identify major risks out of the eight risks mentioned above. These risks are: change in political capital both at state level and at local level; shift in weather patterns – impacting agriculture and NTFP production; and government policies – implementation of national park guidelines.

CSRA[14] suggests developing 3–5 scenarios for evaluation. For policy analyses, scenarios can be developed by combining factors/risks that are of highest importance to the system in future. For analysis, scenarios can be developed through the combination of these three factors in two different states (favourable/unfavourable) influencing livelihood strategies of a household (Table 4).

The major vulnerabilities and benefits to average household income under each scenario have been evaluated based on the exposure of various income categories to each risk (Table 5). A summary of these vulnerabilities and benefits is given in Table 6. The scenarios are described below.

Scenario 1: This scenario assumes that national park policies are fully implemented, however, the political alignment and weather conditions remain favourable. The impact of implementation of national park policies is high and will expose close to 47% (Table 5) of average household income. The loss of income is due to a ban on access to forest resources (timber, NTFP and grazing) and ban on stone quarries around protected areas (due to formation of eco-regions). However, strong political capital helps negotiate the livelihood rights of the local community. Due to favourable political capital, state government can create ways to protect livelihoods of local communities, by allowing (controlled) access to forest resources and create jobs with the tourism industry and forest department. Even then, such actions will be insufficient to take care of the income of all the households. Thus, even with favourable political capital only close to 21% of the average household income can be buffered. Favourable weather pattern will help buffer the income by an approximate 30%. However, since only 10% of the households can sustain themselves with agriculture. The rest (90%) still depend upon labour along with forest-based income. Overall roughly 27% of the average household income becomes vulnerable.

Scenario 2: This scenario assumes complete implementation of the national park policies. It assumes that weather conditions will be unfavourable but political alignment will remain favourable to villagers. The implementation of the park policy will affect about 47% (Table 5) of their overall income. Good political capital might be able to save up to 20% of this income. An unfavourable weather can impact an approximate 30% of average household income. Good political capital can buffer the impact by providing compensation (16%) to limited (land holding) families but the timing of compensation is arbitrary (as found from interviews). Overall, an approximate 40% of the average household income becomes vulnerable.

Scenario 3: In this scenario, we assume that all the factors will be unfavourable, i.e. national park policies will be fully implemented, weather conditions and political alignment both will be unfavourable. The impacts of

Table 5. Average HH income vulnerability to different scenarios

	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5	
	Rs	%	Rs	%	Rs	%	Rs	%	Rs	%
Establishment of national park boundary										
Relocation	0	0	0	0	0	0	0	0	0	0
Restriction on NTFP collection	5,354	7	5,354	7	5,354	7	0	0	0	0
Restriction on fuelwood and timber	14,771	18	14,771	18	14,771	18	0	0	0	0
Ban on quarries	13,389	17	13,389	17	13,389	17	0	0	0	0
Wildlife raids on crops (25% loss)	3,225	4	3,225	4	3,225	4	0	0	0	0
Loss of farm labour due to loss of crops	1,585	2	1,585	2	1,585	2	1,585	2	1,585	2
No relocation	0	0	0	0	0	0	0	0	0	0
Access to NTFP	0	0	0	0	0	0	5,354	7	5,354	7
Access to fuelwood and timber	0	0	0	0	0	0	14,771	18	14,771	18
Maintenance of quarries	0	0	0	0	0	0	13,389	17	13,389	17
Repayment for loss of crops	0	0	0	0	0	0	1,585	2	1,585	2
Benefits from tourism jobs	6,000	7	6,000	7	6,000	7	6,000	7	6,000	7
Benefits from forest jobs	1,532	2	1,532	2	1,532	2	1,532	2	1,532	2
Vulnerability from national park	38,324	47	38,324	47	38,324	47	1,585	2	1,585	2
Benefits of national park	7,532	9	7,532	9	7,532	9	42,631	52	42,631	52
Impact weather patterns	0	0	0	0	0	0	0	0	0	0
Benefit to the crops	12,899	16	0	0	0	0	12,899	16	0	0
Benefit of short-term labour	4,733	6	0	0	0	0	4,733	6	0	0
Benefit for farm labour	6,340	8	0	0	0	0	6,340	8	0	0
Loss of crops	0	0	12,899	16	12,899	16	0	0	12,899	16
Loss of short term migration	0	0	4,733	6	4,733	6	0	0	4,733	6
Loss of farm labour	0	0	6,340	8	6,340	8	0	0	6,340	8
Vulnerability from weather patterns	0	0	23,972	30	23,972	30	0	0	23,972	30
Benefits of weather patterns	23,972	30	0	0	0	0	23,972	30	0	0
Impact political capital	0	0	0	0	0	0	0	0	0	0
Delayed implementation	0	0	0	0	0	0	0	0	0	0
Reduced restrictions NTFP by 50%	2,677	3	2,677	3	0	0	0	0	0	0
Reduced restriction wood 50%	7,386	9	7,386	9	0	0	0	0	0	0
Allowing mining in the areas by 50%	6,694	8	6,694	8	0	0	0	0	0	0
Compensation for crop loss	0	0	12,899	16	0	0	0	0	12,899	16
Vulnerability of political capital	0	0	0	0	0	0	0	0	0	0
Benefits from political capital	16,757	21	29,656	37	0	0	0	0	12,899	16
Combined (vulnerability NP – political benefits)	21,567	27	32,640	40	62,296	77	1,585	2	12,658	16
Combined benefits (avg)	31,503	38	7,532	9	7,532	9	66,603	82	42,631	52

Table 6. Summary of vulnerabilities and benefits to average HH income under different scenarios

	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5	
Impacts/benefits	Rs	%	Rs	%	Rs	%	Rs	%	Rs	%
Vulnerability from national park	38,324	47	38,324	47	38,324	47	1,585	2	1,585	2
Benefits of national park	7,532	9	7,532	9	7,532	9	42,631	52	42,631	52
Vulnerability from weather	0	0	23,972	30	23,972	30	0	0	23,972	30
Benefits from weather patterns	23,972	30	0	0	0	0	23,972	30	0	0
Vulnerability from political capital	0	0	0	0	0	0	0	0	0	0
Benefits from political capital	16,757	21	29,656	37	0	0	0	0	12,899	16
Combined (vulnerability NP – political benefits)	21,567	27	32,640	40	62,296	77	1,585	2	12,658	16
Combined benefits (avg)	31,503	38	7,532	9	7,532	9	66,603	82	42,631	52

weather and national park access policies will not be buffered from the poor political capital. In total about 77% of the average household income will be severely affected (Tables 5 and 6). This scenario has the most severe implications for households. Forty two per cent of the households without land will come in conditions where they can be pushed out of the area because of lack of access to resources and hence reduced livelihood opportunities.

Scenario 4: This scenario assumes that the three factors are in favourable conditions, i.e. national park policies, political alignment and weather conditions. This scenario is the most benefiting where the income of most households will be better off (compared to the present) and there will be increased prosperity. Considering that the current access to income from quarrying, collecting NTFP and from timber and fuelwood is maintained. This scenario will support roughly 82% (Tables 5 and 6) of the average household income.

Scenario 5: This scenario assumes that there will be favourable national park policies, and political alignment and unfavourable weather conditions. Having favourable political capital will reduce impact of weather and increase the bargaining ability of local communities. The probability of having a favourable national park policy is higher when there is high political capital. In this scenario, the favourable capital will buffer approximately 52% (Tables 5 and 6) of the income that is vulnerable to the national park. Unfavourable weather can impact roughly 30% of the average household income. Impact of weather can be buffered by the political capital through increased compensation (16%) to families that practice agriculture. However, as mentioned in the earlier section, compensation on weather related events goes only to those who have land. In that case, 42% of the houses will still be directly affected. 16% of the average household income will become vulnerable.

Scenario 6: This scenario assumes favourable national park policies but unfavourable political alignment and weather conditions. As discussed, without political capital, favourable policies of national park cannot be bargained. So this scenario will essentially be reduced to scenario 3. In this case 77% of the average income will be vulnerable and 42% of families will be at risk of getting displaced.

Discussion: climate and public policy in rural livelihood resilience

This research analysed the resilience of livelihoods in Pipaliya Goli to shocks and uncertainty. Through focus-group discussions and SWOT analysis, three most likely and threatening risks were identified. The scenario analysis helped in evaluating the possible impact of individual and combination of risks. Through comprehensive evaluation of these scenarios, we can ascertain that local livelihoods are vulnerable and not resilient to the identified risks of changes in weather patterns, shift in government policies and change in political capital (Table 6). Through this analysis, we reinforce the existing understanding that shifts in government policy have a greater impact on household incomes as compared to shifts in weather patterns. Strong political capital can buffer against some of the risks from policies and weather. However, poor political capital would increase the likelihood of significant impacts on households' income and hence increase vulnerabilities. These findings support the arguments made by[63–65] which highlight the dependence of rural livelihoods on forest resources and the impacts of protected area policies on rural livelihoods.

In the present day, climate change is considered a major risk to communities worldwide. However, in this case-study, we found that rural household livelihoods have a much larger exposure to government policies as compared to climate change. The worst conditions will occur when unfavourable shifts in government policies, coincide with impacts of unfavourable weather on poor communities that do not have good political representation. In such a case, large number of village households will experience forced migration, leading to a significant change in their lives, identity and livelihoods.

Hence, while investing in local climate adaptation for rural communities, it is important to note that their vulnerability does not simply originate from weather shocks but also from fluctuations in government policies, which enables or constrains much of their livelihood capabilities. The study also showcases and strengthens the existing argument that a diverse livelihood portfolio for a poor rural household is certainly better to limit the exposure of a single risk.

As this project demonstrates, SLF and CSRA provide complementary approaches to understand and evaluate a complex social-ecological system, for its response to different shocks, and hence its resilience. SLF provides a holistic approach to identify major drivers (assets, processes, policies and institutions) that are important for sustenance of households in a given system. This enables the identification of risks associated with these drivers. Such risks can then be systematically evaluated for their impact on the overall system. Thus, SLF provides a very strong foundation to conduct resilience analysis. CSRA, meanwhile, is able to guide the analysis forward, beyond simply understanding the past development of the system, and helps develop scenarios based on perceived threats that the system can face in possible future. Thus, identification of major threats, their systematic prioritization and finally creating scenarios based on those threats allows the resilience analysis of a complex social-ecological system.

This combination of two approaches brings new challenges and opportunities for research associated with measurement of household resilience. There are various categories of livelihood strategies, i.e. accumulation, consolidation, compensatory and security[66]. The choice of a particular category depends upon the household's experience of socio-economic conditions, and learning from past experiences. This is an important dimension that differentiates between households based on their current

state and past experiences. Although the current analysis uses a generalized estimation for all livelihood behavior, future iterations might provide more nuanced analysis by segregating households based on their current state and experience.

While SLF is able to identify major drivers that help in sustenance of households, it is still just a snapshot in time. The interaction between different assets, process, policies and institutions is temporally dynamic. Future analysis should aim to capture this temporal variability of household behaviors and dynamics between assets, processes, policies and institutions. Further, difficulty in quantification of such dynamics makes it harder for measurement of resilience. Future analysis can cover the gap by using newer techniques such as complex-system modelling that can handle temporal dynamics and variability[52].

The current research demonstrates the merit of combining SLF and CSRA frameworks for the forward looking resilience approach. Under current climate change discourse where mainstreaming adaptation in development process has become the norm, it is important for development agencies to evaluate resilience and measure change through their interventions. While both SLF and CSRA have been developed independently, our research represents a novel attempt to combine these two approaches successfully for the analysis of livelihood resilience. The combination of frameworks and techniques adopted for analysis offers new methodologies for conducting a systematic livelihood resilience analysis of poor, natural resource-dependent communities. Further research should test these methodologies across different geographies and different resilience challenges, with the goal of generating a robust, standardized model for resilience analysis combining CSRA and SLF.

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