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SPECIAL SECTION: The Commons: A Revisit

Understanding How Local-level Environment Stewardship Initiatives Increase Livelihood Resilience to Climate Change: Insights from Rajasthan, India

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Abstract: Common property resources (CPR) are central for the sustenance of biodiversity and rural communities in India. Weak institutional governance and the lack of tenure rights for local communities over CPRs is resulting in degradation and over-exploitation of resources making rural communities vulnerable across India. Climatic variabilities further exacerbate existing socio-ecological imbalances multifold. Within the broader area of vulnerability and adaptation to climate change, this paper explores how restoration of CPRs through local environment stewardship initiatives contributes to the resilience of rural livelihoods in the face of climate change. A mixed-methods approach was employed to study this aspect in six villages in two districts in Rajasthan. It was found that secure property rights and collective management of CPRs enhances household resilience and improves ecological health. It concludes that processes supporting local self-governance need to be central to local adaptation to climate change, as they naturally create resilient and sustainable rural livelihoods.

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1. INTRODUCTION

India is particularly vulnerable to climate change, as around two-thirds of its population is rural and depend on climate-sensitive natural resources (Chatterjee *et al.* 2005). The increasing need to secure the livelihoods of these communities has therefore set the stage for climate change adaptation through social, institutional, physical, and structural alterations (Carabine and Lemma 2014; Hijioka *et al.* 2014). However, these adaptation strategies do not necessarily translate into reduced vulnerability of human systems, and, therefore, it is highly important to engage with people with different knowledge, experiences, and backgrounds to jointly address the challenges in framing adaptation approaches (Preston and Stafford-Smith 2009; Tompkins *et al.* 2010; Eakin *et al.* 2012).

Rajasthan shows the highest climate sensitivity among all regions in India due to more severe and frequent spells of drought (Rathore and Verma 2013). This adds another layer of vulnerability to existing rural developmental challenges, as 75% of the state's population is dependent on climate-sensitive sectors for its livelihood. Further, the state has only 1.2% of India's water and cultivable land resources, and over 20% of rural Rajasthan is landless (Rathore 2005). These conditions limit crop production, making livestock rearing and dependence on common property resources (CPRs) such as forests, pastures, waste lands, and natural water bodies, critical.

Access to CPRs is an important determinant of economic well-being in rural communities across India (Jodha 1986; Jodha 1992; Beck and Ghosh 2000; Beck and Nesmith 2001; Lesorogol 2008; Wolford *et al.* 2013; Thapliyal *et al.* 2019). CPRs are non-exclusive resources whose usage rights and obligations are shared by all members of the community (Ostrom *et al.* 1988; Ostrom 1990; Bromley and Cernea 1989; Janssen and Anderies 2013). CPRs therefore constitute an important component of the rural landscape in India, especially in Rajasthan, where they have socio-cultural, economic, and ecological significance. The commons-livestock-agricultural complex provides stability and security to rural households in an unpredictable environment (Rao *et al.* 2015). Studies conducted at the village level estimate that CPRs contribute 12–23% to the incomes of rural households (Jodha 1990).

In spite of the poverty-alleviating nature of CPRs (Jodha 1992; Reddy and Chakravarty 1999; Agarwal 2001, Ibisch *et al.* 2010), they continue to record declines in land quality and size (Jodha 1985; Mwangi and Wardell 2012). Although there is a risk of large-scale resource exploitation in case control of CPRs is transferred to communities, one must acknowledge that these communities used to have traditions of shared norms and mutual trust, and their behaviour in the experiments shows that communities still tend to be non-exploitative, non-commercial, and cooperative when prioritizing, planning, and managing resource sustainably (McGinnis and Ostrom 2014). While literature on rural communities and climate change adaptation exists in the Indian context, studies on rural communities, CPRs, and adaptation to climate change are limited (Bantilan *et al.* 2012; Aryal *et al.* 2020).

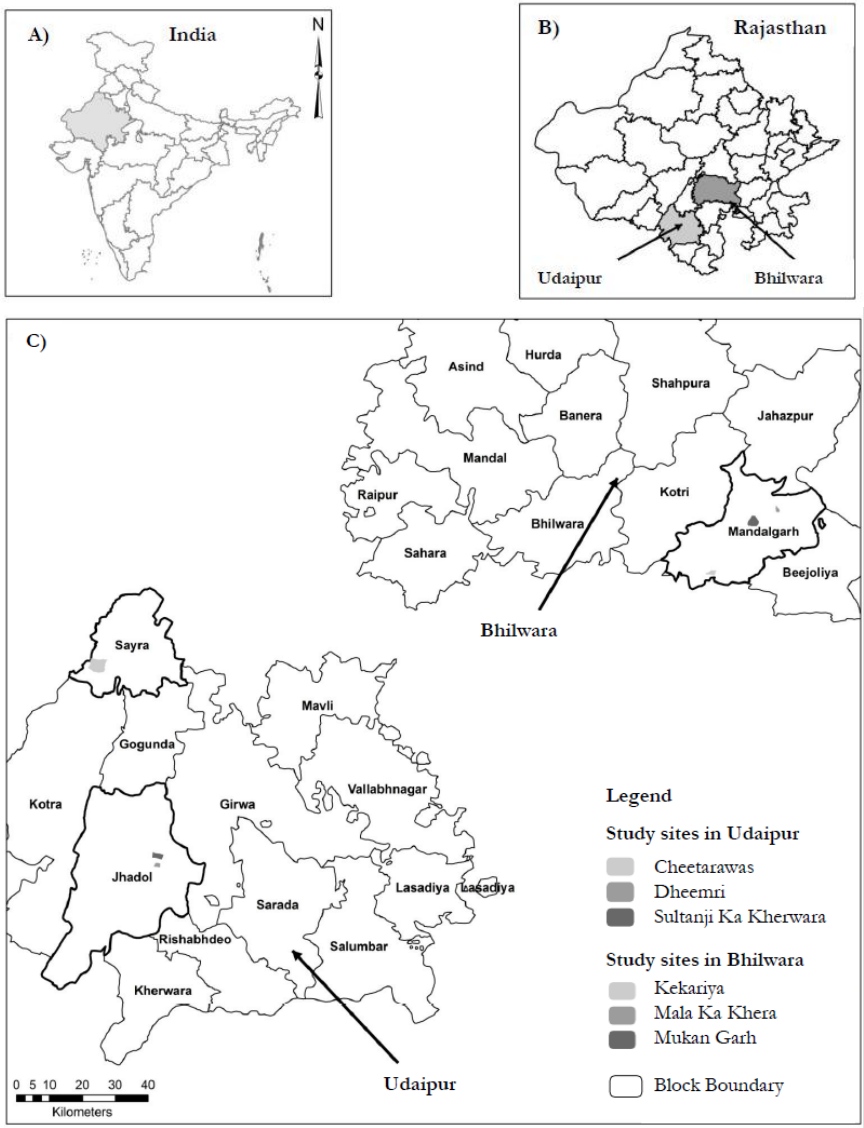
In view of this, in our paper, we study how the restoration of CPRs through environment stewardship initiatives at the local level can contribute to climate-resilient rural livelihoods. We studied six villages in Udaipur and Bhilwara districts, Rajasthan. We applied Ostrom's socio-ecological systems (SES) framework (Ostrom 2009) to understand how the complex social and ecological components of a system interact against the backdrop of a changing climate and resource usage.

2. MATERIALS AND METHODS

2.1 Study area and sample

We conducted this study in the state of Rajasthan, which is located in the north-western region of India (Figure 1). The Foundation for Ecological Security (FES) has been working in seven districts in Rajasthan since 1988, covering a total of 5,590 habitations, undertaking work towards conservation of natural resources, particularly CPRs, through the collective action of local communities. Hence, for this paper, we deliberately chose six villages across two districts—Udaipur and Bhilwara—based on the following criteria: i) over ten years of conservation work and ii) the availability of two-point data on ecological and socio-economic indicators over a period of five years. We present the characteristics of the villages in Table 1.

Figure 1: Location of the study [A) India map showing the state of Rajasthan; B) location of the study districts in Rajasthan state; C) location of the study talukas within each district]



Source: Adapted from Administrative Atlas of India, Census of India, 2011, and local government directory, 2015–16.

Table 1: The characteristics of the districts and chosen villages

Udaipur district: agro-ecological region: Northern Plains (and Central Highlands), including the Aravallis, hot semi-arid eco-region; average rainfall: 624.9 mm; temperature range: 0^{o}–48^{o}; soil type: red gravelly soil and red sandy soil.		
Village name	Demographic profile	Types of CPR and area
Sultanji ka Kherwara, Jhadol Block*	○ Population: 150 HHs. ○ Caste composition: OBC (75%); ST (24%): FC (1%). ○ Farmer composition: landless (7%); marginal (55%); small (37%); medium (1%). ○ Livestock profile: cattle(17%); buffalo (2%); sheep (1%); goat (80%). ○ Livelihood profile: agriculture and livestock rearing (75%); wage employment (20%); off–farm employment (5%)	Forest land: 140 ha.
Cheetarawas, Sayara Block	○ Population: 150 HHs. ○ Caste composition: ST (100%). ○ Farmer composition: marginal (98%); small (2%). ○ Livestock profile: cattle (32%); buffalo (2%); sheep (2%); goat (64%). ○ Livelihood profile: agriculture and livestock rearing (100%),	Forest land: 190 ha.
Dheemri, Phalasiya Block	○ Population: 185 HHs. ○ Caste composition: ST (100%). ○ Farmer composition: marginal (3%); small (97%). ○ Livestock profile: cattle (53%); sheep (1%); goat (46%). ○ Livelihood profile: agriculture and livestock rearing (75%); wage employment (10%); off–farm employment (15%).	Forest land: 88 ha.

contd...

Bhilwara district: agro-ecological region: Northern Plains (and Central Highlands), including the Aravallis, hot semi-arid eco-region; average rainfall: 597.2 mm; temperature range: 7.3°–46°; soil type: shallow black soil, mixed red and black soils		
Village name	Demographic profile	Types of CPR and area
Mala ka Kheda, Mandalgarh Block	○ Population: 40 HHs. ○ Caste composition: OBC (90.8%); ST (9.2%). ○ Farmer composition: landless (0%); marginal (50%); small (25%); medium (25%). ○ Livestock profile: cattle (14%); buffalo (14%); sheep (29%); goat (43%). ○ Livelihood profile: agriculture and livestock rearing (86%); wage employment (9%); off–farm employment (6%).	Two managed grazing land: 30 ha and 15 ha.
Mukan Garh , Mandalgarh Block	○ Population: 230 HHs. ○ Caste composition: SC (57 %); OBC (37%); FC (6%). ○ Farmer composition: landless (1%); marginal (52%); small (26%); medium (17%). ○ Livestock profile: cattle (21%); buffalo (19%); sheep (9%); goat (60%). ○ Livelihood profile: agriculture and livestock rearing (85%); wage employment (14%); off–farm employment (1%).	Forest land: 50 ha. Managed grazing land: 30 ha. Unmanaged revenue waste land: 18 ha.
Kekariya , Mandalgarh Block	○ Population: 110 HHs. ○ Caste composition: OBC (85%); ST (5 %); SC (5%); FC (5%). ○ Farmer composition: landless (4%); marginal (89%); small (5%); medium (2%). ○ Livestock profile: cattle (35%); buffalo (25%); sheep (6%); goat (33%). ○ Livelihood profile: agriculture and livestock rearing (82%); wage employment (12%); off–farm employment (6%).	Forest land: 100 ha. Managed revenue wasteland: 30 ha. Unmanaged revenue waste land: 150 ha.

Sources of Data: IMD (2019); FES Data Platform (2019); FES internal database 2013–2019; Hydrogeological Atlas of Rajasthan 2013 (GoR 2013); Agriculture Contingency Plans for Bhilwara and Udaipur districts (GoI 2012a, 2012b).

Notes: 1. Major crops, i.e. maize, pulses, sorghum, barley, wheat, and mustard, are the same for all sites.

2. * Block is the lowest administrative division in India.

3. List of acronyms: OBC – Other Backward Castes; ST – Scheduled Tribes; SC – Scheduled Castes; FC – Forward Castes or General category; HHs – Households.

2.2. Data collection process

FES uses a range of scientific survey formats to monitor ecological, social, and economic changes in its project areas over time. From among these, we selected three data sources for the time period 2013–2019 to build a comprehensive narrative on various aspects of the study. The data sources we used include:

i) Socio-ecological monitoring: FES uses International Forestry Resources and Institutions (IFRI) survey instruments to obtain socio-ecological data at the village level. IFRI facilitates multi-country, multi-year data collection and analyses data about forests, people, and institutions using a combination of research methods (IFRI 2013).

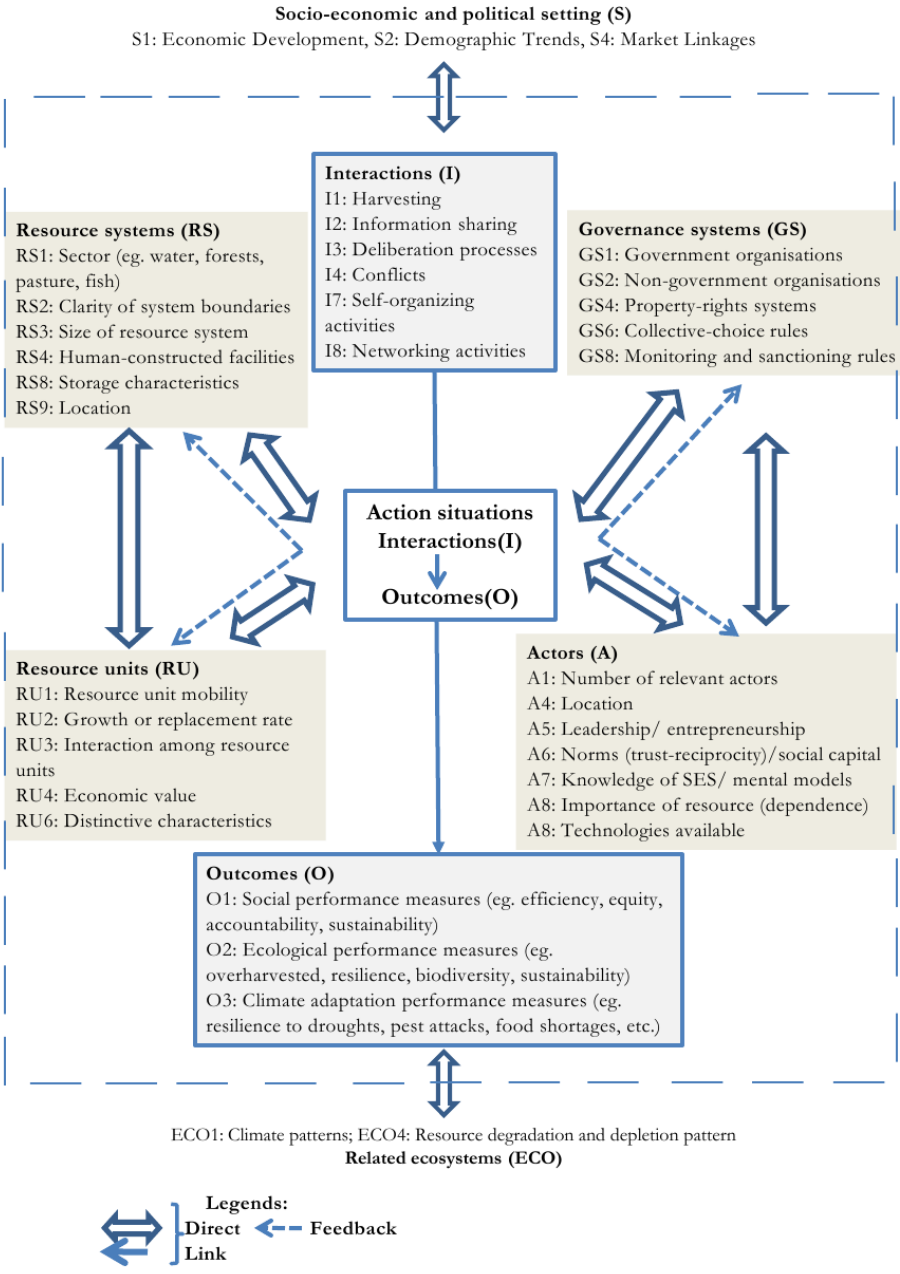
ii) Annual ecological monitoring: FES uses a comprehensive ecological monitoring approach to assess changes in the ecological condition of CPRs under community protection. It conducts regular annual ecological assessments through geographic information system (GIS) and community participatory methods on several parameters to track changes in community-managed CPRs and unmanaged CPRs. However, we restrict our study to biomass, vegetation density, and biodiversity aspects.

iii) Secondary data and independent studies on climate change adaptation: To link various climate change adaptation perspectives, we gathered data from two studies we had conducted in Rajasthan, covering aspects of the communities' perception of climate risks, the impacts they faced, and their adaptation responses.

2.3 Theory

Our study's aim stems from Ostrom's Social-Ecological Systems (SES) framework (Ostrom 2007; 2009), which suggests that socio-ecological outcomes are a function of the complex interactions among the diverse social and ecological components of that system. Building on the same stream of thought, in this paper, we apply a modified version of Ostrom's SES framework to analyse our findings (see Figure 2) on how local stewardship initiatives help systems adapt to extreme climatic events. To summarize, Ostrom's framework consists of four major subsystems—resource systems, resource units, governance systems, and actors. The interplay between these separate subsystems is mediated by complex interactions that produce outcomes that again feed back into the system to improve its functioning, robustness, and resilience. The focal SES interacts with social, economic, and political systems—and related ecosystems—considering them external variables that affect the system's vulnerability and adaptability in the long term.

Figure 2: Application of adapted version of Ostrom's SES framework



Source: Adapated from Ostrom (2007; 2009)

We therefore considered the six study villages to be six different SESs. We studied the socioeconomic and political context of each SES using the variables of livelihood and economic development, demographic trends, and market linkages, which gave insights into the socioeconomic status of households (HHs), their cultural background, and societal evolution. To understand the related ecosystems, we integrated climate variabilities and the impacts faced by communities living in the SES, as climatic variations have an effect on both, the social and ecological components of a system. The resource systems within each SES were the CPRs used by the communities, i.e., forests in the case of Udaipur district and grazing lands, revenue waste lands, and forests in the case of Bhilwara district. Here, we studied both biophysical aspects, i.e., location, size, productivity, and storage characteristics, along with social aspects, such as human-constructed facilities, as factors that determine the access rights and dependency patterns of HHs on the CPRs in the SES. For resource units, we mapped the types of products and changes in dependency patterns over time. We also mapped the characteristics of the products (mostly vegetation) in each location, by paying attention to their growth, as it affects the region's micro-climate. Under governance systems and actors, we looked at local relevant actors, community leadership, knowledge systems, and dependency on the resource, as they influence local stewardship initiatives that work to conserve CPRs. In governance systems, we also look at administrative systems, local rules and systems, and the role of associated stakeholders. To understand interactions, we looked at patterns of resource use and dependency on CPRs; forest–livelihood interactions; community perceptions about the condition of resource systems; use of technology; deliberation processes; conflict points; self-organizing activities; and networking activities, as they are important indicators of local stewardship. And lastly, for outcomes, we analysed social, ecological, and climate adaptation performance measures, based on which we elaborated how crucial actors and governance systems are maintaining the SES's equilibrium to absorb and respond to shocks.

3. RESULTS

3.1 The socio-cultural and economic setting in the study sites

In Udaipur district, the three study sites we focused on were Cheetarawas, located in Sayara block, Dheemri located in Phalasiya block and Sultanji ka Kherwara, located in Jhadol block. Cheetarawas and Dheemri are predominately tribal habitations, while Sultanji ka Kherwara has a predominantly OBC population. The main sources of livelihood for households (HHs) in these sites are agriculture, livestock rearing, sale of

forest produce, and wage labour. They also see a high rate of rural–urban migration, mostly for off-farm employment. As Udaipur district falls in the southern Aravalli hill region, which is predominantly forested, the forests hold great social and cultural significance for the inhabitants. All three study sites are located around 50–70 km away from Udaipur city, while the nearest town markets are around 10 km away. Though remotely located, Udaipur city stills plays a significant role in accessibility to larger markets and other urban services.

In Bhilwara, the study sites, Mala ka Kheda, Mukan Garh, and Kekariya, are all located in Mandalgarh block. Here also, agriculture and livestock rearing are the main livelihood sources for HHs. These sites have access to various marketplaces within their gram panchayats (8–12 km), Mandalgarh town (20–35 km), and Bhilwara city (40–65 km). Good road connectivity provides ample opportunity for HHs in the region for marketing dairy products and employment in the large–scale textile industries in Bhilwara. In addition to this, high mineral availability, such as limestone deposits, is also attracting attention from the cement mining and marble industries. Due to these factors, the status of migration is quite low in the study sites in Bhilwara as compared to Udaipur.

3.2 CPRs: use and vulnerability to climate change

In Udaipur, the reserve forest area was the main CPR. Cheetarawas, Dheemri, and Sultanji ka Kherwara have access to about 190 ha, 88 ha, and 140 ha of reserve forest lands respectively; these fall under the forest department's jurisdiction, but a village forest protection and management committee (VFPMC), constituted under the Joint Forest Management arrangement, manages them. These forest areas are shared by other habitations, making them a highly contested resource. The forest tract in Cheetarawas, located on the fringes of Kumbhalgarh wildlife sanctuary, is dense and mature, with abundant wild flora and fauna. Meanwhile, the forests of Dheemri and Sultan ji ka Kherwara have more shrub-like vegetation. In all three sites, the forests hold important cultural and social significance and act as an important source of several forest products, fodder, fuel wood, and water for the inhabitants. All three sites have a history of massive deforestation by various actors and are further impacted by frequent droughts and reduced rainfall over the years. However, local environment stewardship initiatives (which we discuss further in Section 3.3) have helped restore these forest resources, considerably stabilizing the livelihoods of tribal and other poor HHs in the region. The inhabitants of the region harvest and sell a range of forest produce, namely custard apple *(Annona squamosa),* tendu leaves *(Diospyros melanoxylon),* java plum *(Syzygium cumini),* Indian jujube *(Ziziphus mauritiana),* date *(Phoenix dactylifera),* goose

berry *(Phyllanthus emblica), khair (Acacia catechu), baheda* or myrobalan *(Terminalia bellirica),* Dyer's oleander *(Wrightia tinctoria), ratanjot (Jatropha curcas), umbiya (Miliusa tomentosa),* flame of the forest *(Butea monosperma),* bamboo *(Dendrocalamus strictus*), and a variety of fodder grasses.

In the Bhilwara study sites, there were three different types of CPRs: the reserve forest managed by the village forest protection management committee (VFPMC); grazing land managed by the village pastureland development committee (VPDC); and unmanaged revenue waste land under the jurisdiction of the revenue department. All the HHs in the study sites are dependent on all the CPRs; however, the availability of products from each CPR varies considerably, influencing their dependency patterns. Forest lands, spanning across 50–100 ha, were once a good source of fuel wood and fodder for the community, but due to strict governance and restrictions, imposed by the Forest Department, the communities are unable to access these lands and have a higher dependence on other types CPRs for fuel wood and fodder. Revenue waste lands, which are mostly unmanaged, have been neglected, and are used indiscriminately for fuel wood, fodder, forest produce, and timber. Continuous degradation over the years has depleted these resources, reducing their availability considerably. The village pasture lands and revenue waste lands span across 30 ha, 35 ha, and 40 ha in the villages of Mukan Garh, Mala Ka Khera, and Kekariya, respectively. Over the past five years, the dependence of communities on managed grazing lands has increased, especially for fodder consumption; their dependence on CPRs for timber has reduced but has remained the same for fuel wood and intangible benefits.

Our interaction with HHs at both sites revealed that their dependency on the sale of forest produce has increased over time. In the Udaipur sites, we found increased dependency on certain forest produce, such as custard apple, bamboo, *baheda*, and *palash*, due to a higher market value, particularly in Cheetrawas. Although in recent years migration has increased in the region, the forests continue to be a good source of income for a certain section of HHs. In Bhilwara, the greatest dependency across all the study sites was on managed grazing lands compared to other CPRs. This can be attributed to the higher availability of fodder due to better management practices. From the forests, tendu leaves, *amla* (goose berry), *ber* (jujube), and certain species of fodder have become economically significant for the socioeconomically weaker HHs, as they help meet their subsistence needs. Dependence on CPRs for fodder in both the Udaipur and Bhilwara sites have increased manifold between 2013 and 2019, while dependence on CPRs for timber and fuel wood species have somewhat reduced in the Bhilwara study villages, specifically with the introduction of several

government schemes that propose cleaner and greener alternatives to timber for house construction and fuel wood for cooking.

In this context, already marked by several issues, changes in rainfall and temperature and the occurrence of extreme events not only have an ecological impact on the CPRs—they also influence how communities may use or manage resources, exacerbating already existing vulnerabilities. Independent studies on climate change adaptation in both sites indicated that communities identified a range of climate risks in the region (see Table 2). In the Udaipur sites, the major climate risks they perceived were erratic rainfall patterns, dry spells, and cyclonic storms. In Bhilwara, HHs reported erratic rainfall patterns, high-intensity rainfall, and a rise in temperature. Based on participant perceptions, the sites in Udaipur were more affected by changes in climate phenomena than the sites in Bhilwara. However, in both sites, HHs reported that climate risks have intensified over the last five years.

Table 2: Climate risk perceptions of communities in the study sites

Climate risks identified	Impacts perceived	
	Udaipur	Bhilwara
Reduced overall precipitation	M	L
Dry spells	H	M
Erratic rainfall patterns	H	H
High-intensity rainfall	L	H
Rising temperature	M	H
Rising winters temperatures	L	L
Increase in drought situations	M	L
Delayed onset of the monsoons	L	L
Cyclonic storms in monsoons	H	L

Note: Acronyms: Scale: H = high impact, M = medium impact, L = low impact

In terms of impacts (see Table 3), in the Udaipur sites, the major impacts reported by the HHs seemed to have a direct bearing on their natural resources, as cyclonic storms uprooted trees, destroyed forest conditions, and increased the incidence of forest fires. This impacted the availability of forest produce, fuel wood, and fodder. With regard to livestock, they reported an increase in disease incidence and a reduction in crop residues due to crop loss. Regarding agriculture-related impacts, they reported crop loss in the germination and harvest stages, an increase in pest attacks and diseases in crops, and a reduction in crop yields.

The impacts of climate risks on agriculture and livestock were similar across all sites in Bhilwara. However, high-intensity rainfall caused the breakage of watershed structures, leading to flash floods and waterlogging. HHs also

reported that reductions in fodder and fuel wood were more predominant in the unmanaged CPRs. Further, HHs in both the districts felt that increasing temperatures during the summer months caused heat stress, which prevented HH members from working outdoors for longer hours. Workers, especially women, lacked the physical strength required to work in government wage programmes or agricultural fields in the heat, depriving them of their daily wage and livelihood.

3.3 Local environment stewardship and common property resources conservation

In all the study sites, separate committees were present to govern the different CPRs. In case of forest lands, VFPMCs were organized under the Joint Forest Management arrangement; VPDC was formed for managed pasture lands as per the rules of the Rajasthan Panchayati Raj Act; and Tree Grower's Cooperative Society was constituted for managing revenue waste lands. The committees in all study sites consisted of locally relevant actors, such as community resource persons, village representatives, or members of the executive body of the village institution. They had specific bye-laws that defined the rules for accessing, using, withdrawing, and managing the CPRs. These committees also developed annual regeneration plans, taking into consideration the diverse needs of different social groups in the village, including women, which encouraged the participation of multiple stakeholders in the conservation and management of CPRs.

However, there were cases of both strong and weak institutional governance in the study sites as the evolution of institutions is non-linear in nature (see Table 3).For example, the VFPMC in Cheetarawas was very strong and had been managing the forest land for about fifteen years. However in the last five years conflicts among the communities have become frequent, and the rules are poorly enforced due to internal and external factors. This has impacted the conservation and management efforts. While efforts are being made by the institution to reduce conflicts, encroachments still exist and the regeneration rate of forest resources is also comparatively low. Contrary to this, the forests of Dheemri and Sultanji ka Kherwara reflected the positive results of consistent CPR co-management practices by communities, resulting in improved vegetation density and green cover. The forest in Dheemri was deteriorating with the rampant felling of trees in the 1960s and 70s. The community soon realized the importance of a healthy ecosystem and decided to protect their forests. In an effort to prevent people from cutting trees, a few of the community members went to a nearby temple called Kesariya Jiand performed the

Table 3: Household responses to climate change adaptation

Climate change impacts	Adaptation responses by communities	U	B
CPR related			
Decrease in availability of certain tree and fodder species	Increased collective action in CPR management	P	P
Damage to trees through uprooting/ breakage	Increased plantation activity in forests	P	P
	Implementation of harvesting rules	P	P
Reduced surface water bodies	SMC work in private lands	P	P
	SMC work in CPRs	P	P
Breakage of watershed structures causing flash flooding	Repair of structures	A	P
	Increased SMC works in CPRs and other areas	A	P
Reduced fodder in grazing/revenue waste lands	Rules and regulations to protect and regenerate lands	A	P
Livestock related			
Increased disease incidence in livestock	Shift in species composition or breeds	P	P
	Increased veterinary care	P	P
Sudden disease outbreaks in poultry	Reduced poultry rearing	A	P
	Shift in species composition	P	A
Reduction in crop residues due to crop loss	Agroforestry	P	A
	Shift to livestock or mixed farming	P	P
	Conservation of common lands	P	P
Agriculture related			
Crop loss in the germination and harvest stages	Double sowing	P	P
	Crop diversification	P	P
	Increased dependency on forest products	P	P
Increase in pest and disease attacks in crops	Increased usage of chemical pesticides	P	P
	Look at weather forecasts	A	A
Reduction in crop yields	New crop alternatives	P	P
	Increased dependency on forest products	P	A
	Higher dependence on wage work	P	P
	Increased dependence on PDS	P	P
	Increase livestock production	P	P
Reduced groundwater	Use of water-efficient systems	P	P
	Water budgeting initiatives at the village level	P	P
	Well deepening	P	P

Sources: Independent studies on climate change adaptation by FES, 2015–16.

Note: Acronyms: P – present; A – absent; CPR – common property resources; SCM – soil and moisture conservation; U – Udaipur; B – Bhilwara.

sacred ritual of *kesarchidkaav* (throwing saffron along the forest boundary). Since then, there has been no felling of trees, and the community believes

that if anyone causes harm to the forest, they will be punished by God. Today, the forest is divided into various management units, wherein each habitation has user rights over a separate forest patch. The management units, demarcated by streams, are in proportion to the population of each habitation, such that the benefits are equitably shared. Similarly, in Kekariya, a patch of revenue waste land was leased to the community by the revenue department. With proper management and strong governance practices, the degraded land was finally revived and converted into grazing land. Today, it provides myriad benefits to the community.

In Kekariya and Mukan Garh, the rules governing the management of grazing lands allow villagers to collect only dry twigs that fall from trees for use as firewood. The grazing land is closed for four to five months during the monsoons to allow grass and new regenerating plants to grow. The cutting of branches and grazing of animals is strictly prohibited during this period. In Mala Ka Khera, the committee closes access to grazing lands for two years after plantation activity. In case the rule is broken, the village institution imposes graduated sanctions. Across all the villages, the penalty for breaking rules depends on the extent of damage done and also on the economic background of the offender. The fine is usually fixed at INR 2,000 for vulnerable people (socially excluded, landless, marginal, small landholding farmers), while it may shoot to as high as INR 15,000 for offenders from comparatively privileged backgrounds. After the payment of the fine, the lower and poorer castes are allowed to take the branches that they have chopped off the trees.

3.4 CPRs and adaptation to climate change

In this section, we elaborate on the interactions between HHs and CPRs, examining outcomes in terms of social and ecological returns and how they have helped these communities adapt to climate change (see Table 3). We found that the results of the local stewardship initiatives for CPR conservation differed significantly in the two study sites, depending on differential governance systems, resource conditions, and other local factors. In Cheetarawas, in spite of the high incidence of conflicts and low regeneration rate of forest products, there has been a significant improvement in the availability of forest resources, since the VFPMC was formed, thus providing benefits to communities, particularly buffering them from losses in agriculture and livestock production. The increased sale of certain forest produce in the past five years provided poorer HHs an average annual income of INR 5,000–40,000 per household, depending on the kind of forest produce they sold and its availability. One such example is the collective marketing of custard apple, which earned people in Cheetarawas INR 3,75,000 in 2019, benefitting several HHs.

In Bhilwara, all study sites showed increased vegetation density in the managed grazing lands, thus leading to an increase in the availability of fodder and water resources. This resulted in increased livestock holding capacity per HH, and large farmers in particular showed a greater preference for rearing buffaloes. Therefore, there is a strong presence of dairy cooperatives, either within the village or in the nearby gram panchayat. The average quantity of dairy sales per HH in these villages was around 200–350 litres per month, which generated an average household income of INR 1,25,00–2,00,000 annually. Also, they generate various dairy products, including curd, ghee, paneer, and butter, for self-consumption. The availability of more fodder in the managed CPRs helped the HHs continue dairy production, thereby helping them cope with crop loss and the reduced availability of crop residues and manage disease incidence in dairy animals better.

Other responses that we observed in both sites with regard to CPRs and efforts by the local community to reduce the impacts of climate risks in the region involved increased plantation, soil and moisture conservation activities, further tightening of the management, and new harvesting rules to enhance regeneration efforts. In Bhilwara, as high-intensity rainfall was an issue, the management undertook the repair of damaged watershed structures and the construction of new ones. This not only helped reduce general water scarcity and flash flooding, but it also helped in further regeneration of vegetation in the grazing lands.

Further, this increase in community-led collective action to manage CPRs helped in checking water run-off and in improving the soil and moisture regime in the region. For instance, in Mukan Garh, the construction of water harvesting structures has contributed to groundwater recharge and an increase in the water column in wells by about 15–20 feet. This has had a cascading effect on agriculture and livestock-based livelihoods, as is reflected in the increased productivity of wheat and maize over the past few years.

The use of water-efficient systems and water-budgeting initiatives in both the districts further helped offset losses in crop production. As their incomes became stable, HHs managed other losses in agriculture by increasing their use of chemical pesticides and fertilizers, diversifying their crop (i.e., a shift from maize to wheat, and from chilli to mustard), double sowing, and selling forest produce.

When it came to livestock, regeneration of CPRs helped in securing dairy-based livelihoods, particularly in Bhilwara, despite drought-like conditions and erratic rainfall patterns that caused losses in crops, both in terms of

income and crop residues. Further, though the communities reported high disease incidence in livestock, the availability of abundant fodder helped keep the incidence low and manageable through better nutrition. Bhilwara also saw an increase in livestock keeping.

From the ecological perspective (see Table 4), in the Udaipur sites, our data revealed that there was a 35.8% increase in the above ground biomass in Dheemri and Sultanji ka Kherwara, whereas there was a 14.6% decrease in Cheetrawas. We saw a similar trend in the species diversity index and number of species. In the former, the community's efforts to protect CPRs were visible both ecologically and in its subsequent returns towards enhancing livelihoods, while weak local management and governance led to lower regeneration in Cheetrawas.

Table 4: Ecological outcomes of local stewardship initiatives in the study sites

Particulars	Udaipur						Bhilwara			
Type of resource systems	Forest land*		Forest land**		Grazing land		Forest land		RWL	
Study year	'14	'19	'14	'19	'14	'19	'14	'19	'14	'19
Number of species	25	22	21	32	12	12	11.5	15	10	9
Shannon Diversity Index	2.6	2.4	2.4	2.7	1.7	1.2	1.7	1.8	1.8	1.7
Above ground tree biomass (tons/ha)	140.9	120.2	24.8	33.7	10.2	11.8	21.8	30.7	4.2	5.2
No. of trees (0–5 cm DBH class)	212	333	629	784	391	546	741	1063	173	184
No. of Trees (> 10 cm DBH class)	454	451	49	82	42	49	62	151	24	30

Sources: IFRI dataset 2013 and 2019.

Note: Acronyms: DBH – diameter at breast height; * Cheetrawas, ** Dheemri and Sultanji ka Kherwara

In Bhilwara, however, we saw an improvement in natural resources in all CPRs in 2013–2019. We found a 21–54% increase in standing biomass in both forests and community-managed grazing lands in all three sites. There was also an increase in tree density, but a decrease in the diversity index, which revealed an increase in only dominant species. The waste lands, however, showed different results—there was an increase in standing biomass, but it mainly consisted of the invasive species, *Prosopis juliflora*;

there was otherwise a reduction in species diversity, density, and fodder availability.

4. DISCUSSION AND CONCLUSION

The communities in the study sites in both districts are located in varied geographical regions and landscapes. Though agriculture and livestock production are their primary occupations, we found that they showed a high dependence on CPRs to maintain their basic needs, as a supplementary source of income (particularly poorer HHs), and for profitable livestock rearing.

Our findings showed that goods and services obtained from CPRs, such as fuel wood, fodder, and forest produce met both, the income and daily subsistence needs of the poor and marginalized. Thus, by undertaking various restoration activities on CPRs, which were once stressed and degraded, they improved groundwater levels, biomass production, and biodiversity, which led to overall stabilization in farm-based livelihoods. This was more evident in Bhilwara compared to Udaipur. Further, productive CPRs and their regeneration efforts supported livestock rearing by smallholders (Ali 2007) in Bhilwara, which helped buffer against crop losses and helped them continue dairy production even under drought-like conditions. In addition to this, we can consider the shift to buffalo rearing in the region as a sustainable and lucrative adaptation to climate change. This is because buffaloes can be reared on fodder from CPRs and do not require high-quality green feed like crossbred/exotic cows, whose fodder is otherwise produced with precious ground water.

While CPRs, when managed properly, can transform and improve rural livelihoods, extreme climatic events, coupled with mismanagement practices and lack of collective effort at the community level, can have negative impacts on them, thus affecting food security and increasing poverty and social inequality—as we have seen in Cheetrawas, even though it is a densely forested area. Further, we also observed that the condition of the CPRs (see Table 4) also influenced the rate of migration—less productive CPRs in the Udaipur sites can be linked to higher migration (despite their remoteness) than Bhilwara. In such a situation, climate risks in the region add an additional layer of risks, increasing the existing vulnerability of socio-economically weaker sections, as they are most dependent on CPRs (Bantilan *et al.* 2012). We thus conclude that CPRs act both as a stable source of livelihood as well as a safety net against risks arising from climate change.

In order to ensure that the benefits from CPRs are sustainable in the long term, it is important to govern and manage them judiciously. We find that when local communities have secure property rights over CPRs and manage them collectively through self-governing local institutions, the result is enhanced household resilience through the reduction of poverty and social inequalities as well as improved ecological health (Dupar and Badenoch 2002). We conclude that processes that support local self-governance need to be strengthened and are central to local adaptation to climate change — as we have seen in many instances where CPRs have buffered the impacts of climate change. In other words, our paper emphasizes the need for integrating climate vulnerability and related adaptation strategies at the local level by means of collective action to boost local institutions to improve their planning and implementation of developmental activities (Agarwal 2008).

For centuries, CPRs, except forests, have been considered to be of no economic value, while the traditional use of these lands has supported the livelihoods of economically and socially backward rural communities for decades (Jodha 2000). Further, CPRs in any form are storehouses of biodiversity that have contributed significantly to water and nutrient flow, and hence have enhanced the resilience of farming systems and livestock breeding for generations. These have been further strengthened through local tenurial arrangements (Gaur *et al.* 2018). Although mostly unmanaged, there are village-specific bye-laws to govern CRP management and use, and these need to be strengthened through linking institutions and by coordinating responses across the government, the private sector, and civil society to enhance the inherent adaptive capacities of these communities. Therefore, we have highlighted the need for viewing forests, pastures, and waste lands as durable community assets, which when managed collectively, aid local-level climate change adaptation processes. These adaptation strategies are strengthened by aligning the objectives of meeting livelihood security while maintaining the access and availability of natural resources. The decentralized governance of shared resources, therefore, aids collective decision-making, and the principles of inclusion and equity, sharing of responsibilities, and access to benefits have acted as a common denominator across all existing village institutions in both the districts.

Lastly, the application of the SES framework in analysing the interactions and outcomes of social and ecological systems provides valuable insights into the nature of governance systems across the study sites and the degree of local environment stewardship practised. In Bhilwara, for instance, different rules exist for the management of various CPRs. In the Udaipur villages, on the other hand, the inability to address local-level conflicts in

resource use and the lack of proper monitoring and sanctioning mechanisms have created stark differences across the forest conditions in the two blocks. The extent of collective action, strength of village institutions, and variations in rules and sanctions determine the state of vegetation cover and product availability for each CPR, and consequently, its capacity for livelihood resilience. In fragile systems, as we saw in the case of Cheetarawas village, institutions for reducing climate risk and promoting adaptation may be too weak to empower communities in complex decision-making, particularly in instances of resource conflict. Hence, resolving institutional challenges in the management of natural resources—including lack of coordination, monitoring, and enforcement—would be a big step towards more effective climate governance (Hijioka *et al.* 2012). The need now is therefore to advocate a pro-active stance (Jodha, 2000) to community-led climate change adaptation, particularly in the context of CPRs, which would lead to a genuine devolution in the domain of development.

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