Exploring the Dynamics of social-ecological resilience in East and West Africa:Preliminary evidence from Tanzania and Niger

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Abstract

Background: Social-ecological resilience refers to the dynamic process of adaptive learning, reorganization and meaning-making demonstrated in linked human, animal, and plant ecosystems often organized in formal and/or informal social institutions, as they anticipate, withstand and/or judiciously engage with adversity while maintaining function without fundamentally losing their identity.

Objective: To present two sets of examples that illustrate the complex ways in which *transformation* and *persistence*, two key aspects of the adaptive cycle may work together to preserve established patterns of human and/or animal uses of water resources and food plant species, in rural East and West Africa, respectively around the Serengeti National Park (Tanzania), and "Park W" (Niger), with the aim of identifying possible indicators of social-ecological resilience.

Methods: Selective combinations of ecological and anthropological, quantitative and qualitative methods, including participatory tools of investigation and analysis.

Results and Discussion: Our preliminary results are presented with minimal commentary and discussion in order to avoid hasty and/or unwarranted interpretation of the ongoing purposely iterative processes of investigation and analysis in the two study sites. Nevertheless we have identified a number of possible indicators of social-ecological resilience that may be tested in other localities in Africa and elsewhere.

Key words: Social-ecological resilience, Traditional Ecological Knowledge (TEK), Traditional Resource Management (TRM), interdisciplinary research, Sonjo, Zarma, Serengeti, Park W.

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Introduction

This paper explores the notion of social-ecological resilience around two internationally designated conservation parks: the Serengeti National Park in Tanzania, East Africa, and Park W in Niger, West Africa. It was both instigated and informed by the deliberations of the participants of the International Resilience Workshop held at Tufts University's European Center, Talloires, France, during 2-6 July 2007. [insert link to IRW website here].

Interdisciplinary natural resource and economic ecologists use the term 'social-ecological system' in order to draw scientific scholarly research and public policy attention to the interdependence of human and non-human ecosystems in the context of rethinking 'sustainable development'[1]. There are practical implications of the arbitrary and often conceptually problematic delineation between social and ecological systems that limits researchers' and policy makers' understanding of "sustainability". Alternative systems of traditional ecological knowledge (TEK) and traditional resource management (TRM) warrant serious consideration and that interdisciplinary studies of linked social-ecological systems hold the key to unraveling their resilience: the capacity to absorb turbulence and continue to function without fundamental loss of identity[1]. In 1999, the "Resilience Alliance" was formed by a group of scientists and practitioners representing several disciplines and relevant sectors with the express aim of collaborating to explore the dynamics of social-ecological systems in order to examine key concepts of resilience (adaptability through transformation and persistence). Exploring social-ecological systems through the "resilience lens" is an innovative development in contemporary international scientific and policy discourse on the sustainability of human and non-human ecosystems – see http://www.resalliance.org/1.php for more detail.

Elsewhere, the study of human (psychosocial) resilience in the face of adversity wrought by conflict and displacement has been the focus of attention of a growing number of researchers and practitioners – see for example Almedom and Glandon[2] as well as Almedom[3] for an overview and analysis of the meaning/s and measurement/s of the construct. While recognizing the differences in meaning and purpose, the above-mentioned International Resilience Workshop sought to bring together diverse perspectives on resilience. This paper seeks to present preliminary findings on the possible indicators of the adaptive capacity of communities—the ability to learn flexibility under

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different conditions—that support their social-ecological resilience in sub-Saharan Africa[4]. Our first data set (Example 1) comes from the first author's field research that aims to:

- Understand traditional water resource management and its impacts on health (including the physical, economic and social components) in a semi-arid environment bordering the Serengeti National Park
- To survey water resource quality using qualitative and qualitative methods.
- To Spatially analyze the social institutions affecting water use, water resource quality for improving water resource development strategies.

The second data set (Example 2) is part of an ongoing field research undertaken by the second author with the following objectives:

- To survey local knowledge within the village of Boumba, Niger and document the indigenous use and conservation of wild resources;
- To verify the conservation status and representation of locally valuable plant species, gain knowledge of the effects of local harvesting on the border regions of Park W and evaluate current park management goals; and
- To determine maximum harvest levels and help guide sustainable land use policies for the park and its border regions.

Both of these ongoing field studies involve local stakeholders who are involved in the process of data gathering and on-site analysis at different levels, and are expected to use the study findings for the purposes of informing public health and conservation policy and practice at local, regional, as well as national levels.

Example 1: Samunge, Tanzania

The first author set out to determine if one social-ecological community, the Sonjo in rural Northern Tanzania, demonstrated some of these attributes. The Sonjo and the Maasai are the two dominant tribes that inhabit the region East of the Serengeti National Park—one of the principal tourism highlights in East Africa and the focus of intense ecological study. Previous work in the Serengeti-Mara Ecosystem has examined the potential vegetation regime shifts as related to elephants and fire that are both influenced by human-wildlife interactions[5]. However there is little information related to the usage of water resources in the surrounding communities and the potential interplay between water management and water-related diseases.

We used participatory techniques, including group discussions, seasonal calendars, household interviews, questionnaires, observations, and key-informant interviews to assess the utilization, management and influence of water resources on the largest and oldest of the Sonjo villages: Samunge[6]. This village is geographically varied, lying at the base of a valley and largely isolated from neighboring villages, external water sources, and communication. Water availability is confined to a few springs that feed seasonal rivers critical for sustaining communities and wildlife. Water resource quality in this region varies seasonally and geographically due to local geology and patterns of utilization by wildlife, livestock and humans. Water quality was determined by bacterial analysis using the QunatiTray® Colilert-18 method (IDEXX laboratories, Westbrook, ME, USA) to enumerate *E. coli* colonies[7]. The Sonjo were originally agriculturalists and have more recently adopted a number of pastoralist customs from their Maasai neighbors—in part due to the pressing need to diversify their resource use[8]. The initial settlement of Samunge, in the upper elevations, permitted year-round irrigation for all residents. Samunge was then resettled into the lower portions of the valley according to land-redistribution policies following Tanzania's independence. The Sonjo use a combination of traditional resource management practices and formal institutions to manage the environment that they so heavily depend upon for ecosystem services; including the protection of micro-catchment forests, equitable use of grazing lands and water resources[8,9]. Furthermore, they have developed various mechanisms that buffer the community against environmental variability, including livestock redistribution, water resource management, a pasture management system with seasonal communal and private grazing lands, strong social networks built around accepted norms of resource use, agricultural diversification and a forest management system that protects watersheds.

The adaptive capacity to adjust to changing environmental conditions has become ever more useful as increased population growth has forced the Sonjo to settle on lands beyond the original village and their traditional methods of management. To extend local protection of water resources, the Sonjo have developed social, spiritual, political and physical mechanisms based on TEK developed over generations that purport to reduce potentially contaminating behaviors and limit the consumption of and contact with poor quality water[10]. The *benamiji* (*mwenamjie* singular) are the original traditional water rulers that govern the protection of watersheds, water withdrawals for irrigation, and water use. However, the expansion of Sonjo into regions utilizing non-traditional water sources that are beyond

the control of *benamiji* has required the village council to establish a second set of water managers. Animals are perceived as the primary source of water contamination and it is customary to water livestock in the early afternoon—after water is withdrawn for consumption and used for laundry and bathing. Water users at each of the resources in the village also attempt to physically separate withdrawals along the stream based on their potential to contaminate the resource. The most benign uses, such as withdrawing water for household consumption, are furthest upstream (see Box 1). Social capital plays an important role in preserving these norms of use.[10] For this reason, livestock are watered as far downstream as possible before water is diverted for irrigation. Such a system reinforces the local concept of spoiled water. Women form strong relationships with each other while gathering water for the family, washing clothes and watering livestock. Relationships are also strong between long-time neighbors within sub-villages, clan members that share ancestry and age-cohorts from school. These relationships help to reinforce the temporal partitioning of water resources (see Figure 1) and are believed to reduce disease transmission by limiting activities that spoil water sources to downstream reaches (see Figure 2).

Example 2: Boumba, Niger

To understand how local botanical and ecological knowledge can inform global discourse on issues such as conservation and natural resource use, this study uses a participatory research framework in the context of the socio-ecological system surrounding the village of Boumba, Niger. This study aimed to examine how residents of the Boumba village conceptualize, value, use, and manage the plant resources that are found in the surrounding fields, woodland, gardens and the bordering Park W (see Figure 3).

The study site, Boumba, is located along the Niger River near where it is adjoined by the Mékrou, on the edge of the Park W boundary. The second author spent considerable time in this village and got to know the local healers, environmental agents, and village chief. We defined the limits and the members of this socio-ecological system using participatory community analysis techniques. Based on the maps created during a community mapping exercise (Figure 3) the study area extended beyond political boundaries of the village to areas the community can access on foot or by local means of transportation and therefore view as a part of their resource base. Recognizing the contested nature of the term community[11] Boumba community members for the purposes of this study we re defined as self-identified long term residents and therefore represented a mix of ethnicities, histories, and demographics. For this paper, we will focus predominately on the village ethnic majority, the Zarma, as they figure most importantly in the discussion and identification of edible plant resources. As Almedom et al[6] advocate for a triangulation of methods in order to obtain complete and reliable information, a variety of methods including, key informant interviews, free-listing exercises, history line, seasonal charts and systematic walks, were employed to explore local concepts of plant resources.

Often called leaf eaters, Zarmas have a long-lived asset of TEK[12], which they use in their strategies for supplementing their diet to survive times of scarcity[13] and increase their income. Children supplement their diet with foraged nuts and seeds, mothers create meals out of weeds, and fathers build houses out of grass[14]. Although this sort of plant use is common throughout many subsistence communities in Niger and much of the world, locally Zarmas are known as experts of edible leaves. Their breath of knowledge of edible leaves and love for a dish featuring these edible leaves is recorded in Nigerien pop songs, traditional sayings and validated in our discussions with local residents of Boumba[15]. This group of plants is dominated by gathered plant foods, but often includes plants that are cultivated on smaller scales or are promoted through traditional resource management. So far little is known about the impact of human foraging on this region, even less about the impacts on Zarma TEK and culture as climate change continues to threaten to change the plant community compositions and habitat boundaries.

Results

Box 1. A schematic demonstrating the spatial partitioning of water resources among the various uses by villagers. Each subsequent use is believed to contribute to the contaminant load of the water. There may be physical barriers, such as logs or Acacia branches separating areas in the stream where livestock are watered from the other areas.

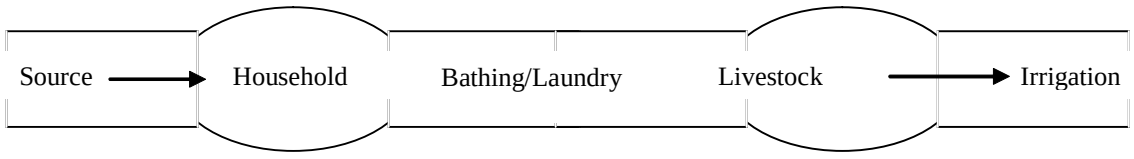


Figure 1: Mean (±SE) time of water related activities as reported to have taken place during the day through interviews in Samunge, Tanzania. 61 different households were interviewed during May-June 2007 representing the geographic and demographic diversity of the village. If sunrise or sunset were reported, then 6:30am or 6:30pm was used, respectively. If respondents reported morning or midday, then 7:00am or 12:00pm was used. Local correspondents justified such values.

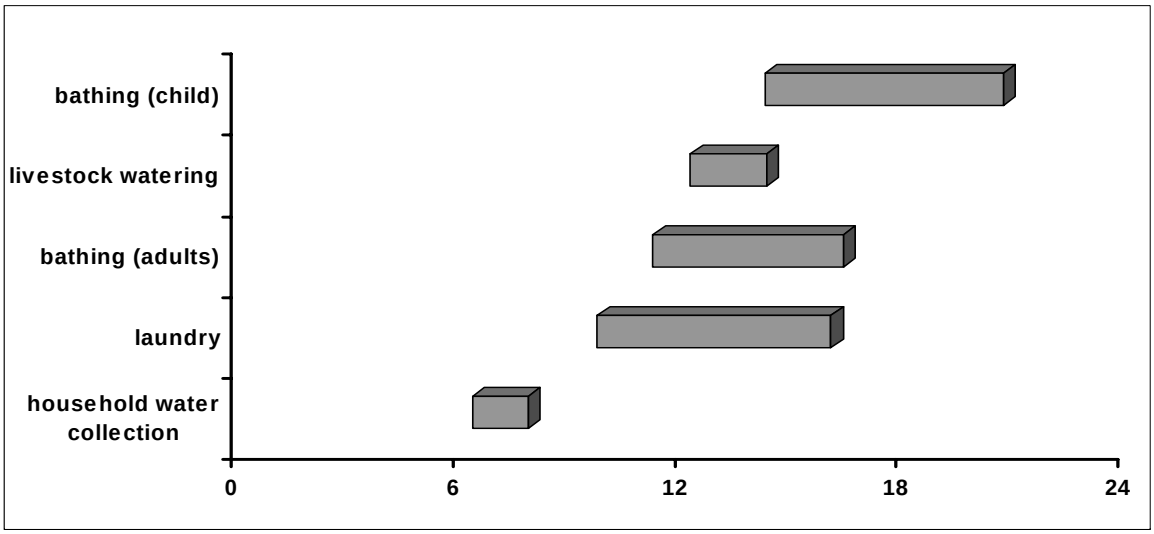


Figure 2. Mean (±SE) most probable number of *E. coli* colonies per 100 ml water sample taken upstream from where water is withdrawn for household consumption and downstream from where livestock are watered in July 2008 (N = 3). The Ngela watershed is traditionally managed by the *benamiji* and elected village leaders manage the other two watersheds. Adapted from Strauch et al.[11]

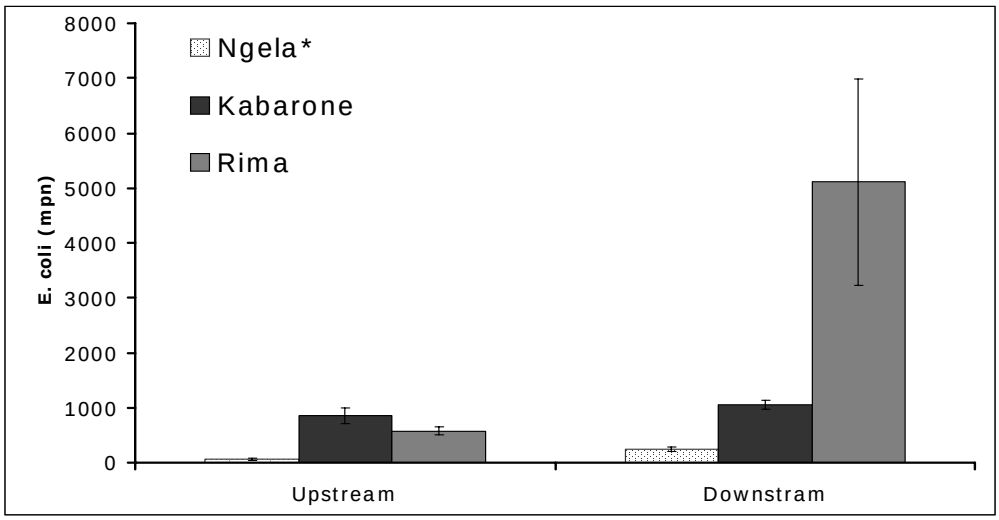
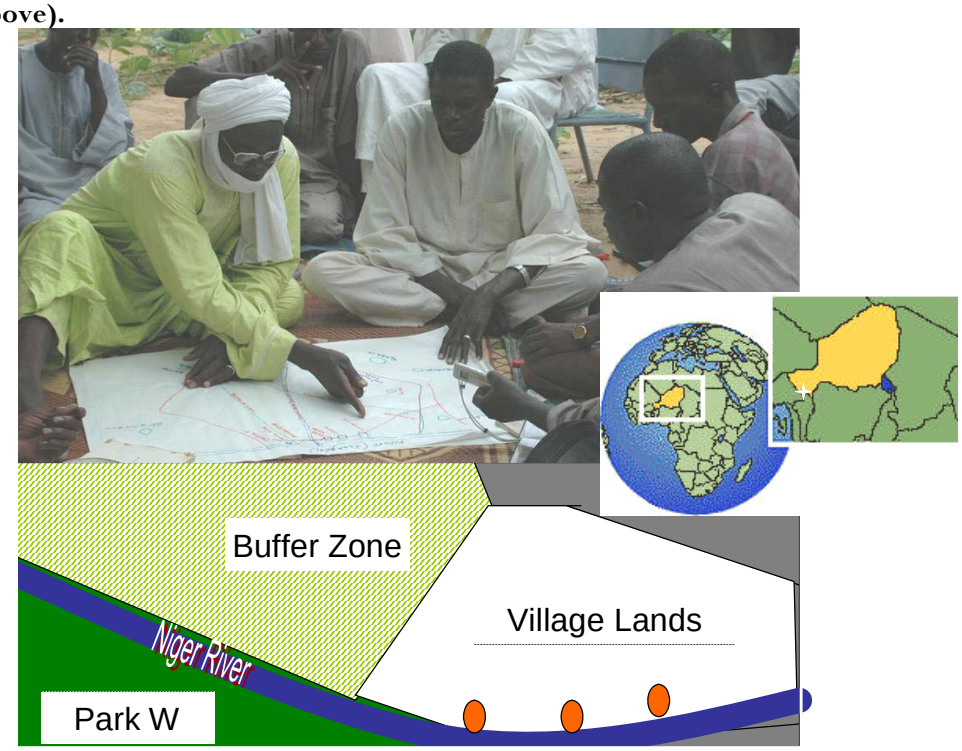


Figure 3: A schematic of the study site showing the placement of the Boumba settlements (orange) in relation to the three management zones: the park (green), the buffer zone (striped) and the locally managed lands (white). The schematic is based on maps created by local leaders and forestry agents (above).



Box 2: Favorite Foods not Famine Foods: a resilient strategy[14]

Favorite foods not Famine Foods: A resilient strategy?

Hyp: "famine foods" should be a ~~discrete~~ and cohesive concept

Results

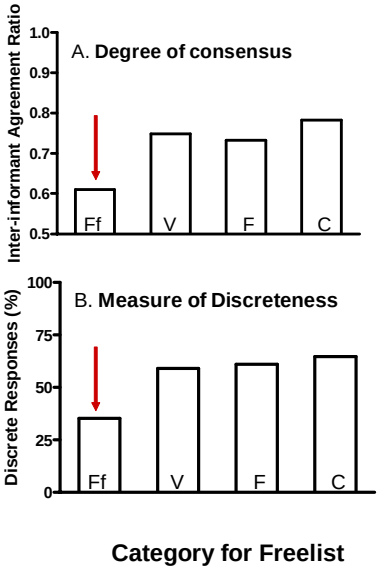
- Not Cohesive: Lower Inter -informant Agreement Ratio
- Not Discrete: Fewer discrete responses

Explanation

- Incorporation of "famine food" resources into "favorite foods"

New Hypothesis

- When famine foods become favorite foods resilience to famine on a whole is increased



Discussion

Current sustainability research and resilience theory has proposed models which help us to understand what characteristics define resilient systems and how such systems move through the adaptive cycle, to gain or lose resilience. There have been many examples given to help us understand factors important in promoting resilience of ecological systems[16,17] or in sociological systems[18,19], but the evidence is lacking in the interaction of these systems. We used resilience concepts of stability and change to understand our exploration of local water resource management in Tanzania and of local famine foods in Niger.

Access to a clean water supply is an important part of rural life in East Africa and essential for maintaining good health and hygiene in arid and semi-arid environments[20]. Water scarcity exacerbates the health consequences of poor water quality and resource management. In a world of increasingly simplified systems, traditional resource management may have advantages over non-traditional techniques to manage the physical, social and biological dimensions of water resources[21]. The combination of political and social flexibility with traditional conservation policies demonstrated by the Sonjo has contributed to the region's social-ecological resilience. The Sonjo have transformed their system of resource management over the generations to meet the needs of a changing community which supports the argument by Holling et al.[21] that the inherent complexity and unpredictability of social-ecological systems can be best viewed from a co-evolutionary perspective. To predict local social-ecological resilience, the adaptive capacity of communities to cope with changes in water resource availability and water quality must be stressed, especially in the face of population growth and finite resources[4].

Climate change is expected to exacerbate current problems of water supply in sub-Saharan Africa[22]. It is likely that Samunge will experience an increased length in the dry season and at the same time, more severe rainfall[23]. These changes will exacerbate water supply problems in the region by lengthening dry periods and intensifying wet periods and determining if the Sonjo will be resilient to such changes is difficult. Households generally store enough water for three or four days of consumption, but if the natural water resources on which the Sonjo rely upon dry up, there may be serious consequences. Land that is irrigated produces a bountiful diversity of crops that may be harvested throughout the year and the loss of irrigation is likely to be devastating to the nutritional base. The Sonjo have already begun rainfed cultivation and increased livestock production in many regions. Heavy precipitation is already identified by villagers as reducing water quality by transporting fecal waste into surface water sources and increased rainfall intensity will only exacerbate water quality issues created by population growth.

While TRM in Samunge reduces conflicts over disparate water uses, the whole system is still vulnerable to catastrophic shifts. TRM currently reduces the contaminant load over non-traditionally managed water sources (see Figure 2), but as a greater proportion of the village relies upon non-traditionally managed resources, the village becomes more vulnerable to outbreaks of water-related diseases. Niamir-Fuller[24] argues that water-scarce social-ecological systems, such as the previously discussed example, are resilient until, "deforestation, over-cultivation and continuous grazing pressure simplify its structure and reduce its functional options." Increases in land clearing for cultivation, the expansion of fire to maintain grazing lands and a dependence on communal forest resources for fuel are slowly eroding local ecological resilience. Wildlife is now scarce, soil erosion is common and water resources are being stretched to their limit. A growing population is expanding cultivation and herds of livestock, possibly pushing the system closer to a new regime if formal or traditional methods of management fail to curtail their impact on the local environment.

With mounting concern over climatic changes, a system that is currently showing elements of resilience may be pushed over the threshold into a new, undesirable basin. The community's flexibility to adapt new political structures for managing water and land resources outside of the traditional institutions of control without changing it's fundamental identity demonstrates the potential adaptive capacity of the Sonjo[21]. The consequences of this system being pushed into an unstable or undesirable regime may be devastating to local wildlife resources. How the community responds to future perturbations will determine if the system collapses and reforms a new identity or if it there is enough flexibility for the system to stabilize.

Current investments in the development of water-related infrastructure in sub-Saharan Africa are predominantly limited to large-scale irrigation projects and municipal distribution systems in urban environments. This is primarily the fault of international non-governmental organizations that tend to focus on funding single large projects for development. Sustainable water resource development requires an integration of the drivers of change in social-ecological systems: the ecosystem, people and technology, local

knowledge, and property rights[1]. Mechanisms that help a community maintain normality when faced with perturbations to their social-ecological system increase that community's resilience. Small-scale investments in water infrastructure that complement current methods of resource management and permit the type of flexibility in use as needed by the Sonjo would be a better use of funds than the often proposed large-scale regional projects focused on irrigation.

In Niger, as in much of Africa, plant foods that are not among the top agricultural products, including edible leaves, are often referred to as "famine foods". With this label comes the assumption that such a category of foods is composed of plants harvested preferentially in times of famine. Our study sought to understand which groups of plants fall into this category. However, when we examined local understanding of this category of foods in Boumba, a community that routinely experiences food shortage, we found the local understanding to be not only different from what was published in the literature[26], but also did not match within itself[15]. In contrast to the literature, the plants listed by participants specifically excluded certain gathered plants and included several agricultural products both local and imported[26]. But at the same time there was a lower degree of consensus among participants as to what really is a famine food. Very few plants were listed exclusively as a famine food. Furthermore, the qualitative data indicates that many of these plants are not "famine foods" but favorite foods (see Box 2).

Social mechanisms such as favoring key "famine" resources in times of plenty can maintain stability by preserving the knowledge of that resource, promote its conservation in times of agricultural bounty and help people cope both physically and socially in times of food shortage[15]. Knowing a diversity of edible plants and their preparations helps women and their families survive periods of food scarcity. While depending on favored foods, during times of stress, may help to maintain the social fabric and promote resilience. By maintaining dietary practices that are often linked to social institutions, local knowledge of the value of biological diversity to famine survival is stored and used even outside of the context of famine[12]. This increases both the social and ecological resilience by allowing persistence of traditional practice to reduce the negative impact of sudden and/or turbulent transitions from times of plenty to times of scarcity. Furthermore, social mechanisms such as adapting to new crops can promote provide a level of dynamism also vital in maintaining resilience. Of the few discrete responses, a third were newer agricultural products or imports, e.g., cassava or corn. While this finding was originally unexpected because of the way wild plants are associated with "famine foods" in the literature it is not surprising when looked at from a social-ecological system resilience perspective. By associating themselves with both wild and cultivated plant resources, the Zarma are able to increase the diversity of food resources that they rely on, and thereby promote and preserve plant biodiversity. Most famine intervention programs seek only to supplement main calories, rather than promote the preservation of such networks of diversifying resource use. And when programs turn their eyes to the lesser-known plants, they seek to improve them and bring them into cultivation, rather than promoting preservation in the field. If we are to look at the system as linked, then cultivation becomes less important and diversity and stability of the whole social-ecological system through the role of supplementary resources[16] comes sharply into focus.

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