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Toward an Integrated Social-ecological Assessment of a Traditional Upland Rice-based Agroecosystem in Southern Philippines

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ABSTRACT:
Located in Southern Philippines, the Sarangani traditional agroecosystem currently sits at the nexus of ecological devastation, bio-cultural erosion, and pervasive modernization. Upland farms in these remote areas are inhabited predominantly by smallholder tribal households who cultivate rice landraces using traditional farming methods. Integrated agroecosystem assessment revealed Sarangani social-ecological system (SES) components, along with connections and feedback loops that underlie their interactions. DPSIR and CCA jointly identified drivers of change in Sarangani SES, revealed its key features, and investigated the whole gamut of issues impacting it. CCA, based on an Ishikawa cause and effect diagram, identified upland poverty, tribal culture and government mismanagement as root causes of intractable problems in the Sarangani SES while DPSIR successfully gauged the suitability of responses instituted by the local government. Study results can thus be used as bases for policy/programs that will resolve problem root causes in the Sarangani SES. In addition, steps must be undertaken to mitigate the effects of climate change which has proven to be utterly devastating in these vulnerable areas. Finally, for traditional agroecosystems like the Sarangani SES, interventions that uphold human well-being while conserving tribal culture/resources and preserving the environment are therefore warranted.

Keywords: social-ecological systems, DPSIR, causal chain analysis, Sarangani, traditional agroecosystem

1. Introduction

The old-fashioned worldview which considered the natural world as distinct and apart from the social world has been supplanted by an alternative developmental paradigm known as the social-ecological system (SES). The social aspect of the SES includes human societies, economies, cultures, and constitutive components impacting the biosphere while the ecological component refers to the biosphere where human societies thrive. Berkes, Colding and Folke (2003) defined SES as ' a linked system of people and nature in which people depend on nature and nature is influenced by people '. SESs are thus, complex adaptive systems in which human societies are embedded in nature and where both components interact dynamically and constantly. In a study featuring the Ifugao rice terraces in the Northern Philippines, Aguilar et al. (2020) pointed out the propensity of humans to alter the biosphere in a radical, irreversible and oftentimes, destructive manner. This paper revealed the highly disturbed state of the Kiangan traditional agro-ecosystem and the erosion of Ifugao culture and belief systems due to the ingress of modernization, mindset change among locals and weak institutional support. In another study, Wu et al.

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(2020) used data that spanned over a millennium to identify major drivers of change (i.e. political, climatic and socio-economic) in social-ecological interactions in rural China. In particular, higher demand for food to feed the burgeoning population in urban areas served as the impetus for increasing cropland areas through forest clearing with the Chinese government railroading the process.

Gain et al (2020) described SESs as nested, multilevel systems whose social and ecological components are regulated by bidirectional interactions and mutually impacting feedback loops. Complexities associated with SESs arise from their complex and dynamic interdependencies, nonlinearity (Liu et al 2023), cross-scale interactions (Goncalves et al 2020) and the 'artificial and arbitrary' nature of relationships between human and ecological components (Liu et al 2023), among other factors. Consequently, the exact nature of SESs remains poorly understood leading to severe environmental problems and developmental challenges (Gain et al 2020). These same factors complicate the Sarangani SES, along with the multiple dimensions (cultural, ecological, political, economic) that significantly impact this fragile agroecosystem.

To gain a thorough understanding of complex SES interrelationships, Gain et al (2020) extolled the benefits of combined qualitative and quantitative methods while Liu et al (2023) stressed the importance of multi-scale, paradigm-shifting assessment methodologies. In particular, this latter paper espoused the complementary use of theoretical frameworks, quantitative modeling methods (i.e. agent-based modeling) and traditional methods (i.e. participatory rural appraisal, community-based participatory research) to elucidate the factors that underpin a particular SES. Among the theoretical framework ideas are the DPSIR or Driver-Pressure-State-Impact-Response framework (Goncalves et al 2020), ecosystem services framework (Berthet et al, 2022; Goncalves et al 2020), SESF or Ostrom's social-ecological system framework (Nagel and Partelow 2022) and the vulnerability framework (Turner et al 2003).

Crafting interventions that simultaneously take into consideration human well-being, ecosystem protection and resource conservation is a formidable challenge to nations the world over. In the developing and data-poor country setting, Leslie et al. (2015) demonstrated better sustainability of the SES approach over those utilizing biophysical or social science approaches alone. One potential application of the SES framework is in local resource management systems. Since the time Berkes and Folke (1998) espoused the SES concept, a flurry of studies had been published, all of which promoted multi-disciplinary and collaborative approaches to address issues confronting problematic SESs. However, for traditional ecosystem assessment strategies, one common limitation is the oversimplification of SES interrelationships which oftentimes leads to inaccurate findings and inappropriate actions/responses. For this study, the Driver-Pressure-State-Impact-Response (DPSIR) framework and causal chain analysis (CCA) were utilized to identify major forces impacting the Sarangani SES and investigate relationships and interactions between them. DPSIR, defined as a 'coherent structure for the integration of information of biophysical and socio-economic interactions across spatiotemporal scales', disentangles SES components to understand their individual effects as well as their interrelationships (Pinto et al. 2013; Vidal-Abarca et al. 2014; Balzan et al. 2019). CCA (aka root cause analysis), on the other hand, traces the putative cause-to-effect pathways and has been proven to be effective in addressing the underlying causes of problems that beset

traditional SES. Moreover, since it is relatively simple, robust and informative, CCA is a very practical yet effective decision-making tool for policymakers. It is then envisaged that the synergistic use of DPSIR and CCA will help distill inputs from various disciplines into a policy-relevant framework, thereby giving instituted interventions better chances of success.

Sarangani Province in Southern Philippines is composed of seven municipalities (or towns) that are bisected into eastern and western halves by General Santos City. Lumads (tribes with non-Muslim ethnicity) inhabit the remote uplands of the province after being driven to these areas by migrants who settled in the more accessible lands after the post-World War II period. Lumads such as Blaans, T'bolis and Tagakaolos predominate, with Blaans occupying a broader territorial range. Blaans reside exclusively in the upland areas of Malapatan, Glan, Alabel, and Malungon. T'bolis inhabit Maitum, Kiamba and Maasim, while Tagakaulos reside exclusively in Malungon and Datal Anggas in Alabel (Sarangani Province, 2011). For sustenance, these tribes cultivate upland rice (as a main caloric source) along sloping/steep terrains once a year, without synthetic inputs and under subsistence and rainfed conditions. Recent field visits in the Sarangani uplands, however, revealed widescale ecological destruction due to slash-and-burn farming, excessive resource extraction, extreme weather conditions, natural disasters and encroachment of modern agriculture, among other factors. These pressures and the devastation that they cause underscore the need to investigate the complex interplay of the province's biocultural resources, the physical environment and human well-being amidst emerging socio-economic and ecological scenarios during current times.

2. Methods

2.1 The Study Sites

Figure 1 shows the 16 upland barangays (villages) visited by the research team in Sarangani Province. These are Datal Bukay and New Aklan in Glan, Mutu Ladal in Maasim, Kihan, Kinam and Banlas in Malapatan, Ihan, Cabnis, Glamang and Datal Anggas in Alabel, Datal Tampal and Malabod in Malungon, Upo, Angko and Batian in Maitum and Malayo in Kiamba.

2.2 Data Collection

Data used in this study were gleaned from a diverse array of sources. Information about the Sarangani traditional agroecosystem, the peoples inhabiting it, their customs and traditions as well as problems and threats they encounter were documented during field and community visits. Pertinent information was likewise obtained from local government agencies, graduate/undergraduate theses from universities and an exhaustive review of the internet for published literature, especially those from scientific journals. Furthermore, participatory rural appraisal (PRA) techniques such as community visits and focus group discussions (FGD) were also carried out to obtain necessary information, while field observation and personal conversations with locals were also done to gain perspective about the present state of the Sarangani SES and the major driving forces that figured out significantly in its transformation.

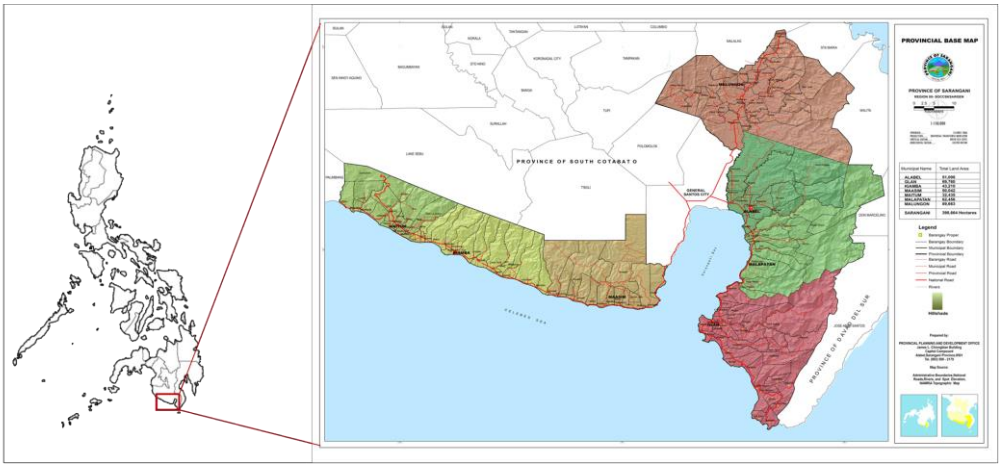

Figure 1. Location Map of Sarangani Province, Philippines (Source: Sarangani Province 2011)

2.3 Data Integration, Analysis and Dissemination

Collected data were subsequently integrated, synthesized, analyzed and interpreted using DPSIR and CCA. In the DPSIR framework, a ***driver*** refers to a need of humans or the community that has to be addressed. When humans act on this need, they exert ***pressure*** on the agroecosystem which in turn alters its ***state***. Consequently, this ***impacts*** the biological, chemical, physical, socio-cultural and economic state of the agroecosystem and leads to ***responses*** by society and policymakers. Additionally, a fishbone (Ishikawa) cause and effect diagram was constructed and used as the basis for CCA which diagnosed the problem at its core to come up with appropriate and long-lasting solutions. CCA can serve as a guide for movers and policymakers so that they will avoid the pitfalls of going for superficial solutions and instead resolve problems by addressing underlying issues.

Once inputs from various disciplines are distilled into a policy-relevant and actionable framework, these can be written as policy recommendations for submission to the province's Sanggunian (legislative body) for possible policy formulation in the form of ordinances. Study results can likewise be utilized for the crafting of interventions (i.e. programs) that will benefit locals in the upland communities. Finally, these results can be published in peer-reviewed scientific journals for wider circulation and readership.

3. Results

3.1 The Sarangani Uplands Social-ecological System

Shown in Figure 2 are the components, feedback loops and interactions that characterize the Sarangani SES. Its two main components, *viz.* social-cultural and biophysical systems operate via mutually impacting feedback loops whose effects can be ascertained through verifiable outcomes (*viz.* the status of bio-cultural resources, human health/well-being and the upland agroecosystem). Figure 2 likewise highlights the potential impacts of policy/management decisions on the Sarangani agroecosystem and the people inhabiting it. In these areas, the centrality of traditional rice farming in community life is very apparent. Moreover, tribal culture has been discovered to be largely intertwined with

the traditional agroecosystem and the tribal farmers' way of life. Presently, however, this fragile balance is being threatened by various driving forces and pressures.

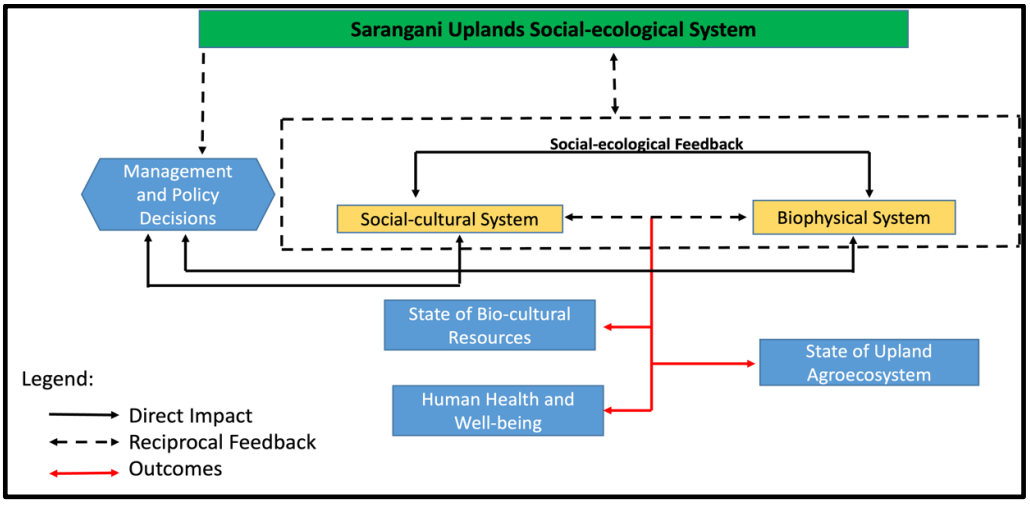

Figure 2. The Sarangani Uplands Social-ecological System

3.2 The Sarangani Uplands: Biophysical System

As shown in Figure 1, seven municipalities (viz. Malapatan, Malungon, Maasim, Maitum, Glan, Kiamba and Alabel) compose Sarangani Province. With only 14.5% of its total land area having an altitude of ≤ 100 meters above sea level (masl), Sarangani is classified as an upland province (Sarangani Province 2011). In addition, Sarangani's overall terrain, characterized primarily by undulating slopes, rolling hills and steep mountains, provides further evidence to this fact. By 2014, FMB-DENR revealed that 68% of the province's total land area were covered by lush forests with majority of it located in Maasim, Kiamba and Maitum. Later reports however revealed that only 10% of these areas had remnant forests with cover losses of 10.3 kha from 2001 to 2017 (Globalforestwatch.org). During this same period, the municipality of Maitum reflected the highest cover loss rate of 7.0% (Figure 3a&b).

In a published study, Zapico et al. (2019) predicted that the remaining watershed areas will be shrinking further in the coming years due to excessive resource extraction and the tribal practice of kaingin (slash-and-burn) activities in preparation for the planting of SAAD rice seeds and intensified abaca or Manila hemp (Musa textilis L.) farming (in Maitum and Kiamba, respectively). SAAD (Special Areas for Agricultural Development) is a government project that was instituted in 2017 to address problems of rice insufficiency through agricultural intensification in the Sarangani uplands. A cursory inspection of a kaingin field in the Maitum uplands revealed burned-down stumps of tree ferns (Cyathea spp) and age-old endemic trees (Figure 3c). In some farms, farmers harvested remaining tree saplings for commercial charcoal production (Figure 3d) prevented forest regrowth in the upland areas transforming them into wide expanses of unproductive grasslands that

are of nominal ecological and agricultural value. Upland rice and Sige-sige corn (recycled glyphosate-tolerant corn) cultivation along steep slopes without soil conservation measures further exacerbated ecosystem degradation in these areas (Figure 3e).

Figure 3 a-e. The biophysical situation in the Sarangani uplands. (a) Denuded mountains (b) felled logs along the roadside (c) aftermath of slash and burn (d) charcoal being hauled for lowland markets (e) transgenic corn and rice cultivation

Consequently, farmland and soil quality deterioration were all too common occurrences in the Sarangani uplands during field inspection. In a recent study documenting ethnopedological and scientific knowledge of Sarangani upland farmers, Zapico et al (2024) revealed a considerable decline in soil quality in these areas primarily due to anthropogenic activities and freak weather events. Moreover, anthropogenic activities and climate change exacerbated perennial problems in the Sarangani uplands making the traditional agroecosystem and the tribal communities less resilient to problems and perturbations that they encounter on a regular basis. The dangers to these communities become hugely magnified because Sarangani tribes tend to establish communities in risk-prone areas (*i.e.* along riverbanks and beside steep mountain slopes close to their rice fields). Farmers reported that in two instances, two villages (Kyondog and Centro in Malapatan) had to be physically transferred to other locations after being submerged in thick mud in the aftermath of landslide and flashflood events, respectively. Based on a study in the Himalayas, Sen et al (2009) similarly reported that farmland degradation is aggravated by hillside cultivation, deforestation and fire-based agriculture. Kesavan and Swaminathan (2008) reiterated these views and underscored the ecological and social problems besetting the world today as well as the "growing damage to life support systems provided by ecosystems and the devastating effects of global climate change".

3.3 The Sarangani Uplands: Socio-cultural System

Forty-five percent population of Sarangani Province is composed of *Lumads* or tribes with non-Muslim ethnicity (Figure 4a&b). In Sarangani Province, these groups had been pushed to the remote hinterlands due to the encroachment of communities and agroforestry systems into their erstwhile areas of habitation. Furthermore, a 2019 census

of the National Statistics Office certified Sarangani Province as the 3rd poorest province in the Philippines after Lanao del Sur and Sulu (NSO 2019). The Sarangani upland tribes are also the poorest and most marginalized sectors receiving the smallest social service allocations from the government (Carino 2012; LBRMO 2013). Furthermore, the remoteness of their villages and their inaccessibility has severely hampered government efforts to carry out official census in these areas. Consequently, the exact numbers of these tribal peoples are not known.

In the Sarangani uplands, an apparent reality is the centrality of traditional rice farming to the tribal community and way of life.. The importance of upland rice is manifested by the number of varieties cultivated by farmers, the annual festivities being celebrated during harvest time and the persistence of traditional farming in remote communities (Figure 4e). Recent studies, however, revealed concomitant rice varietal losses in these areas because of seed introductions, changing mindsets of farmers, increasing frequencies of pest infestation, weakening seed supply systems, market-oriented agriculture, climate change-related devastation, environmental degradation, and peace and order problems (Zapico et al. 2020). Moreover, studies by Espina (2015), Eayte (2015), Suarez (2017), Rodriguez (2018), Ramos (2018) and Buay (2018) reported that traditional varieties of corn, coffee, root crops, *Musa* spp, vegetables, spices and medicinal plants in the Sarangani uplands were dwindling in numbers because of lowland influences and the destruction of their natural habitats.

Additionally, tribal culture in these areas was observed to be rapidly eroding because of the ingress of modernization and mindset change among farmers, market linkage, poverty and education. Since the past 2 decades, the encroachment of lowland peoples and modernization have resulted in a paradigm shift, especially among the young generation of tribes. Considering upland farming as tedious and not a viable income source, the youth migrate to towns and cities to find jobs or get an education. When they graduate, these tribal youth usually remain in the lowlands because of better economic opportunities. This tribal diaspora has resulted in the abandonment of rice fields, resulting in wide scale farmland degradation. In addition, a significant number of tribal men remaining in the communities opt for non-farming jobs (i.e. driving a motorcycle, construction work) over rice farming. Furthermore, biocultural erosion in these communities become exacerbated by the oral nature of knowledge transmission and the death of tribal elders (Figure 4a) who are revered as the traditional knowledge keepers.

The arrival of lowland migrants, in particular, resulted in a paradigm shift, especially among the young generation of tribes. To escape the drudgery of upland farming, the youth migrate to towns and cities to find jobs or get an education. When they graduate, these tribal youth usually remain in the lowlands because of better economic opportunities. At present, many upland fields have remained untilled because tribal men choose non-farming jobs (*i.e.* driving a motorcycle, construction work) over rice farming. Occurrences of

cultural erosion these days are further compounded by the death of tribal elders (Figure 4a) who are the ultimate keepers of traditional knowledge.

Figure 4a-e. Socio-cultural realities in the Sarangani uplands (a) elderly woman farmer planting rice (b) tribal women in Sarangani (c) children showing symptoms of kwashiorkor (d) child (lying down) with suspected inbreeding defects and (e) post-harvest feast

Finally, the declining health and well-being of tribal farmers trumps all other problems and considerations in the Sarangani uplands (Figure 3c&d). Using body mass index (BMI), dietary health habits, vaccination and breastfeeding by pregnant mothers as health and nutritional indicators, Manzo (2017) revealed rampant malnutrition among children in selected upland communities in Sarangani Province. These results were corroborated by Cosme (2019) who discovered that household diets in the areas are largely carbohydrate-based and deficient in terms of proteins, minerals and vitamins. Severe nutrient deficiencies resulted in widespread protein malnutrition (kwashiorkor and marasmus) that was observed among the children during fieldwork. Observable symptoms of severe protein malnutrition were chubby cheeks, bloated bellies, stunted growth and underdeveloped limbs.

4. Discussion

4.1 Linking Biophysical and Socio-cultural Systems

For this study, interactions and relationships between human systems and the environment were assessed by cause and effect analysis using the fishbone (Ishikawa) diagram, DPSIR and CCA. For the Sarangani situation, DPSIR and CCA were jointly used to elucidate the issues and concerns that impact the agroecosystem and the people inhabiting it.

4.1.1 The DPSIR Framework

Identified major ***drivers*** in the Sarangani SES were tribal culture, climate change, socio-political and economic factors. Also underscored by DPSIR (Figure 5) were ***pressures*** (*viz.* changes in agricultural practices, extreme weather events, modernization/outmigration, land use changes, demographic changes, mismanagement and unregulated environmental/resource extraction) that wrought significant changes to the Sarangani uplands and the peoples' way of life. In particular, agricultural modernization, the shift to cash crops (i.e. *Sige-sige* corn, abaca and pineapple, among others) and the associated use of chemical inputs drastically altered the upland landscape and the capacity of the SES to provide ecosystem goods and services (Odio 2018). The effects of these changes were further exacerbated by unsustainable land use changes such as shifting cultivation to more sedentary agriculture, the change to crop plantation settings and the granting of concessions to mining and logging corporations. The fast rate of forest clearing resulted in changing forest dynamics, the predominance of cogon grass in the fields, habitat degradation, death/displacement of endemic floral and faunal species, and consequently, food and water deficits in these areas. Climate change, another major pressure in the Sarangani uplands, compounded the deleterious effects of the other ecosystem pressures, resulting in more problems and perturbations. Furthermore, the lack of policy for environmental protection and sustainable use altered agroecosystem dynamics and landscape features, worsened water deficit problems and ultimately, negatively impacted agricultural productivity.

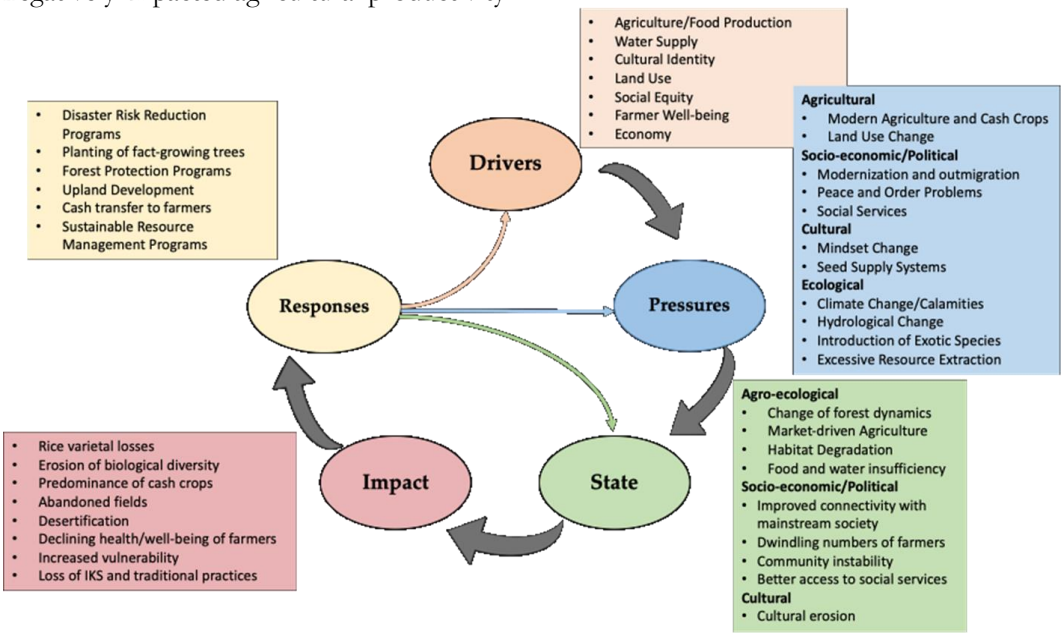

Figure 5. DPSIR Framework Showing Interrelationships of Factors Impacting the Sarangani Social- Ecological System

In the socio-economic and political spheres, the lure of modernization and better economic opportunities caused tribal diaspora (especially among the younger generation) to lowland towns and cities. Other factors that spurred tribal outmigration were prevalent

poverty, the uncertainties associated with upland farming, the failure of the government to deliver basic social services and peace and order problems in these far-flung areas (Zapico et al. 2019). Furthermore, market-driven agriculture in the Sarangani uplands can be considered as a double-edged sword owing to its favorable and unfavorable consequences. On the one hand, it resulted in improved connectivity with mainstream society, better access to social services and improved household income. On the other hand, better linkages with the lowlands resulted in dwindling numbers of farmers, abandoned fields and the rapid erosion of tribal culture, traditions, and endemic natural resources.

Upland rice varieties, in particular, were noted to have decreased in numbers because of the shifting priorities of farmers, agricultural modernization, climate change and other factors (Zapico et al 2020). Consequently, diminishing kinds and quantities of food sources likewise compromised the health and well-being of upland families and caused rampant poverty, hunger and malnutrition (Cosme 2018). These changes increased community instability and vulnerabilities, resulting in decreased resiliency and adaptive capacity of the locals to challenges they regularly grapple with (Rellon 2017).

In response to problems besetting the upland tribes and their environments, several programs/policies and ordinances were instituted by the local and national governments, non-government organizations (NGOs) and international funding agencies such as the European Union and the Asian Development Bank. Several of these were aimed at reforesting the denuded upland areas, apprehension of *kaingin* violators and poachers, improving the abilities of the upland tribes to respond/adapt in the event of natural or man-made catastrophes, food security through mass cultivation of upland rice (SAAD project) and conditional cash transfers to upland households (Zapico et al. 2019). Additionally, information drives were carried out to educate the upland tribes about disaster preparedness while farmer field schools were occasionally conducted to introduce farming techniques, and consequently improve agricultural productivity. Finally, the government addressed problems relating to acculturation by maintaining schools of living tradition and showcasing tribal rituals during annual festivities.

4.1.2 Causal Chain Analysis

A Ishikawa (Fishbone) diagram (Figure 6) was constructed to ascertain cause-and-effect relationships of factors, pressures and driving forces that underlie two intractable problems (food insecurity and wide scale upland devastation) that Sarangani tribal farmers grapple with on a regular basis.

Subsequently, inputs from the fishbone diagrams were used to make causal chain loops for the Sarangani food system (Figure 7) and agroecological system (Figure 9). For the food system, identified problems were incidences of crop varietal losses due to biotic and abiotic stresses, and lower yields that consequently resulted in food shortage and malnutrition, especially among children. Other identified problems were acculturation and the predominance of recycled transgenic corn in farmers' fields which caused significant genetic and cultural losses, as well as farmland degradation.

Figure 6. Ishikawa Diagram for Food Systems

Figure 7 shows the CCA flowchart for Sarangani food systems. The superficial solutions pathway identified intermediate/obvious problem causes such as crop varietal losses, food shortage/malnutrition, the predominance of *Sige-sige* corn (recycled transgenic corn), low agricultural productivity and cultural erosion. In these areas, the introduction of cash crops, encroachment of lowland resources and influences resulted in concomitant losses of tribal crop resources and associated indigenous knowledge systems (IKS), a development that can potentially lead to irreversible genetic losses and cultural homogenization. Recently, a conducted study on the genetic diversity analyses of Sarangani traditional upland rice using morphological and multispectral traits and single nucleotide polymorphisms (SNPs) revealed a very narrow genetic base for this very important caloric staple (Zapico 2021). On the other hand, climate change (in red), while having deleterious effects on the Sarangani agroecosystem, cannot be classified as a root cause because it is a prevailing reality and nothing can be done to resolve it at the level of the community.

The local government of Sarangani, to solve or mitigate the effects of these problems, distributed sacks of rice to famished upland households and ramped up the implementation of the 4Ps program which provided cash (approximately $83/month) to poverty-stricken families (Zapico et al. 2019). To address food insecurity problems among tribal households, the Mindanao-wide SAAD program was implemented in the Sarangani uplands. Moreover, tribal communities showcase tribal rituals during annual festivals to renew appreciation and love for traditional culture.

As seen in Figure 7, these superficial interventions have low leverage points (S<R) and do not stand a good chance of actually resolving persistent problems in the Sarangani uplands. These types of interventions are generally popular, especially among term-limited politicians who rely on a huge support base among their voting constituents. Oftentimes, these events are ostentatious displays for maximum public impact. It should be noted, however, that while superficial solutions may be beneficial in the short term, they are usually not sustainable, with some creating more problems in the long term. The SAAD program, in particular, resulted in the wide-scale slash and burn of forests in several areas of the Sarangani uplands. Some SAAD farmer recipients, having no farmlands to plant rice seeds on, razed surrounding forests for rice farming. Moreover, the Sarangani uplands, owing to their steep terrains, are ill-suited for agricultural intensification. Hillside

cultivation, according to several studies (Elauria et al 2017; Paningbatan 1990), has been identified as a major cause of farmland degradation in upland areas in the Philippines.

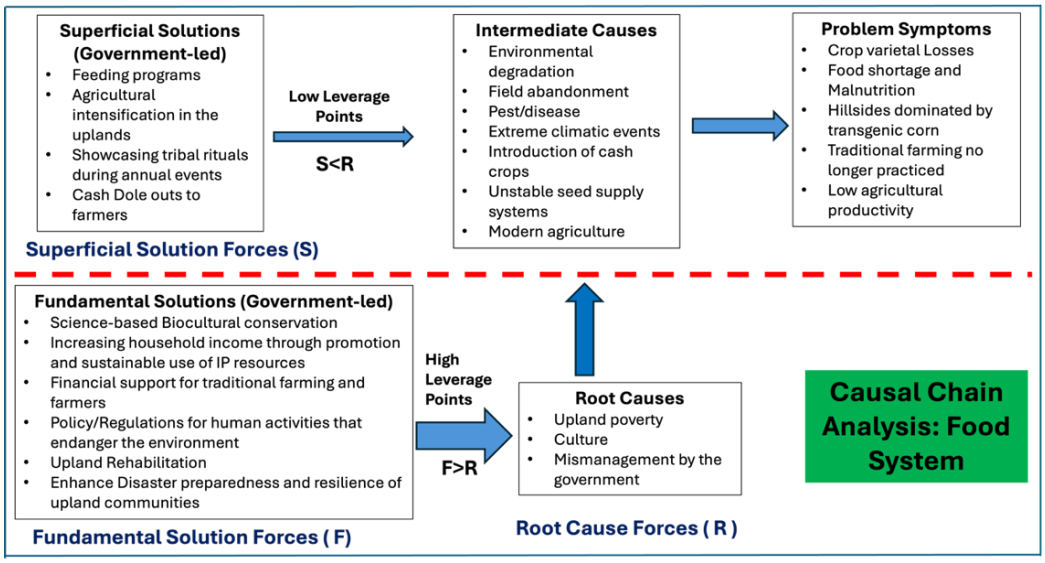

Figure 7. Causal Chain Analysis Flowchart for Problems Affecting the Sarangani Food System

As shown in the fundamental solutions pathway, the **root causes** of perennial problems in the Sarangani uplands are upland poverty, tribal culture and the absence of consistent government support/regulatory mechanisms for tribal communities and agroecosystem degradation. The cultural practice of *kaingin*, as compounded by hillside cultivation and excessive resource extraction also wrought widespread ecosystem deterioration, threatening the very existence of the upland tribes in these areas. For these root causes, proposed interventions are (*1*) science-based biocultural conservation, (*2*) policy support for upland agriculture and upland rehabilitation, (*3*) policies regulating farming and resource extraction practices that can potentially harm the environment, (*4*) increasing household income through promotion (agri-ecotourism) and sustainable use of IP resources, (*5*) identification of niche markets, (*6*) incentivization of traditional farming, and (*7*) the enhancement of resilience and adaptability of the upland communities to disasters and the devastating effects of climate change. Since culture is dynamic and constantly evolving, measures to undertake must be timely, flexible, farmer-friendly and sustainable. Documentation of traditional culture for posterity is imperative since the oral manner of knowledge transmission by the Sarangani tribes makes it prone to loss. The incorporation of traditional knowledge into the academic curricula in primary schools will ensure that this cultural treasure will be transmitted to succeeding generations. Furthermore, cultural

eco-tourism ventures that have minimal environmental impacts will help conserve traditional resources while providing the tribal farmers with a steady income source.

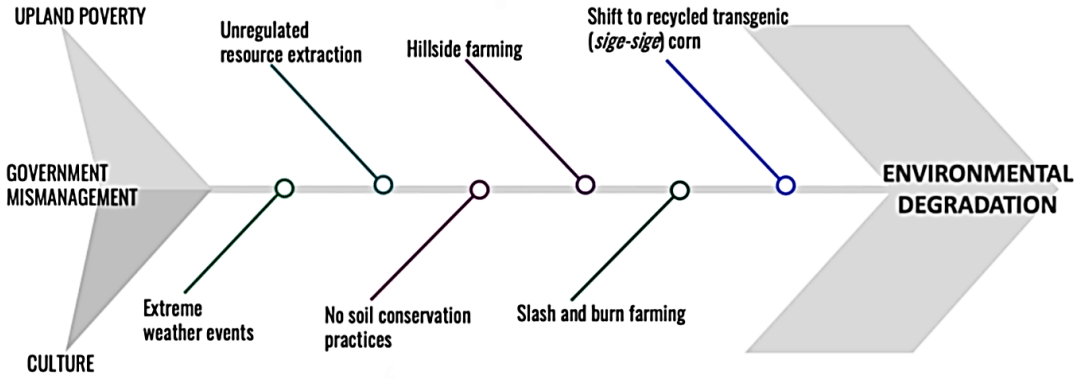

Figure 8. Ishikawa Diagram for Agroecological System

Figure 8 and CCA for the agroecological system (Fig 9) show cause-and-effect relationships that underlie environmental degradation in these areas. Extreme weather events, exacerbated by global climate change, resulted in ecological devastation in the Sarangani uplands. Other identified factors that contributed to environmental destruction were excessive resource extraction, the tribal practices of slash-and-burn and hillside farming without soil conservation measures in place. In particular, farmland degradation can be ascribed to the deleterious effects of hillside cultivation, swidden farming and unregulated deforestation as compounded by natural catastrophes (*i.e.* flash floods) which strip the fields of topsoil. These devastating effects are compounded by deforestation that causes shrinkage of watershed areas, consequently resulting in water deficits, more extreme weather/climate events, altered forest dynamics, wildlife extinction and genetic diversity losses, especially for traditional crops. As for the tribal people, major problems emanate from a paradigm shift towards modernization, cash-oriented farming, poverty and the difficulties and uncertainties associated with living in the Sarangani uplands. In addition, the displacement of traditional rice with *Sige-sige* corn, along with its associated glyphosate use, led to the wide-scale denudation of mountains and the predominance of cogon grass along the hillsides.

A more casual look at problem symptoms will result in the identification of excessive resource extraction, hillside farming, slash and burn, extreme climatic events, the introduction of cash crops, modern agriculture, and lack of soil conservation measures as the intermediate causes of these problems. In the Sarangani SES, the identification of immediately obvious causes of the problem spawned superficial solutions such as reforestation using exotic trees, policing of forests for poachers, illegal loggers and swidden farmers and the introduction of organic farming and farmer field schools.

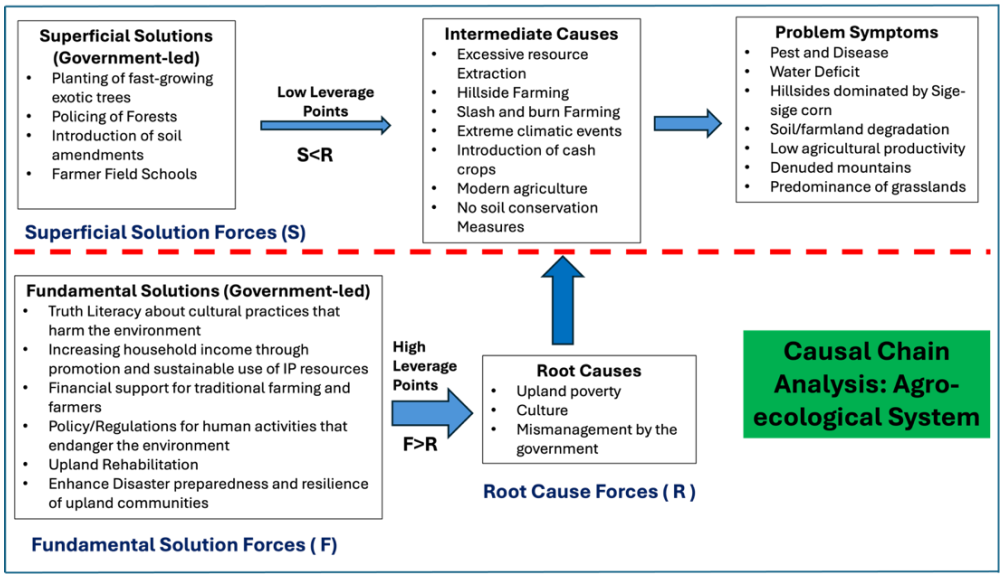

Figure 9. Causal Chain Analysis Flowchart for the Sarangani Agro-ecological System

On the other hand, probing deeper leads to the identification of the root causes of encountered problems (*i.e.* upland poverty, culture, mismanagement by the government). Unfortunately, these root causes, owing to the complex effects they cause, cannot be instantly resolved with unilateral and short-term interventions. Instead, more targeted approaches such as (***1***) the promotion of truth literacy about cultural practices that harm the environment, (***2***) upland rehabilitation using endemic species, (***3***) increasing household income through promotion and utilization of IP resources, (***4***) financial support for traditional farming and farmers, (***5***) policy/regulations for human activities that harm the environment and (***6***) enhancement disaster preparedness and resilience of upland communities through government-led initiatives.

4.2 The Sarangani SES: The Way Forward

The Sarangani uplands are a microcosm of traditional SESs worldwide. Like other traditional agroecosystems, the Sarangani SES was shaped by its unique terrain, climatic conditions, isolation and tribal culture, among others. Using combined DPSIR and CCA, this study identified several challenges to the Sarangani SES and managed to shed light on scenarios that had been unfolding in the upland communities for the past years. In particular, the DPSIR framework was able to successfully identify driving forces and pressures, determine ecosystem status/impacts and provide a way to assess the feasibility of interventions that were carried out to solve/mitigate problems in the Sarangani uplands. Moreover, revealed by the study are several key characteristics of the Sarangani SES *viz.* (***1***) highly integrated biophysical and socio-cultural processes (***2***) unpredictable and downward-oriented SES trajectories (***3***) mutual feedback between social and ecological processes (***4***) nature of drivers/pressures vary significantly through time and slightly in space and (***5***) causes and effects of problems are directly and indirectly anthropogenic. In their respective studies, Colding and Barthel (2019) and Delgado-Serrano et al. (2015)

likewise reported similar SES tendencies. Moreover, this study highlighted aspects of the Sarangani SES that had previously been over-simplified, leading to ill-advised policy and management decisions. Deeper analyses using DPSIR and CCA identified sources of complexity such as the relationship between human activities on the one hand, and agrobiodiversity through spatiotemporal patterns, and environmental and cultural transformation on the other. By factoring in this complexity in the decision-making process, sustainable, appropriate and evidence-based interventions can be crafted for the improvement of the quality of life of tribal households in the Sarangani uplands.

Several factors, however, hinder the successful implementation of much-needed interventions in the Sarangani uplands. First is slash-and-burn farming (or kaingin) which is cultural to the tribes. This type of farming accelerates forest cover losses, and aggravates problems in badly degraded ecosystems. Second is the terrain of the Sarangani upland agroecosystem which is characterized by steep slopes and rolling hills and which is not suited to agricultural intensification. Third is the degree/scale of farmland degradation. In many areas visited, formerly fertile farmlands had been transformed into barren fields or unproductive grasslands dominated by cogon grass and hardy herbs. For the Sarangani uplands therefore, agricultural intensification is not an option.

These upland problems necessitate interventions aimed at soil conservation. This can be accomplished through soil conservation methods (i.e. slope agriculture land technology or SALT), upland rehabilitation using endemic tree species and the regulation of hillside farming and herbicide use along steep slopes. Moreover, the tribal practice of intercropping and planting of legumes during the fallow period must be promoted to improve soil quality. Finally, enhancement for subsistence farming is recommended with support from the local government through incentivization of traditional farming, niche marketing and value-adding using geographical indicators, cultural and scientific information. Through these multifaceted interventions, it is envisaged that the state of the Sarangani upland environment and the conditions in the tribal households will be uplifted.

Furthermore, one limitation of the study is the use of qualitative data and local accounts, resulting in limited generalizability and extrapolation of obtained results. This cross-sectional study of the Sarangani SES takes a snapshot of the tribal community and investigates constructs that are likely to change over time. Therefore, cause and effect relationships and trends through time cannot be established. Longitudinal studies address this weakness by enabling deeper analysis of dynamic changes that occur in SESs along a temporal scale. Nigel and Partelow (2022) revealed that longitudinal studies, owing to the nature and depth of their analyses, improve ability to assess causality in SESs while allowing for a direct analysis of change (Stidham et al 2014) that transpire in an agroecosystem like the Sarangani uplands. Therefore longitudinal studies, as opposed to one-time investments, unveil trends and patterns that are critical for policy development and environmental management (De Silva 2016; Nigel and Partelow 2022).

Another hindrance to successful project implementation is the attitude of the upland tribes towards proposed interventions. Unless deeply embedded in tribal culture, these interventions have very low chances of success. In these communities, top-down strategies do not work on the longer term. Interventions usually work while project funds are available and cease when these run out. Subsequently, the tribal farmers revert to old ways, sometimes resulting in even greater problems. This lack of sustainability warrants a

paradigm shift among the tribes- a reality that can only be accomplished by finding a 'tribal champion' who can effectively communicate the merits and benefits of proposed interventions.

Table 1. Recommendations for Policy Action

ISSUES in the Sarangani SES	Suggested Responses	Priority Requirement
• Agrobiodiversity Losses	• Intensified collection, genetic diversity analyses and *in situ*/*ex-situ* conservation of tribal crop resources, enhanced utilization	• Urgent action followed by long-term attention
• Cultural Erosion	• Documentation, incorporation of traditional knowledge in the primary school curriculum, cultural eco-tourism projects	• Long term attention
• Household Health/Nutrition	• Addressing problems of malnutrition and disease through household visits, enhanced utilization of indigenous vegetable resources, medicinal plants and other food sources	• Urgent action followed by long-term attention
• Low agricultural productivity	• Financial (microloans, crop insurance) and technical support (pest control, soil conservation etc), provision of an incentive scheme for farmers planting RLs using traditional farming methods, linking farmers to niche markets	• Urgent action followed by long-term attention
• Environmental Degradation and Wildlife Losses	• Upland rehabilitation using endemic species, soil conservation measures, regulation of hillside cultivation and *Sige-sige* corn cultivation, regulating slash and burn farming	• Urgent action followed by long-term attention

*policy support is required for the sustainability of these proposed interventions

Based on the joint use of DPSIR and the CCA frameworks, an issue-response table is constructed (Table 1). Suggested responses herein are geared towards the conservation of bio-cultural resources and improving farmer and environmental well-being in the Sarangani SES. Table 1 shows the problems/perturbations prevalent in the Sarangani SES and suggests interventions along with notations about the urgency/ priority of their implementation. To avert cultural losses, the incorporation of traditional knowledge in the primary school curriculum is recommended. Further studies are however warranted to assess the long-term effectiveness of educational programs in fostering cultural pride and knowledge transmission. If successful, indigenous knowledge integration in the academic curriculum can improve community resilience while empowering the tribal youth to participate in sustainable cultural preservation efforts. Hopefully, these would encourage them to remain in the farms and choose upland farming as their eventual profession, thereby ensuring the continued presence of the tribes and the perpetuation of traditional resources and culture in these areas.

It has to be emphasized that the success and sustainability of interventions hinge on strong policy support. Since these interventions have long-term implications for the upland tribes, their implementation must transcend the term limits of local politicians. Finally, this study was carried out to provide policymakers with effective decision-making tools that they can

utilize to solve deep-seated problems in the Sarangani uplands. Since the proposed responses are intentionally directed at the root causes of problems in the Sarangani SES, they are presumed to be long-term and sustainable solutions that can potentially prevent problem recurrence, especially if implemented correctly and backed by effective ordinances and legislation by the local government.

5. Conclusion

For traditional agroecosystems worldwide, crafting a developmental strategy with outcomes that benefit both indigenous peoples and nature is a daunting task. While many ecosystem assessment methodologies have been implemented, obtained outcomes were seldom satisfactory, and seamless operationalization has proven to be elusive up to this time. By adapting the SES to diverse contexts, while taking into account cultural and ecological diversity, the Sarangani upland communities will be a step closer to the attainment of sustainable development goals (SDGs) such as the eradication of poverty and hunger and the promotion of household health and well-being, sustainable communities and viable partnerships with various stakeholders.The SES approach, along with DPSIR and CCA, likewise directs policymakers to address problems at their root causes and provides sufficient bases for developing long-lasting, sustainable, dynamic, and evidence-based interventions. Through the combined use of these two approaches, problems besetting the Sarangani uplands will be better understood and interventions that are perfectly dovetailed to this traditional agroecosystem will be crafted, thereby improving the quality of life of upland tribes in these areas. Finally, while this paper singularly studied the Sarangani SES at the regional level, its results reflect changes and transformations happening in the macrocosm of traditional agroecosystems all over the globe.

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References

Aguilar, C.H.M., Altoveros, N.C., Borromeo, T.H., Dayo, M.H.F. and P. Koohafkan. 2020. Traditional rice-based agroecosystem in Kiangan, Ifugao, Philippines: drivers of change, resilience, and potential Trajectories. Agroecology and Sustainable Food Systems. 1-21. https://doi.org/10.1080/21683565.2020.1813861

Balzan, M.V., Pinheiro, A.M., Mascarenhas, A., Morán-Ordóñez, A., Ruiz-Frau, A., Carvalho-Santos, C., Vogiatzakis, I.N., Arends, J., Santana-Garcon, J., Roces-Díaz, J.V., Brotons, L.C., Campagne, S., Roche, P.K., de Miguel, S., Targetti, S., Drakou, E.G., Vlami, V., Baró, F., and I.R. Geijzendorffer. 2019. Improving ecosystem assessments in Mediterranean social-ecological systems: a DPSIR Analysis. Ecosystems and People. 136-155. https://doi.org/10.1080/26395916.2019.1598499

Berkes, F., J. Colding, and C. Folke, Eds. 2003. Navigating social-ecological systems: Building resilience for complexity and change. New York: Cambridge University Press.

Berkes, F., and C. Folke. 1998. Linking social and ecological systems: Management practices and social mechanisms for building resilience. Cambridge: Cambridge University Press.

Berthet ET, Bretagnolle V and Gaba S. 2022. Place-based social-ecological research is crucial for designing collective management of ecosystem services. Ecosystem Services 55 (2022) 101426. https://doi.org/10.1016/j.ecoser.2022.101426

Buay, B.M. 2018. Traditional Healers and Indigenous Medicinal Plants of Sarangani Upland Communities. Unpublished undergraduate thesis, Mindanao State University, General Santos City, Philippines.

Carino, J.K. 2012. Country Technical Notes on Indigenous People's Issues: Republic of the Philippines. http://www.ifad.org/english/indigenous/pub/documents.

Colding, J., and S. Barthel. 2019. Exploring the Social-ecological Systems Discourse 20 Years Later. Ecology and Society. 24(1): 2. doi.org/10.5751/ES-10598-240102

Cosme, A.P. 2019. Dietary Species in the Sarangani Upland Households: Diversity, Accessibility and Distribution. Unpublished undergraduate thesis, Mindanao State University, General Santos City, Philippines.

Delgado-Serrano, M., E., Oteros-Rozas, P., Vanwildemeersch, C., Ortíz Guerrero, S., London, and R. Escalante. 2015. Local perceptions on social-ecological dynamics in Latin America in three community-based natural resource management systems. Ecology and Society. 20(4):24. http://dx.doi.org/10.5751/ES-07965-200424

de Silva S. 2016. Need for longitudinal studies of Asian wildlife in the face of crises. Global Ecology and Conservation. 276–285. http://dx.doi.org/10.1016/j.gecco.2016.03.010

Díaz, M.E., Figueroa, R., Alonso, M.L.S., and Vidal-Abarca, M.R. 2018.Exploring the complex relations between water resources and social indicators: the Biobío Basin (Chile). Ecosystem Services. 31:84–92. doi:10.1016/j.ecoser.2018.03.010.

Eayte, R.M. 2015. Coffee Genetic Resources in Sarangani Province: Diversity, Distribution and Vulnerabilities to Climate Change. Unpublished undergraduate thesis, Mindanao State University, General Santos City, Philippines.

Espina, P.G. 2015. "Status of Corn Diversity in the Marginal Uplands of Sarangani Province: Implications for Conservation and Sustainable Use. Unpublished undergraduate thesis, Mindanao State University, General Santos City, Philippines.

FMB-DENR. 2014. Philippine Forestry Statistics, Forest Management Bureau-Department of Environment and Natural Resources (FMB-DENR), Manila.

Gain, A.K., Giupponi, C., Renaud, F.G. and Vafeidis, A.T. 2020. Sustainability of complex social-ecological systems: methods, tools, and approaches. Regional Environmental Change 20: 102 https://doi.org/10.1007/s10113-020-01692-9

Gonçalves, L.R., Oliveira, M. and Turra, A. 2020. Assessing the Complexity of Social-Ecological Systems: Taking Stock of the Cross-Scale Dependence. Sustainability, 12, 6236; doi:10.3390/su12156236

Kesavan, P.C., and M.S. Swaminathan. 2008. "Strategies and models for agricultural sustainability in developing Asian countries", Philosophical Transactions of the Royal Society B: Biological Sciences, Vol. 363 No. 1492, pp. 877-891.

Manzo, K.A. 2016. Factors Affecting the Health and Nutritional Status of Children in Selected Upland Communities of Sarangani Province, Philippines. Unpublished undergraduate thesis, Mindanao State University, General Santos City, Philippines.

LBRMO (Legislative Budget Research and Monitoring Office). 2013. Budget Facts and Figures. http://www.senate.gov.ph/publications

Leslie, H.M., Basurtoc, X., Nenadovic, M., Sievanena, L., Cavanaugh, K.C., Cota-Nietof, J.J., Erismang, B.E., Finkbeinerh, E., Hinojosa-Arangof, G., Moreno-Báezf, M., Nagavarapub, S., Reddya, S.M.W., Sánchez-Rodríguez, A., Siegela, K., Ulibarria-Valenzuela, J.J., Weaver, A.H., and O. Aburto-Oropeza. 2015. Operationalizing the social-ecological systems framework to assess sustainability. Proceedings of the National Academy of Sciences. vol. 112 | no. 19 | 5979–5984. www.pnas.org/lookup/suppl/doi:10.1073/pnas.1414640112/-/DCSupplemental.

Liu F., Dai, E., Yin, J. 2023 A Review of Social–Ecological System Research and Geographical Applications. Sustainability. 15, 6930. https://doi.org/10.3390/ su15086930

Nagel, B., and S. Partelow. 2022. A methodological guide for applying the social-ecological system (SES) framework: a review of quantitative approaches. Ecology and Society 27(4):39. https://doi.org/10.5751/ES-13493-270439

NSO. 2019. National Statistics Office. Republic of the Philippines.

Odio, V.M.E. 2019. Assessment of Ecosystem Goods and Services Derived from Sarangani Traditional Upland Agroecosystems. Unpublished undergraduate thesis, Mindanao State University, General Santos City, Philippines.

Partelow, S., and K. J. Winkler. 2016. Interlinking ecosystem services and Ostrom's framework through orientation in sustainability research. Ecology and Society 21(3):27. http://dx.doi.org/10.5751/ES-08524-210327

Pinto, R., de Jonge, V.N., Neto, J.M., Domingos, T., Marques, J.C., and J. Patrício. 2013. Towards a DPSIR driven integration of ecological value, water uses and ecosystem services for estuarine systems. Ocean Coast Management. 72:64–79. doi:10.1016/j.ocecoaman.2011.06.016.

Ramos, C.J.M. 2018. Fruits, Vegetables and Spices used by Upland Tribal Communities in Sarangani Province: Utilization and Conservation Initiatives. Unpublished undergraduate thesis, Mindanao State University, General Santos City, Philippines.

Rellon, V.C. 2018. Resilience Assessment of the Selected Upland Communities in Sarangani Province. Unpublished Undergraduate Thesis. Mindanao State University, General Santos City, Philippines.

Rodriguez, C.R.M. 2018. Morphological Characterization of Musa Species in the Sarangani Uplands. Unpublished undergraduate thesis, Mindanao State University, General Santos City, Philippines.

Sarangani Province. 2011. Status Report on the Millenium Development Goals using CBMS Data.

Sen, K.K., Rao, K.S. and K.G. Saxena. 1997. Soil erosion due to settled upland farming in the Himalaya: a case study in the Pranmati watershed. International Journal of Sustainable Development and World Ecology, Vol. 4 No. 1, pp. 65-74.

Stidham M, Olsen C, Toman E, Frederick S, McCaffrey S, Shindler B. 2014. Longitudinal Social Science Research in Natural Resource Communities: Lessons and Considerations. Society and Natural Resources, 27:1104–1108. https://doi.org/10.1080/08941920.2014.905895

Suarez, G.J. 2017. Genetic Diversity and Indigenous Knowledge Associated with Non-Rice Carbohydrate Sources of Selected Blaan Communities in Sarangani Province Unpublished Undergraduate Thesis. Mindanao State University, General Santos City, Philippines.

Turner BL, Kasperson RE, Matson PA, McCarthy JJ, Corell RW, Christensen L, Eckley N, Kasperson JX, Luers A, Martello ML, Polsky C, Pulsipher A, Schiller A (2003) A framework for vulnerability analysis in sustainability science. Proc Natl Acad Sci 100(14):8074. https://doi.org/10.1073/pnas.1231335100

Vidal-Abarca, M.R., Suárez Alonso, M.L., Santos-Martín, F., Martín-López, B., Benayas, J., and C. Montes. 2014. Understanding complex links between fluvial ecosystems and social indicators in Spain: an ecosystem services approach. Ecological Complexity.20:1–10. i:10.1016/j.ecocom.2014.07.002.

Wu, X., Wei, Y., Fu, B., Wang, S., Zhao, Y., and E. F. Moran. 2020. Evolution and effects of the social-ecological system over a millennium in China's Loess Plateau. Science Advances. 6: eabc0276 7.

Zapico, F.L. 2021. Genetic, Ecological and Biocultural Assessment of Sarangani Upland Rice and Traditional Agroecosystem. Unpublished Doctoral Dissertation. University of the Philippines – Los Banos, Laguna, Philippines

Zapico, F.L., Dizon, J.T., Borromeo, T.H., McNally, K.L., Fernando, E.S., and J.E. Hernandez. 2020a. Genetic erosion in traditional rice agro-ecosystems in Southern Philippines: drivers and consequences. Plant Genetic Resources; 1–10. doi:10.1017/S1479262119000406

Zapico, F.L., Dizon, J.T., Borromeo, T.H., McNally, K.L., Fernando, E.S., and J.E. Hernandez. 2020b. Upland Rice: Cultural Keystone Species in a Philippine Traditional Agroecosystem. Asian Journal of Agriculture and Development. 93-104. https://doi.org/10.37801/ajad2020.17.2.6

Zapico, F.l., Hernandez, J.E., Borromeo, T.H., McNally, K.L., Dizon, J.T., and E.S. Fernando. 2019. Traditional Agro-ecosystems in Southern Philippines: Vulnerabilities, Threats and Interventions. International Journal of Disaster Resilience in the Built Environment 10(4): 289–300.

Zapico, F.L., Aguilar, C.H., Abistano, A., Turner, J.C., and L.J. Reyes. 2015. Biocultural Diversity of Sarangani Province, Philippines: An Ethno- Ecological Analysis. Rice Science. 22(3): 138−146. https://doi.org/10.1016/j.rsci.2015.05.018

Zapico, F.L, Dizon, J.T., Fernando, E.S. 2024. Comparing Indigenous Soil Quality
Knowledge Systems and Scientific Soil Assessment in a Traditional Upland Rice-
based Agroecosystem in Southern Philippines. Journal of Engineering, Environment and Agriculture Research. Vol 3(1): 5-18.