Doctoral Thesis (Abridged)

博士論文（要約）

Indigenous Guna perspectives on sustainable development challenges: A transdisciplinary approach to identify impact interlinkages

(持続可能な開発課題に対する先住民グナ族の視点：
トランスディスプリナリーアプローチによる開発インパクト連関の特定)

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"what we need is to be able to explain our point of view to them [National Government], and for them to explain how they see us, ***it is just a simple matter of talking to each other****, to listen to each other…*
But they rather attack us through the media,
and of course, we are not animals,
I am a human being the same as you, I think, I feel,
we have to response against this bad image they portrait on us…

we have the same issues, pains, and concerns as you do,
we also have children, I am constantly thinking about their future,
I want them to stay away from the wrong paths,
to be someone in this life,
like any other father,
however,
we have been tagged as savages…*"*

- Soledad Miria General Secretary
personal communication, 2018

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Summary

The Gunas are one of the eight recognized indigenous group in Panama with settlements along the north-eastern region of the country. They represent the second largest indigenous group and account for 19% of the total indigenous people in Panamá and 2% of the total national population. Their livelihoods come mainly from tourism, agriculture, and fishing (although the last two are mainly for subsistence). The Gunas are the first indigenous group to enjoy full administrative and political autonomy over their territory known as Gunayala. This region consists of 51 communities scattered mainly among the islands located in the San Blas archipelago. Of these 51 communities, two are communities of afro-descendants and are settled in the mainland, while the remaining 49 are Guna communities (38 settled in islands, 11 settled in the mainland). The community is the main social unit for the Gunas, and each community is guided by a local chief (known as "sagla"). Their highly organized socio-political structure has been praised as a success and a model for other indigenous groups in Panama.

However, their ancestral homeland faces multiple sustainability challenges. The increased interaction with the outside world in the last 20 years has triggered rapid changes in the Gunas value system. The saglas of these indigenous communities are struggling to balance a development agenda and maintaining their traditional socio-ecological system (SES). While the Guna worldview puts their people under the role of caretakers of nature with a lifestyle that preserves their costal and island ecosystems, the younger generation has started adopting new values that prioritize development over tradition and harmonious co-existence with nature. Even though their socio-political system is considered to be one of the best organized among indigenous people worldwide the actual development outcomes have been rather poor having a much lower Human Development Index (HDI) and Multidimensional Poverty Index (MPI) compared to the national average. Even though the Gunas have a strong representation in Panama´s legislative branch, there seems to be a lack of attention to Gunayala´s needs, which combined with its difficult access location, misunderstood worldview from latin societies, frictions with the national government over resource access, and insufficient funding, have led to these poor development outcomes.

Despite many indigenous communities worldwide experiencing similar changes that catalyse shifts in their traditional livelihoods, lifestyles, and social interactions, there is scare literature studying these phenomena from the local viewpoint. While the inclusion of indigenous people's perspective has received ample attention in the current academic discourse and the processes of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), little progress has been made. There is still a lack of robust transdisciplinary research that effectively uses mix research methods to address the complex interlinkages between the social, economic, and environmental pillars of sustainable development in indigenous settings. There is a need to develop such studies in close partnership "with" indigenous groups, rather than studies "about" them.

This study aims to unravel the current sustainable development challenges in Gunayala from their point of view, how the different sustainability outcomes are interlinked (both positive and negative) and suggest pathways to achieve a sustainable development. Specific objectives are:

(1) identify the current research state-of-the-art for indigenous coastal and marine social ecological systems through an extensive systematic review of the literature;
(2) determine the current sustainable development challenges in Gunayala from the perspective of local communities and key stakeholders;
(3) map a network of the key sustainable development challenges using a causal framework of driving forces, pressures, states, impacts and responses (DPSIR);
(4) evaluate the DPSIR causal framework at community level and incorporate the outcomes through network centrality analysis;
(5) develop research dissemination tools and produce recommendations that will help catalyze sustainable development in Gunayala.

The research reported in this thesis was conducted in close collaboration with Gunayala's regional and local authorities, as well as local partners from the University of Panama Indigenous People Office (OPINUP), following the Free, Prior and Informed Consent (FPIC) principle. The research followed a three-stage approach. During the first stage a systematic review identified the main types of research conducted in indigenous settings, as a means of informing the overall approach of this thesis. During the second stage 32 expert interviews were conducted with experts involved in Gunayala's development including international agencies, NGOs, national and local authorities, and community experts. This primary data helped to address objectives (1) and (2) and was collected during fieldwork in February-March of 2018. The third stage sought to address objective (3) through ~270 household surveys that were designed drawing from the outcomes of the first and second stages. The questionnaires were collected through fieldwork conducted in March-April of 2019 in three islands that represent various stages of development and traditional value erosion within Gunayala. The analysis of each stage followed a systemic approach novel for this type of studies using mix research methods. First, a systematic content analysis from the expert interviews helped to map a DPSIR network showcasing the sustainable development challenges in Gunayala. Second, two different survey tools (discreet choice experiment and Likert scale) were conducted at community level to cross-validate the outcomes and to feed the final network centrality analysis. Finally, dynamic web-based dashboards that can present the research outcomes based on different audience needs (NGOs, government, development agencies, local leaders, etc.) have been created as part of the study dissemination (objective 4).

For 1) the systematic review identifies two primary categories of research approaches to study indigenous communities in coastal and marine SES. The first category relies largely on qualitative techniques and contains studies that tend to achieve a comprehensive understanding of the drivers and pressures in indigenous coastal and marine SES, but albeit lack quantitative results to help prioritize

relevant issues. The second category employs a more robust methodological portfolio of research methods, tools, and frameworks that allow the rather accurate measurement of specific phenomena but, however, mostly miss to provide multiple perspectives of the specific issues. These results showcase the need for the cross-fertilization between these types of studies and to promote approaches that actively seeks to conduct mix method research that can effectively integrate different knowledge and value systems.

For 2) expert interviews reveal four distinctive major types of development challenges in Gunayala. First, there are social issues including the steady loss of traditional practices, knowledge, and culture triggered by the increased interactions with latin societies through tourism, social media, and younger Gunas aspirations. Second, there are governance gaps where local institutions are lagging behind to the rapid changes in the region and are unable to effectively regulate emerging challenges. Moreover, there is a lack of capacity to coordinate community development with external partners. Third, relates to environmental issues from the degradation of ecosystem services and the overexploitation of marine resources. Lastly, there are development challenges caused by a growing population requiring better access to healthcare, education systems, and basic services such as sanitation and drinkable water in the islands.

For 3) the content analysis from the expert interviews produced 97 DPSIR networks covering all range of issues captured in objective (2). All 97 DPSIR networks were subsequently integrated into one comprehensive network that encompasses the main sustainable development challenges in Gunayala. The results show that the increased interaction with latin society has catalyse a paradigm shift at local level. The Gunas are shifting from subsistence-based livelihood system with a strong community cohesion to a lifestyle characterised by capital accumulation. This shift has led to positive outcomes providing communities with access to new food items, information, and overall higher living standard. However, it has also brought undesirable consequences such as an increase in crimes rates, the loss of traditional food items, and a rise of non-communicable diseases.

For 4) household surveys revealed the ongoing struggles of the Guna society. The results suggest a dichotomy between preserving Guna traditional values and reaping the benefits of development. On the one hand, tools used to rank development priorities without restriction highlight the loss of traditional values as the key priority. On the other hand, tools that ranked development priorities with preference restrictions showed that recovering traditional values is a much lower priority compared to improving healthcare, keeping tourism as a livelihood source, and developing new infrastructure projects.

For 5) considering the above results, institutional changes are needed to achieve sustainable development in Gunayala. At the regional level, there is a need for a clear long-term plan. Local community authorities rely on the regional leadership to guide their people to navigate the path between development and safeguarding their identity. However, up to now regional authorities have been reactive to such issues rather

that proactively planning ahead the permissible tourism industry development and subsequent revenue allocation. At the international level, evidence shows that donors should be more flexible. Overall, there is a lack of capacity (both human and training) from Gunayala's local institutions at the community level to follow the procedures of international agencies. These processes while designed to increase transparency in funding allocation, they also represent a roadblock and missed opportunities for local communities to secure the funding needed to improve healthcare, educational, and basic services facilities without relying on regional or national authorities.

The Gunas are at a crossroad where they need to decide today the future they want for their people. On the one hand they have perceived the benefits of higher interactions with the external world (e.g. access to education, new income sources, improved health care), on the other hand they have seen a new set of social problems emerging (e.g. drugs, noncommunicable diseases, loss of cultural identity). Furthermore, the exposure to western values through tourism, the introduction of modern education, and the different development aspirations of young Gunas after migrating in cities, have eroded some of the core Gunas' cultural values. This disconnect has translated into a loss of customary laws for managing the Gunas' SES, leading to the overexploitation of natural resources and ecosystem services. Understanding the development outcomes interlinkages from the Guna's perspective will help a) regional authorities to plan ahead Gunayala's sustainable development based on acceptable trade-offs based on their worldview, b) reduce misunderstandings and frictions with national authorities by clearly defining what are the key development aspiration from the Guna's perspective, and c) provide evidence to international donors on what are the priorities that needs to be focus and how they fit into the sustainable development goals.

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Chapter I: Introduction

1.1 Indigenous Communities Challenges

1.1.1 Ongoing sustainable development challenges among indigenous communities

Many indigenous communities around the world have experienced rapid socioeconomic change in the last decades **(Hoehn & Thapa, 2009; Jacquelin-Andersen, 2018; Sotomayor et al., 2019)**. Such changes have catalyzed shifts from traditional livelihoods, lifestyles, and social interactions, to lifestyles characterized by capital accumulation and consumerism **(D'Ambrosio & Puri, 2016; Karst & Nepal, 2019; Rosnon et al., 2019; Sotomayor et al., 2019)**. Such shifts from traditional (and often subsistence-based) livelihoods to modern economic activities has paved the way for the loss of customary laws and institutions, in favor of unsustainable management practices that prioritize rapid economic growth **(Karst & Nepal, 2019)**. Rapid modernization processes often precipitate detrimental impacts on traditionally managed indigenous landscapes and seascapes that are rich in biodiversity and natural resources **(Etchart, 2017)**. Often, such phenomena are concurrent with an increasing reliance on subsidies and government-driven social programs, having a compounding negative effect on the traditional social structures, norms, and institutions related to ecosystem management that are the foundations of indigenous culture and idiosyncrasy **(Karst & Nepal, 2019)**. Collectively all these mechanisms can reduce appreciably the resilience of indigenous communities to environmental and socioeconomic shocks **(Vaccaro et al., 2009)**.

At the same time there have been rather divergent expectations over development outcomes between indigenous groups and modernized societies **(Buergin, 2015; Walsh-Dilley, 2013)**. Indigenous groups often seek to reap the benefits of modernization to improve their livelihoods, while preserving their autonomy, cultural integrity, and freedom to self-determination **(Newman, 2016; Walsh-Dilley, 2013)**. Many indigenous groups want to develop their communities "under their own terms", by balancing their traditional way of living while gaining access to new markets rather than solely pursuing economic prosperity **(Walsh-Dilley, 2013)**. This cautious attitude towards modernization and development initiatives, which are usually pushed by central governments and the private sector, has sometimes branded indigenous group as a barrier to development rather than a willing partner **(Newman, 2016; Partridge, 2016)**.

Due to the unequal balance of power in development and modernization processes, it is not uncommon to force development initiatives upon indigenous group, "coercing" them in a way to modernize **(Newman, 2016; Partridge, 2016)**. However, there is a widespread recognition of the importance to integrate indigenous needs and viewpoints during development and modernization processes **(Zaidan, 2019)**, as many such attempts have failed because the perspective of indigenous groups have been overlooked, leading to uneven development outcomes, increasing inequalities, social injustices, and an overall

marginalization **(Partridge, 2016)**. It has been argued that in order to deliver effective development outcomes, indigenous communities need to become active partners in development processes **(Castillo, 2005; Opperman, 2013)**.

1.1.2 Indigenous and local knowledge erosion trends

The systematic erosion of indigenous knowledge and practices can lead to severe environmental and social impacts. Indigenous group have historically self-manage and maintain a natural balance with their surroundings **(Cullen et al., 2007; Raymond-Yakoubian et al., 2017)**. Disregarding this indigenous knowledge and traditional management systems of resources by outside actors can equally harm the SES and trigger conflicts between parties **(Lin & Liu, 2016)**. Furthermore, implementing programs based on indigenous aspirations without understanding the underlying reasons behind such practices can be equally harmful that could lead to future conflicts **(Hoehn & Thapa, 2009)**. The lack of recognition of indigenous group rights including land ownership and self-determination further exacerbate the preservation and transmission of indigenous knowledge between generations in detriment of their traditional SES **(Memon et al., 2003)**.

Moreover, the increase interaction between indigenous communities and western societies due to globalization are pressuring traditional SES resulting in severe overexploitation on natural resources **(Cullen et al., 2007)**. External policies and national development projects further constrains indigenous communities ability to preserve their traditional socio-ecological systems **(Turner et al., 2013)**. The buildup of commercial fisheries have overtaken traditional artisanal fisheries leading to the overexploitation of previously traditionally managed ecosystems **(Frid et al., 2016; Islam & Berkes, 2016)**. The shift towards new industries given the lack of livelihood alternatives has drove communities towards nontraditional activities such as tourism, which in turn has further erode indigenous values and their SES **(Hoehn & Thapa, 2009)**. Forced relocations of indigenous communities by national governments amid development process has led to the loss of traditional knowledge and practices **(Grice et al., 2012)**.

On the other hand, cases where indigenous knowledge and values were embraced, have led to the empowerment of indigenous communities and overall improvement of resource management **(Berkes et al., 2007; Raymond-Yakoubian et al., 2017)**. The recognition of indigenous knowledge as an equal source of knowledge similar to scientific base studies can further foster a common and shared responsibility of ecosystem conservation **(Drew, 2005; Mantyka-Pringle et al., 2017)**. The increasing trend of government institutions to apply co-management schemes of ecosystems incorporating indigenous knowledge and scientific base knowledge show promising attempts to rehabilitate previously eroded marine and coastal systems **(Memon et al., 2003)**. When indigenous communities are provided with institutional and legal support recognizing their rights grassroot initiatives spurt from the communities to embrace their role as stewards of their land in order to restore and manage their ecosystems **(Fox et al., 2017)**.

1.2 Guna Communities Challenges

1.3 The Guna people and their socio-ecological system changes

The Gunas are one of the indigenous groups experiencing such rapid development transitions **(De León Smith Inawinapi, 2016; Gascón & Martínez Mauri, 2017; Hoehn & Thapa, 2009; Orbach, 2004)**. They are one of the eight recognized indigenous group in Panama with settlements along the northeastern region of the country **(Davis, 2014; Martínez Mauri, 2008)**. Their primary income source comes from tourism, agriculture, and fishing (although the last two are mainly for subsistence). The Gunas account for 19% of the total indigenous group and 2% of the country's total population **(Velásquez Runk et al., 2011)**. Their highly organized society, combined with talented diplomats and advantageous geographical location helped them to gain the first autonomous regions recognized at constitutional level named as "Guna Yala" back in 1938 **(Velásquez Runk et al., 2011)**. These regions known as "comarcas" enjoy full administrative and political autonomy from the national government **(Castillo, 2001; Davis, 2014; Rivera Rosales, 2007)**. These liberties include the management and access to local resources, what development projects are approved, and independent justice and governance systems. There are currently five of such regions, in which three of them are assign to the Guna people. Communities (rather than families) are the basic social unit for the Gunas. Each community has a local chief known as "Sahila".

Guna institutions are divided among three authorities, Onmaggeddummad Namaggaled (Cultural General Congress of Gunayala), Onmaggeddummad Sunmaggaled (General Congress of Gunayala), Neggwebur Onmagged (Local Congress) **(Article 9, Congreso General Guna, 2013)**. The Cultural General Congress is the institution in charge of protecting, compiling, preserving, and defending the history, tradition, and identity of the Guna people and is led by **(Article 15, Congreso General Guna, 2013)**. The General Congress of Gunayala is the maximum administrative/political organism that oversees development projects, management of all regional revenue funds, preserve the autonomy of Gunayala, and become the focal point of interaction with the national government **(Article 22, Congreso General Guna, 2013)**. The Local Congress is the maximum organism in charge of the community spiritual guidance and administrative/political management **(Article 24, Congreso General Guna, 2013)**. All three organism will convene twice per year to review, report, and propose key issues relevant to the function of Gunayala's institutions.

Gunayala is currently facing rapid socioeconomic changes, from a traditional subsistence base society into an economic based lifestyle, having tourism overtaking most the Guna attention at community and institutional level **(De León Smith Inawinapi, 2016; Martínez Mauri, 2018)**. While tourism was initially received with certain level of skepticism, today the revenue derive from the industry is an essential source of income that support the functioning of Guna institutions **(Pereiro, 2016)**. However, these changes have come with a social and environmental cost. Pressures from an increasing tourism industry demands has

led to the overexploitation of key marine resources such as lobster **(Gascón & Martínez Mauri, 2017)**. Increased interaction with western values and commercialization has led to the erosion of traditional values, institution, and practices across Guna communities **(Castillo, 2005)**.

1.3.1 Ongoing sustainable development challenges in Gunayala

Even though their socio-political system is considered to be one of the best organized among indigenous people globally (and a model for neighboring indigenous groups) **(Martínez Mauri, 2012; Orbach, 2004; Velásquez Runk et al., 2011)**, the actual development outcomes have been rather poor **(UNDP, 2015)**. While the country's HDI has been estimated as high in 2014, Guna Yala region was estimated as low, having each dimension (life expectancy, education and income) among the lowest in the country **(UNDP, 2015)**. Multi-dimensional poverty index (MPI) based on the 2010 census shows that in spite of the country's MPI at 14%, Guna Yala is at 82% **(UNDP, 2015)**. These highly disproportioned achievements in human development is further aggravated by the loss of capable workforce. Emigration from Guna Yala has increase by 36% between 2000 and 2010; most of them young males above 25 years searching for better income opportunities **(Quintero, 2004; UNDP, 2015)**. This trend has reduced the Guna population by 3% within Guna Yala, while it grew 59% outside their region. Despite their strong representation in Panama´s legislative branch and the creation of a Vice Ministry of Indigenous Affairs, there seems to be a lack of attention to Gunayala´s needs, which combined with its geography, misunderstood worldview, frictions with the national government over resource access, and insufficient funding, have led to poor development outcomes **(Castillo, 2001; Orbach, 2004; Rivera Rosales, 2007)**.

A systematic misunderstanding of Guna values, development aspirations, and culture have caused the disproportionated development outcome in the region. The education system put in place by the national government build upon the assumption of an homogenous cultural baseline nationwide that disproportionally affect indigenous communities **(Artinelio, 2017; Luisa et al., 2018)**. A failure to understand the Guna aspiration to develop preserving their territorial autonomy, culture, and beliefs has eroded the trust between the national government and Guna institutions **(Gascón & Martínez Mauri, 2017)**. Furthermore, government initiatives that fails to understand Guna's SES while seeks to improve social welfare leads to unintended negative effects. The extension of nationwide social programmes targeting senior citizen while provides an additional source of income, has created unintended consequences that further erodes Guna value systems and accelerated the shift towards a capital accumulation society.

The loss of traditional knowledge (TK) and values has put further pressures in Gunayala's socio-ecological systems (SES). The Guna's worldview, customary laws, TK, and beliefs situate them as caretakers of nature adopting a lifestyle that preserves their SES, younger generations have started losing these traditional values **(Alvarado, 1995; Chapin, 1994; Denniston, 1994; Rawluk & Godber, 2011; Swiderska, 2009)**. This relational bond between people, nature, and tradition is rooted in the beliefs that

both human and non-human share a common internal identity, while other societies (non Gunas) despite having physical similarities with Gunas, their internal identity are fundamentally different and are outside such relational bond **(Martínez Mauri, 2019)**. This relational bond is often embodied in traditional practices still present today through ceremonies such as inna and surba (traditional drink ceremony and come to age), traditional dances, oral account and songs in the Onmaked Nega (local congress) **(Castillo, 2005)**. However, the exposure to western values and worldviews through tourism, the introduction of modern education, and the different development aspirations of young Gunas after migrating in cities, have eroded some of the core Gunas' cultural values **(Martínez Mauri, 2019; Orbach, 2004; Rawluk & Godber, 2011; Swiderska, 2009)**. New social issues are starting to emerge in Guna communities such as teen pregnancy, use of illegal substances, gangs, etc. **(Castillo, 2001)**, This disconnect has translated into the loss of customary laws for managing the elements of the SES, leading to the overexploitation of natural resources and the degradation of ecosystem services **(Alvarado, 1995; Orbach, 2004; Swiderska, 2009)**.

There are two strategic plans that were developed in response to the challenges faced by the Gunas amid these rapid socioeconomic changes. The Comprehensive Development Plan for Indigenous Communities in Panama and the 2025 Strategic Plan of Gunayala (PEGY 2025). The former plan was developed under UNDP technical assistance with the consultation of National government institutions, indigenous communities leaders, and other relevant organizations **(UNDP, 2013)**. The plan is a consolidated guideline to develop all indigenous communities and consist of three pillars namely:

- judicial and political development;
- economic development and;
- social development.

Each pillar contains specific objectives and indicators. While the plan was formally completed in 2013 it was not officially implemented until 2018 when funding from the World Bank was allocated **(Gaceta Oficial, 2018)**. In contrast to this general plan the PEGY 2025 was developed with Gunayala's specific challenges. The PEGY 2025 was developed by the Guna General Congress in 2015 with a 10 years outlook in consultation with local communities **(Congreso General de la Cultura, 2015)**. This plan seeks to provide a general guideline of Gunayala's key development priorities and help their institutions to develop and prioritize projects. The PEGY 2025 consist of five pillars, namely:

- autonomy, governance, and territory;
- Nabwana and her natural resources;
- education, culture, and spirituality;
- health and;
- economy and sustainable development.

1.4 Academic Research Frame of Reference

1.4.1 Indigenous community and their socio-ecological system literature

Despite these rapid socioeconomic changes, there is very little literature studying Gunas challenges in view of new development trends. Although the inclusion of indigenous people's perspective and TK has received ample attention in the current academic discourse **(Apgar et al., 2015; Rawluk & Godber, 2011)** including in the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) **(IPBES, 2015)**, there is still a lack of robust research that seek to understand what are the development concerns and aspirations from the indigenous communities' viewpoint **(Jacquelin-Andersen, 2018; Rawluk & Godber, 2011)**.

Marine and coastal areas are some of the world's most complex Social-Ecological Systems (SES). Several coastal and marine ecosystems are biodiversity hotspots with unique flora and fauna **(CBD, 2016; García & Vasconcelos, 2017; Moore et al., 2017; Thurstan et al., 2018)**. They provide habitats that are essential for species reproduction and the supply of multiple ecosystem services[1] that meet material, cultural, and spiritual needs **(Himes-Cornell et al., 2018; Moore et al., 2017; Oleson et al., 2015)**. These systems are vital for a large portion of the global population, contributing in diverse ways to their livelihoods and well-being **(CBD, 2016; Henson et al., 2017; Hughes et al., 2017)**.

For centuries, indigenous communities around the world have relied on marine and coastal ecosystems as the cornerstone for their social, economic and cultural activities **(Augustine & Dearden, 2014; Cochran et al., 2013; Eckert et al., 2018; Gauvreau et al., 2017)**. These ecosystems are indispensable to indigenous communities as they often represent multiple values (e.g. bequest, intrinsic, instrumental) that are fundamental for their worldviews, beliefs, and cultural norms. This diverse set of values influences how ecosystem services are perceived/valued and depend on different factors such as culture, scale (i.e. individual, collective), and time (i.e. values can change over time) **(Díaz et al., 2016; Pascual et al., 2017).** These values are often expressed through totemic entities and sacred places embedded in marine species and seascapes, which provides a spiritual connection between indigenous communities and their surroundings **(McNiven, 2004; Movono et al., 2018; O'Neill et al., 2012; Patankar et al., 2016)**.

[1] Ecosystem services are the benefits that people obtain directly and indirectly from ecosystems and are broadly grouped across four categories namely a) provisioning services, b) regulating services, c) cultural services and d) supporting services **(MA, 2005)**. Coastal and marine SES provide many different provisioning services, mainly from aquatic organisms and genetic material, for food, fuel, medicine and other direct uses **(MA, 2005)**. Important regulating and supporting services include, among many others, habitat provision, flood protection, erosion control, and water purification **(Barbier et al., 2011)**. Coastal and marine SES also provide many non-material benefits related to spiritual enrichment, recreation, education and aesthetic experience, among others **(Rodrigues et al., 2017)**.

However, anthropogenic activities and natural processes have contributed to the escalating degradation of key coastal and marine habitats such as mangroves, coral reefs, fisheries, tundra, and fjords **(Eckert et al., 2018; Evseev et al., 2018; Henson et al., 2017; Hughes et al., 2017)**. Moreover, some coastal zones where indigenous communities are located are among the most threatened from climate change **(Gauvreau et al., 2017; Hiwasaki et al., 2014; McNamara & Prasad, 2014)**. Conflicts driven from the expansion of commercial fisheries, a lack of government recognition, and heavy marine traffic have compromised the management, access, and usage rights of indigenous communities on marine resources **(Fuentes et al., 2015; Himes-Cornell et al., 2018; Miraglia, 2002; Moore et al., 2017; TEBTEBBA, 2008)**. Such processes affect (often disproportionally) indigenous communities who view such ecosystems as their main livelihood source and social support system **(Augustine & Dearden, 2014; Cochran et al., 2013; Gauvreau et al., 2017; Oleson et al., 2015; Vierros et al., 2010)**.

Indigenous communities have developed and use over generations traditional knowledge systems to manage, use, and conserve marine resources **(Díaz et al., 2016; Gauvreau et al., 2017; Johnson et al., 2016; Oxfam, 2016; Rutherford et al., 2015; Vitale, 2017)**. Scholars have suggested that including the perspectives of indigenous communities is critical (and essentially their right) for the sustainable management of marine/coastal resources **(Begossi, 2014; OHCHR, 2013; Raymond-Yakoubian et al., 2017; United Nations, 2007)** and the effective collaboration among stakeholders **(Gadamus & Raymond-Yakoubian, 2015; Setti et al., 2016; Sobrevila, 2008)**. Stakeholders from government, academia, civil society, and the private sector have identified that the integration of this local knowledge is a top priority for facilitating an effective science-policy interface for the sustainable use and management of biodiversity and ecosystem services **(Gonzalo & Maffi, 2000; Saito, 2017; Thompson et al., 2017)**. This entails, among others, finding new ways of integrating the multiple values, valuation approaches and knowledge systems that capture the breadth of the benefits derived from ecosystems that are important to indigenous communities **(Beck et al., 2014; Himes-Cornell et al., 2018; Pascual et al., 2017)**.

1.4.2 Main barriers to achieve a sustainable development among indigenous communities

However, there has been limited progress in the development of effective ways to combine Indigenous and Local Knowledge[2] (ILK) and modern scientific knowledge for various reasons. First, there is an unequal footing between well-established methodologies from modern science and ILK (which is often unfamiliar to non-indigenous scholars), which has prevented the use of these traditional knowledge systems in current scholarship and practice **(Chilisa, 2017; Ludwig, 2016; TEBTEBBA, 2008)**. Second, the frequent use of economic valuation for coastal/marine ecosystem services often skews the discussion in favour of a single

[2] Indigenous and local knowledge (ILK) can be defined as a "*cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment.*" **(Pascual et al., 2017: 14)**.

(monetary) value, which is different to the multi-value perspective of indigenous people. This single value perspective can set different expectations of what constitutes sustainable resource management and make collaborative work challenging **(Beltrán, 2000; Carter, 2010; Gratani et al., 2011; O'Neill et al., 2012; Vierros et al., 2010)**. Third, there is a general lack of collaboration between scientists and ILK holders, which has marginalized the latter from the production of new research and relevant policies **(Chilisa, 2017; Hiwasaki et al., 2014; Obermeister, 2017)**. Fourth, ILK has often been mobilized based on its utility to pre-conceived notions, and mainly to capture the information needed to advance modern science **(Ludwig, 2016)**, rather than integrate ILK meaningfully to create new ways of eliciting knowledge.

Multiple technical, structural and perception barriers have alienated the active participation of indigenous communities and have contributed to the lack of proper integration between knowledge systems. Technical barriers include (a) communication limitations (e.g. remote communities that speak only their indigenous language), (b) low levels of literacy and formal education among the indigenous groups, (c) poor accessibility due to remoteness and lack of infrastructure; and (d) a technological divide due to the lack of familiarity with modern scientific methodologies and tools **(Hiwasaki et al., 2014; Oleson et al., 2015; Setti et al., 2016; Smith et al., 2017; Vierros et al., 2010)**.

Structural barriers emanate from bureaucratic government systems and often impede the effective participation of indigenous communities in the formulation of management plans. Governments tend to follow top-down approaches that offer certain operational and logistics advantages. Even though top-down approaches allow for a more efficient use of resources, they ultimately fail to integrate ILK and marginalize the perspective and needs of indigenous communities **(Gaymer et al., 2014; Marlor, 2010; Vierros, 2017)**.

Perception barriers relate to the doubts about the credibility of ILK sources. Most ILK practices are rooted in traditions and are mostly transmitted orally between generations, with generally few formally documented cases **(McNamara & Prasad, 2014; Movono et al., 2018)**. Modern scientific methods often perceive these sources of knowledge more as anecdotal accounts rather than reliable information **(Gadamus & Raymond-Yakoubian, 2015; Obermeister, 2017)**. Modern scientific methods "expect" that knowledge must be replicable, pass a series of rigorous tests, and a peer-review process, all of which already frame the integration of knowledge through a specific lens. As a consequence, modern scientific methods are often superimposed over ILK, as a need to justify the credibility of ILK **(Hiwasaki et al., 2014; Marlor, 2010)**.

1.4.3 Role of indigenous knowledge integration

Apart from its academic importance, knowledge integration is increasingly considered essential for creating an effective science-policy interface to solve critical environmental problems. Recently the first work programme of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

(IPBES) re-affirmed the importance of knowledge integration **(Díaz et al., 2015; Perrings et al., 2011)**. In this aspect, the IPBES builds on the Millennium Ecosystem Assessment (MA) and TEEB (The Economics of Ecosystems and Biodiversity) and identifies ILK as an important element (alongside modern scientific knowledge) for finding options to manage SES in a sustainable manner **(Beck et al., 2014; Díaz et al., 2015; Löfmarck & Lidskog, 2017; Tengö et al., 2017)**. Key to this has been the effort to illustrate the multitude of values that peoples ascribe to SES and ecosystems services, including intrinsic, instrumental, relational values **(Pascual et al., 2017; TEEB, 2010)**. There have been strong calls to promote pluralistic valuation as a mean of breaking away from normative approaches that fail to capture the full range of benefits that indigenous people perceive from nature **(Pascual et al., 2017)**.

However, we need to note that apart from the often-discussed dichotomy between ILK and modern scientific approaches, there is also a large variation among the scientific techniques deployed to elicit values in indigenous marine/coastal SES. Currently a large array of very different qualitative, quantitative, and mixed-method techniques are used for this purpose **(see section 3.2.4)**. In fact there is an ongoing debate about the boundaries between quantitative and qualitative research techniques and some of the preconceived notions of utilising mixed-methods **(Morgan, 2018; Sandelowski, 2014)**. Several scholars have pointed that rather than focusing on their dichotomies, we need to focus on the purpose that each method serves and the synergies they can achieve **(Morgan, 2018; Sandelowski, 2014)**. Furthermore, preconceived notions that different methodological approaches may reveal different truths and that using mixed-method approaches automatically translates into a robust methodological study have been challenged **(Greene & Caracelli, 1997; Sandelowski, 2014)**. More importantly, however, such research needs to be designed having the indigenous community context in mind **(Pascual et al., 2017; Spoon, 2014)**.

1.5 Study Aims and Objectives

This study aims to identify the main sustainable development challenges in Gunayala, unravel the Guna's SES amid the rapid socioeconomic changes, pursue a collaborative knowledge integration with TK holders, and develop information sharing tools that foster knowledge dissemination across a broad audience. The study synthesizes national and local perspectives about the development challenges posed to Gunayala and how they impact different aspects of their traditional SES. A series of research questions will guide the analysis and discussions of this study. These questions seek to expand the limited knowledge of indigenous SES amid rapid socioeconomic changes and includes:

(a) How is the academic landscape of similar studies addressing indigenous people in marine and coastal system? **(see section 3.3 and section 7.1.1)**

(b) What are the perspective convergences and divergences from expert actors and local communities related to the main development challenges in Gunayala? **(see section 5.2.1, Figure 48)**

(c) What are the strengths and bottleneck among key stakeholders' interaction? **(see section 4.2.1, section 4.2.2, and section 4.3.2)**

(d) How are Guna traditional livelihood activities affected amid Gunayala rapid socioeconomic changes? **(see section 4.2.3, section 4.3.1, and section 5.3.2)**

(e) What are the effects on Guna TK and traditional practices amid the rapid socioeconomic changes? **(see section 4.2.4, section 4.3.1, section 7.1.2)**

(f) How are Guna worldviews, beliefs, and values changed amid these rapid socioeconomic changes? **(see section 4.2.4, section 5.2.3, and section 6.1)**

(g) What are the main socio-ecological systems and how they interlink with each other? **(see section 5.3)**

(h) How Gunayala sustainable development challenges relate to the broader SDGs discourse? **(see section 5.2.5)**

The objectives of the research seek to answer the posed research questions. The study investigates the current sustainable development challenges in Gunayala from Guna point of view, identify how the different sustainability outcomes (both positive and negative) are interlinked, and suggest pathways to achieve a sustainable development. Specific objectives are:

(1) identify indigenous SES research in coastal and marine systems through an extensive systematic review of the literature;

(2) determine the current sustainable development challenges in Gunayala from the perspective of local communities and key stakeholders;

(3) map a network of the key sustainable development challenges using a causal framework of driving forces, pressures, states, impacts and responses (DPSIR);

(4) evaluate the DPSIR causal framework at community level and incorporate the outcomes through network centrality analysis;

(5) develop research dissemination tools and produce recommendations that will help catalyse sustainable development in Gunayala.

1.6 Research Originality and Contribution

1.6.1 Study originality

This study delves into four novel approaches to indigenous SES studies to explore the sustainable development challenges in Gunayala. First, it seamlessly combines contextual research with causal research to gain a comprehensive understanding of the system and pinpoint the most relevant element within the system **(see section 2.1)**. Second, it integrates local knowledge from key actors in a meaningful way that inform, steer, and shape the study boundaries, tools, and outcomes **(see section 2.5.2)**. Third, it builds a Discrete Choice Experiment (DCE) capable of measuring Drivers, Pressures, States, Impacts, and Responses (DPSIR) of Gunayala's SES **(see section 2.5.3)**. Fourth, it capitalizes on the strength of multiple

ranking tools to explore the dichotomies between attitudes vs behaviors regarding western style development **(see section 2.5.3 and section 2.5.4)**.

Seamlessly combining contextual and causal research: Sustainability science aspire to produce research that provide practical solutions to real world problems (solution-oriented research) **(Steelman et al., 2015; Takeuchi & Komiyama, 2006; Wiek et al., 2012)**. However, we must not overlook the importance of understanding the system and mechanism leading to the proposed solutions (problem-oriented research) **(Kajikawa, 2008)**. This study seeks to seamlessly integrate both types of research. First, the study conducts a comprehensive contextual research (problem-oriented research) to map Gunayala SES, while simultaneously it organizes an in-depth contextual study (solution-oriented research) identifying the most relevant factors and preferred responses to the adverse outcomes of western style development.

Integrating expert actors and local community knowledge to shape the study: Sustainabiltiy science call for an integrative research engaging with multiple levels of stakeholders. The reasons for this approach goes beyond instrumental reasons, it also server to empower actors that are often ommited **(Gaziulusoy et al., 2016; van Kerkhoff, 2014)**. This study followed an integrative process where the outcomes from expert interviews shape the tools and reserch flow of the next steps of the research including community surveys. Subsequently, the outcomes from the community surveys shape the analysis and recommendations of the study.

Designing a DCE to measure DPSIR: The use of DCE have slowly finds its way in studies to capture non-market preferences **(Oleson et al., 2015; Valasiuk & Klimkowska, 2018)**. Recent research have attempted to capture elusive concepts such as bequest values, biodiversity condition preferences, and preferred resource management type **(Ferretti & Gandino, 2018; Oleson et al., 2015; Seeteram et al., 2018)**. However, there is no study that seek to capture a SES through a DPSIR framework using DCE. The capabilty of DCE to simulate real world choices and narrow the focus of the experiment to capture the desired phenomena made it an appropoiate tool to understand the tradeoffs between development and cultural preservation that Gunayala is currently facing **(Kjær, 2005; Oleson et al., 2015)**.

Multi tool triangulation to validate dichotomies. Traditionally, data triangulation seek to validate similar results through different combinations of tools, perspectives, and primary and secondary data sources **(Leech & Onwuegbuzie, 2007; Wilson, 2014)**. However, this study seek to understand the struggles that indigenous communities are facing between reaping the benefits of western development versus preserving their traditional lifestyles and values. Therefore, the data triangulation in this study was design to compared and contrast conflicting views using different stated preferences tools. These tools tapped into the strenghts of a condition free ranking that convey ideal schenarios (Likert) and a prioritization ranking tools that simulate better real life choices (DCE). A side by side comparison of these results will

provide an understanding of the struggles that the Guna people faces between preserving their identities and development aspirations.

1.6.2 Knowledge Contribution

The research outcomes expand the knowledge of indigenous communities facing rapid socioeconomic changes in marine and coastal ecosystem settings across three fronts. First, the study conducts a comprehensive analysis of the SES as a whole rather than isolated components amid the unknow impacts of these changes **(see section 5.3.1)**. Second, it elevates the findings to the broader conversation of Sustainable Development Goals (SDG) and the synergies between SDGs targets **(see section 5.2.5)**. Third, a systematic analysis of indigenous SES research in marine and coastal ecosystem showcase the topology of current studies. This analysis serves as a blueprint for future research in the field by highlighting the strengths and weaknesses of different research types **(see section 3.3)**.

Unraveling SES changes amid rapid livelihood paradigm shift. Rapid socioeconomic changes across indigenous communities is causing traditional SES changes in which the full impacts are still unknown **(D'Ambrosio & Puri, 2016; Martínez Mauri, 2018; Sotomayor et al., 2019)**. The research unravels the current state of these traditional SES amid livelihood changes, value erosion, and western development trends. The results seek to understand beyond isolated impacts of these rapid changes. Instead it explores how each element in the systems link and affect each other (either possitive or negative), what are the drivers for such changes, and what are the prefered responses to mitigate the negative effects of development.

SDG interlinkages. The SDG were design as a set of interconnected targets and there has been many attempts to identify the synergies between them **(ICSU, 2017; UN, 2018; Zhou & Moinuddin, 2017)**. These synergies reveals how targets can contribute to the attainment of other targets and in other cases how they can constrain the achievements of others targets **(ICSU & ISSC, 2015)**. However, most prominent attempts to identify these synergies relied on top-down approaches based on academic expert opinions **(ICSU, 2017)**. This study contributes to the SDG interlinkages debate from a bottom-up approach capture entirely from key stakeholders and local community real world experiences.

Contextual and Causal Research topology. Sustainability science attempts to address real-world problems by capitalizing the strengths and knowledge of multiple research tools, frameworks, and knowledge holders **(Bieluch et al., 2017; Dijk et al., 2017; Schneider & Rist, 2014)**. A systematic analysis of the latest research in the field provides a baseline to compare what have worked so far and what has been lacking. Furthermore, understanding the role of different research types helps set the outcome expectations and provides a clearer path of achieving research objectives.

Chapter II: Research Methods

2.1 Research Approach

Figure 1 shows an overview of the entire research flow. The study can be broadly divided across three sections. The sections are fully integrated where the outputs of each section feeds into the rest of the study. The first section conducts a systematic analysis of existing research related to indigenous people in coastal and marine ecosystem **(see section 2.3)**. The results of this analysis inform about the best practices to conduct collaborative research with TK holders and support the design of a robust mix-method research to integrate a multi-stakeholder perspective. The second section carries out a contextual analysis of Gunayala's development challenges. The strength of conducting a contextual analysis is its ability to capture a comprehensive understanding of indigenous SES from the perspective of the actors involve to develop the region **(see section 3.3.1)**. Base on the SES identified from the contextual analysis, section three conducts a causal analysis. A robust survey including multiple tools capable to run cross-validations of the results was designed to identify clues pointing to various dichotomies faced by the Gunas. Some of these dichotomies include the desire to reap the benefits based on western development paradigms vs preserving Guna traditional values and differences in development aspirations between sampling groups. Finally, the outcomes from the contextual and causal research are merged to understand the key sustainable development challenges of Gunayala.

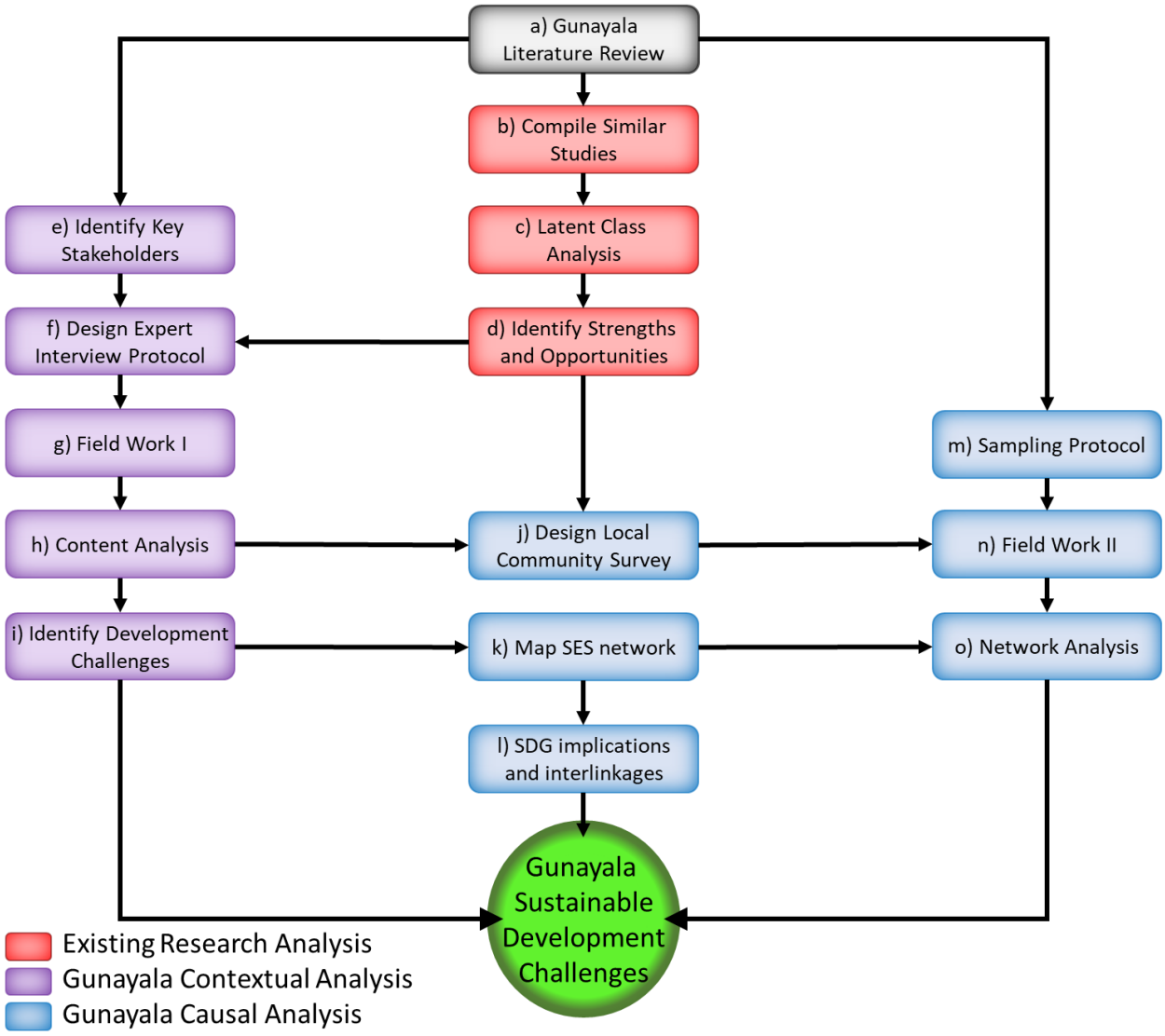

Figure 1 Detailed research flow to capture Gunayala sustainable development challenges

This study follows a conceptual framework that seek to achieve a seamless integration of traditional research paradigms **(Figure 2)**. This framework seek to solve real-world problems, integrate multiple perspectives, applied mixed-method, and contribute to disseminate knowledge to a broader audience aligned to sustainability science aspirations **(Kajikawa, 2008; Kajikawa et al., 2014; Takeuchi & Komiyama, 2006)**. As a result of the iterative nature of this study, the conceptual framework was developed based on the outcomes from the first research section **(see Figure 1)**. The output from the systematic analysis helped to design a research that reduced the compromises when following only one of the traditional research approach **(see section 3.3)**. This framework recognizes the role of both approaches, issue-oriented and solution-oriented research and pursue to understand both the factors leading to the issues while at the same time seeking innovative ways to react to the adverse effect of unsustainable

development trends. It ensures a meaningful inclusion beyond data providers from TK holders by defining key research parameters based on Guna perspective. These parameters where thereafter used to design surveys and analysis to understand the impacts to Gunayala's SES.

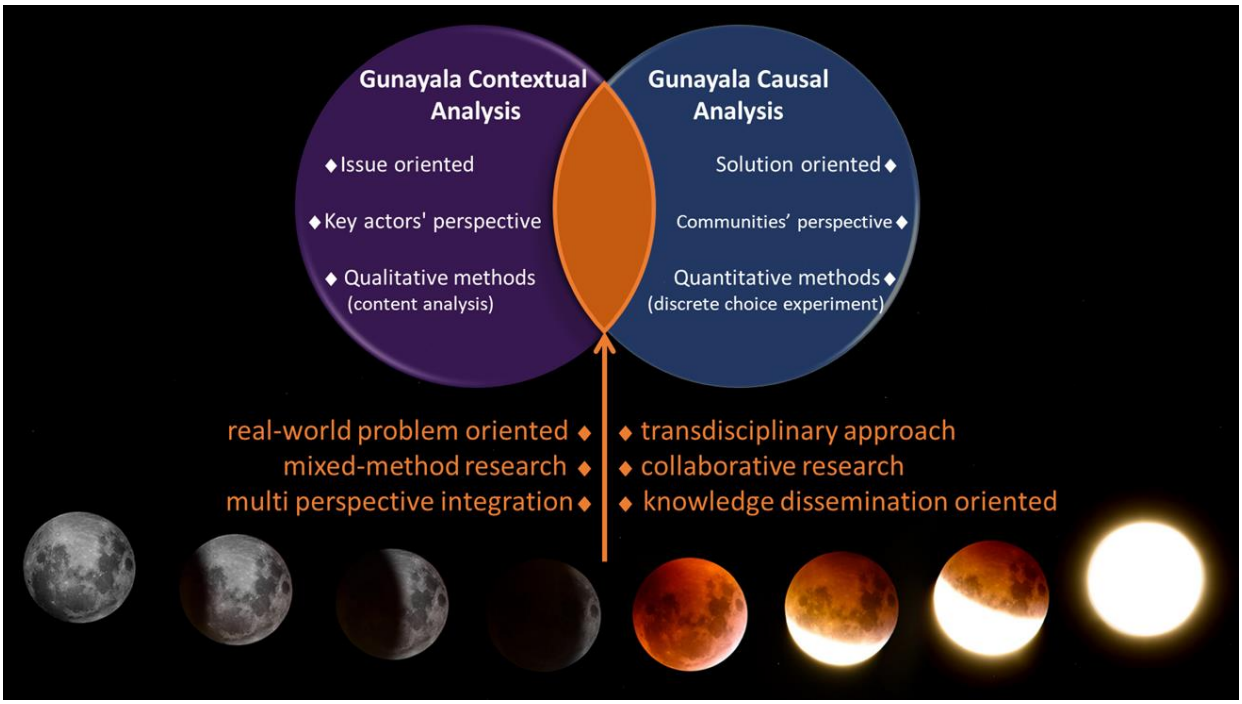

Figure 2 Study conceptual framework
Note: (source: author)

2.2 Study sites

The Gunas account for 19% of the total indigenous people in Panamá and 2% of the total national population **(Velásquez Runk et al., 2011)**. Gunayala consist of 51 communities scattered mainly among the islands located in the San Blas archipelago. Of these 51 communities, two are communities of afro-descendants and are settled in the mainland, while the remaining 49 are Guna communities (38 settled in islands, 11 settled in the mainland). Gunayala is broadly divided into 3 regions (Dubwala, Agligandi, and Nargana), each containing 2 leaders known as "Sagladummagan". Land access to Gunayala is limited to a mountainous road that is only accessible with 4-wheel drive cars. The road was opened in the 1970s as a dirt road, with paving starting in the early 2000s. Access to the island communities is done through motorboats and other vessels.

The community is the main social unit for the Gunas **(Davis, 2014)**. Each community has their own local authorities known as "saglas" that guide and administer the community **(Davis, 2014; Orbach, 2004)**. Their territories, known as "comarcas", are recognized by national law and were created in 1938 ("Comarca

de Gunayala") and in 2000 ("Comarca de Wargandi") **(Castillo, 2001; Hoehn & Thapa, 2009; Jacquelin-Andersen, 2018; Velásquez Runk et al., 2011)**. The Gunas have been enjoying full administrative and political autonomy from the national government since 1953 in these territories **(Castillo, 2001; Davis, 2014; Orbach, 2004; Rivera Rosales, 2007)**. The General Guna Congress is the highest governing institution for the Gunas and convenes twice per year. Its institution consists of representatives of each communities, local leaders, administrative leaders, and cultural leaders. The leaders of the Administrative Congress are in charge of managing access to the region and engaging with the Panamanian government, while the leaders of the Cultural Congress are responsibility for preserving the Guna culture, beliefs, traditional knowledge, and worldviews of their people.

The primary livelihood sources in Gunayala are tourism, agriculture, and fishing **(Orbach, 2004; Rivera Rosales, 2007; Velásquez Runk et al., 2011)**. The region is characterized by lower development compared to the rest of the country. For example, while in 2014 the national Human Development Index (HDI) was estimated as "High", it was estimated as "Low" for Gunayala, with each dimension (i.e. life expectancy, education, and income) being among the lowest in the country **(UNDP, 2015)**. The national multi-dimensional poverty index (MPI) stands at 14% ("Low Poverty"), while for Gunayala stands at 82% ("Highly Poor") **(UNDP, 2015)**. The highly disproportional HDI and MPI levels are further aggravated by the loss of capable workforce, as emigration has increase by 36% between 2000 and 2010, mostly young males above 25 years searching for better income opportunities in cities **(Quintero, 2004; UNDP, 2015)**. As a result, Guna's population in Gunayala decreased by 3%, while it increased by 62% outside their territories **(Davis, 2014; Instituto Nacional de Estadística y Censo (INEC), 2010)**.

The focus of this study are three islands namely Gardi Sugdub, Nargana, and Soledad Miria **(Table 1, Figure 3)**. The three islands have roughly the same population but are at different levels of development, and erosion of cultural values and TK.

Table 1 General characteristics of study islands

Community	Gardi Sugdub	Nargana	Soledad Miria
Total Population †	927	1,215	896
Adult Population†	563	690	459
Development Progress‡	Medium	High	Low
Cultural/TK Condition‡	Medium	Low	High

Source (†Panama 2010 Census; ‡Expert interviews)

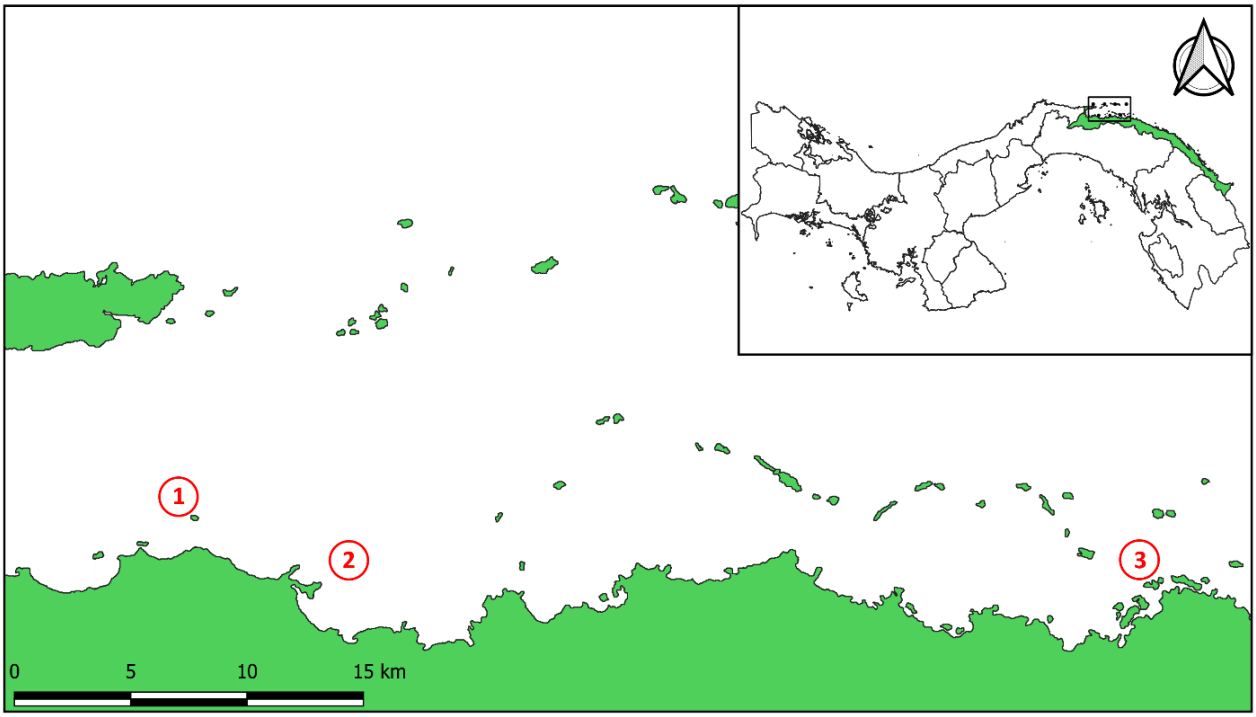

Figure 3 Study sites in Gunayala

Note: 1= Gardi Sugdub (9°28'14.7"N 78°57'40.7"W); 2=Soledad Miria (9°26'47.8"N 78°54'00.7"W); 3=Nargana; (9°26'39.5"N 78°35'06.4"W). For more details of island characteristics refer to Table S3, supplementary electronic

2.3 Existing Research Analysis

2.3.1 Review structure

This study follows a systematic literature review protocol to provide a proper snapshot of the current academic landscape on how indigenous perspectives are considered in studies in coastal and marine SES **(see Figure 1)**. In particular the study followed a four step process described below:

- ***Step 1:*** Systematic literature selection **(see section 2.3.2)**
- ***Step 2***: Systematic extraction and analysis of metadata from the selected literature **(see section 2.3.3)**
- ***Step 3***: Identify patterns in the metadata **(see section 2.3.4)**
- ***Step 4***: Compare and contrast the strengths and weaknesses of the literature collected **(see section 3.3)**

All authors of this systematic review contributed to the design of the overall protocol and its specific steps. To ensure the consistent implementation of the protocol, only the corresponding author executed Steps 1-2. Once the meta-data were elicited in a consistent manner, all co-authors undertook jointly Steps 3-4. Whenever unexpected literature cases not predicted within the protocol were encountered during Step 1-2, all authors were consulted to review and update the procedures as needed.

2.3.2 Studies Selection

The study identified the relevant literature following three rounds of document filtering (see below), with each of these rounds entailing a more extensive review of the literature **(see Figure 1 "a")**. During the first round the study identified potentially-relevant documents using appropriate keywords (see below). During the second round, the abstract of each study was read and then the non-relevant studies were removed from the analysis. For the final round, all documents that were deemed relevant were downloaded, and the entire manuscript was read to ensure that it meets the inclusion criteria (see below).

The study use three categories of search words to identify the reviewed studies **(Okhovati et al., 2017; Zupic & Čater, 2015)**. First, search words had to reflect coastal and/or marine systems such as those outlined in the technical report of the Convention on Biological Diversity (CBD) **(AIDEnvironment, 2004)**. Second, search words had to reflect indigenous people, which is the interest target group of this review. Third, search words had to reflect some type of value system, including ILK, beliefs, customs, and worldviews. All search words are included in **Figure 4**.

Marine system match pattern			Indigenous people match pattern			Values match pattern
coast[al]		protect[ed]	indigenous		people	value
marine		area	aborigin[al]		communit[ies]	valuation
island		[eco]system	native		societ[ies]	belief
mangrove		conserv[ation]	ethnic	+	group	custom
cape		preserv[ation]	original		population	worldview
shore		[co]manage[ment]			trib[es]	traditional knowledge
beach[front]		region[al]				local knowledge
seagrass		zone				indigenous knowledge
reef	+	[self]govern[ance]				
fisher[iers]						
mudflat						
lagoon						
sea						
ocean[front]						
seashore						
seafront						
seaside						

Figure 4 Keywords used in Scopus and Web of Science for the initial literature selection for the systematic analysis of indigenous people in marine and coastal ecosystem research

The literature search queries were performed for the research title, abstract, and keywords. The searched terms needed to be present in any one of those fields to be considered for the second round of literature selection. The study relied on two advanced search functions to ensure a comprehensive coverage of each term, while reducing the number of non-relevant results **(Falagas et al., 2008; Okhovati et al., 2017)**. The first function involved the use of wildcards to avoid discarding relevant results. This function allowed for the definition of stem words and covered all derivative words that contained the same stem (i.e. searching for "coast*" matched with coastal and coastline). The second function allowed for the definition of compound search words, where two keywords must be adjacent to each other within a user-defined distance. This function helped refine the search to relevant material by providing a context to the keyword **(Zupic & Čater, 2015)**. For example, searching for "indigenous + people" will avoid non-relevant results such as "indigenous plant species", while still matching with "indigenous and ancestral people". For this last function, a distance of up to 7 words was set to avoid discarding possible relevant studies.

In order to maximize the journal coverage a literature search in Scopus and Web of Science was conducted, the two most extensive databases for peer-reviewed materials and a frequent source for bibliometrics analyses **(Mongeon & Paul-Hus, 2016)**. The same search words and advanced search functions were use in both search engines without setting any further restrictions (e.g. year, field, publication type). The search in Scopus produced 356 documents and in Web of Science 308 documents. A total of 495 unique documents remained after combining the identified documents and removing the duplicate documents. After analysing the abstract and keywords of each of these documents a total of 145 appeared to match our selection criteria. Then the full text of each of these 145 documents were read and 109 documents met the study criteria and were deemed relevant for the metadata **extraction (see appendix 1 for full list)**.

2.3.3 Metadata Extraction and Analysis

Overall, five types of metadata content were extracted from each study. This metadata was analysed, and the main trends were visualized as a means of identifying possible knowledge gaps, challenges, and barriers for the integration of multiple knowledge system **(see Figure 1 "d")**.

The first type of metadata includes general study characteristics such as the study site and the academic impact of the study. For the former Google maps was used to obtain the approximate longitude and latitude coordinates based on actual reported study sites. For the latter, the study collected the number of citations received until June 2018 and the journal's two years citations per document based on Scimago 2017 Journal Ranking. From the location metadata two heatmaps were created using QGIS version 3.2. These heatmaps illustrate where these studies are more densely concentrated compared to national population and land rights recognition **(see section 3.2.1)**. The first heatmap overlays research density with a layer containing the percentage of land that each country has officially recognized as indigenous

land **(Dubertret & Alden Wily, 2015)**. The second heatmap overlays research density with a layer containing an estimate of indigenous population with different degrees of governmental recognition **(Jacquelin-Andersen, 2018; UNDESA, 2017)**. Countries were color-coded based on indigenous population and classified under five brackets. Due to the high concentrations of indigenous populations in a few countries, the study set the upper and lower limits of the brackets as non-constant intervals in order to achieve an equal number of countries per bracket. Finally, the relative academic impact of these studies is discussed and visualized through a bubble chart comparing journal impact factors and number of citations **(see section 3.2.2)**.

The second type of metadata captures aspects of transdisciplinarity in each study. Journal disciplinary fields as reported by Scopus were used as a proxy for the academic field of each study. Information about the authors' collaboration with different institutions (e.g. academia, civil society, government agencies) across countries were extracted, as well as the different types of stakeholders involved during the development of the research reported in each study (e.g. local communities, private sector, ILK holders). There is an increasing trend of different research fields merging together to address sustainability science issues **(Kajikawa et al., 2014)**.

This study used unique open source visualization tools to visualize the relevant metadata and illustrate the diversity of fields involved in these studies **(Mauri et al., 2017)**. This visualization shows the evolution of the academic fields involved in research related to indigenous people in marine and coastal systems **(see section 3.2.3)**. Chord diagrams helped us convey two layers of information related to the current state of collaboration between the institutions in which the authors were affiliated. First the arcs capture the relative participation of certain types of institutions compared to each other. Second, the size of the links between the arcs explains the collaboration frequency between these institutions. Links that originate and end within the same arc explain the collaboration between same institution types across different countries **(see section 3.2.3)**. Spider web diagrams were used to convey trends about the integration of different types of stakeholders. The spokes within the diagram represent the year of publication while the diagram axis expresses the percentage of studies that integrated a given stakeholder **(see section 3.2.3)**. Finally, this study extracted the degree of stakeholder integration ranging from high levels of public participation (i.e. studies were there was a productive discussion between stakeholders or adopted a co-design approach) to low levels (i.e. studies where stakeholders only received information and were consulted only to extract information) **(see Table 2)** **(Mostert, 2003)**.

Table 2 Means, aims and degree of stakeholder participation

Degree	Research Tools (Means)	Aim
Information	Interviews, Surveys, Focus Group Discussions	Data used to advance a narrative or as input for a methodological tool
Consultation	Participant Observation	Data used to capture in dept daily live activities
Discussion	Participatory mapping, Workshops	Data used to allow participant to influence the flow of the research
Co-Design	Community Planning Workshops	Participant have an active role for the research outcome

The third type of metadata is related to the methodologies used within each study. The study extracted the different data capturing tools (e.g. interviews, questionnaires, workshops), analysis methods (e.g. narrative analysis, remote sensing, descriptive statistics), and theoretical frameworks (e.g. sustainable livelihood approach, value base paradigm, decolonial approach). The study extracted the methodologies that were expressed explicitly or could be inferred within the methodology and results sections of each study. Open source dendrograms **(Mauri et al., 2017)** were used to visualize the landscape of the research methodologies used **(see section 3.2.4)**.

The fourth type of metadata relates to the main issues that indigenous people face in marine and coastal SES when different value systems are being integrated reflecting the viewpoints of the different stakeholders involved. This study use the Drivers, Pressures, States, Impacts, and Responses framework (DPSIR) to systematize this information as this approach (a) offers a thorough understanding of an entire SES, (b) captures causal relationships between its different elements (i.e. drivers, pressure, state, impact, response), and (c) has been extensively used in marine and coastal ecosystem **(Gari et al., 2015; Kristensen, 2004; Lewison et al., 2016)**. Apart from extracting the different DPSIR elements from each study, the type of impact was also capture (either negative or positive for the SES) and the effect of the DPSIR element for the SES. The study elicit the magnitude of these effects based on our critical reading of each study and use a five-level Likert scale (1=Significant degradation, 2=Moderate degradations, 3=Remains the same, 4=Moderate improvement, 5= Significant improvement). For studies where the trend was inconclusive or uncertain, a category of “uncertain” was assigned.

The study summarize the DPSIR outcomes using an alluvial diagram **(Mauri et al., 2017)** where (a) each DPSIR element shows the relative influence of each variable over the SES; (b) the links between DPSIR elements show the cause-effect relationship; and (c) the width of the links represents the frequency of these connections across the different studies **(see section 3.2.5)**. Additionally, the study summarizes the main variables within each DPSIR element in a Table as a means of showing the trend and the

consensus level. This consensus reflects the level of agreement between the different studies, where a value of 1 represent a full consensus while a value of 0 represent a complete disagreement **(Tastle & Wierman, 2007)** **(see section 3.2.5)**. Finally, bar charts for each DPSIR element depict the ratio between positive and negative impacts of each variable to the SES.

The fifth type of metadata focuses on the values elicited in each study. In particular for each study ecosystem services were identified, and then extracted the type of values represented for the subjects of the study (i.e. bequest, instrumental, relational, intrinsic, existence, option) **(Díaz et al., 2016; Pascual et al., 2017; TEEB, 2010)** and the valuation method used (e.g. ethnoecological, economic valuation, non-market oriented valuation) **(Díaz et al., 2016)**. The trend of these perceived benefits from ecosystems was also analysed through a five-level scale (1=Significant degradation, 2=Moderate degradation, 3=Remains the same, 4=Moderate improvement, 5=Significant improvement). When needed a category of uncertainty was used. An alluvial diagram was used to depict the flow between types of perceived values, ecosystem services and valuation methods **(see section 3.2.6)**. Finally, to summarise the results a table containing trends, consensus and uncertainty levels was created **(see section 3.2.6)**.

2.3.4 Latent Class Analysis

To classify these studies a Latent Class Analysis (LCA) was used. LCA is a statistical tool that allows the analysis of multivariate categorical data **(see Figure 1 "c")**. LCA allows the identification of latent classes among studies, or in other words, it allows the clustering of studies based on similar research patterns. LCA uses observed variables defined by the user as a means of finding this cluster through unobserved or "latent" classes **(Haughton et al., 2009; Henry et al., 2015)**.

The study extracted 12 different observable variables that characterize each study including research design (e.g. case study, action research, experimental), type of research question (i.e. exploratory or descriptive), methodological approach (i.e. qualitative, quantitative, mixed) (*see* Table 3 *for full list*). The analysis was conducted using open access poLCA R package **(Linzer & Lewis, 2011, 2013)**. The LCA models were re-estimated ten times until the maximum likelihood solution was found and the analysis was run for up to five classes. Following the parsimony criteria the study use the model with the lowest Bayesian information criterion (BIC) to determine the appropriate number of classes to select **(Linzer & Lewis, 2011, 2013)**. A sensitivity, specificity, and accuracy analysis were conducted to determine the suitability of the selected model **(Dziak et al., 2018)**. These tests allowed for an assessment of the proportion of studies that were accurately predicted compared to the estimates from the LCA model. Ultimately, the study used the research classes identified through the LCA to organize the results of the metadata analysis **(see section 3.2.2)**. The ability to group similar types of research studies and go through an exhaustive analysis for each of these clusters help us to clearly compare strengths and weaknesses in the current academic landscape.

Table 3 Observed variables used to identify the latent classes

Variable	Details	Options	Comments
Temporal	Time scale of the research	1 = cross-sectional 2 = longitudinal 3 = mixed	"mixed" refers to cross-sectional studies with a heavy component of historical account by the stakeholders
Ecosystem Service Approach	If the study explicitly addresses the ES approach	1 = explicit 2 = implicit	
Design	The research design approach	1 = action Research 2 = case study 3 = experimental 4 = Historical 5 = meta-analysis 6 = observational 7 = philosophical	
Research Question	The type of research questions the study seeks to address	1 = descriptive 2 = exploratory	
Objective	The overall goal of the study	1 = assessment 2 = raise awareness 3 = resource management	
Research Type	The research methods used	1 = mixed methods 2 = qualitative 3 = quantitative	
Scale	The geographical scale of the research	1 = local 2 = regional	
System	The type of ecosystem	1 = coastal 2 = marine 3 = island	
Multi-stakeholder	If more than one stakeholder was involved in the study	1 = no 2 = yes	
Multi-Values	If more than one value was capture in the study	1 = no 2 = yes	
Multi-Institutions	If more than one institution type was involved among the authors	1 = no 2 = yes	
Multi-Tools	If more than one research tool was use (i.e. interviews, FGD, etc.)	1 = no 2 = yes	

2.4 Gunayala Contextual Analysis Methods

2.4.1 Expert interviews

The study conducted a total of 28 expert interviews between February and March 2018 **(see Figure 1 "f")**. The interviews were selected through a stakeholder analysis and represent the main organizations and agencies at the national level relevant to Gunayala development (10 experts), as well as 14 local experts such as the Guna Cultural Congress (highest authority in charge of preserving Guna's identity), and 8 experts from development agencies and NGOs that work in Gunayala **(see Figure 1 "e")**. **Table 4** outlines the full list of respondents, including their institution and position.

To account for a comprehensive representation of key actors involved in Gunayala's development a snowball sampling was incorporated in the interviews. A dedicated module identifying interactions with other actors and the type of interactions (services, capacity building, funding, etc.) helped to pinpoint additional actors to include in the analysis. While there is no clear definition under which point data saturation is achieved in a research **(Francis et al., 2010; Guest et al., 2006)**, a saturation analysis of finding new DPSIR elements reveals that at the 15th interview the study identified 100% of the DPSIR elements of system **(Figure 5)**.

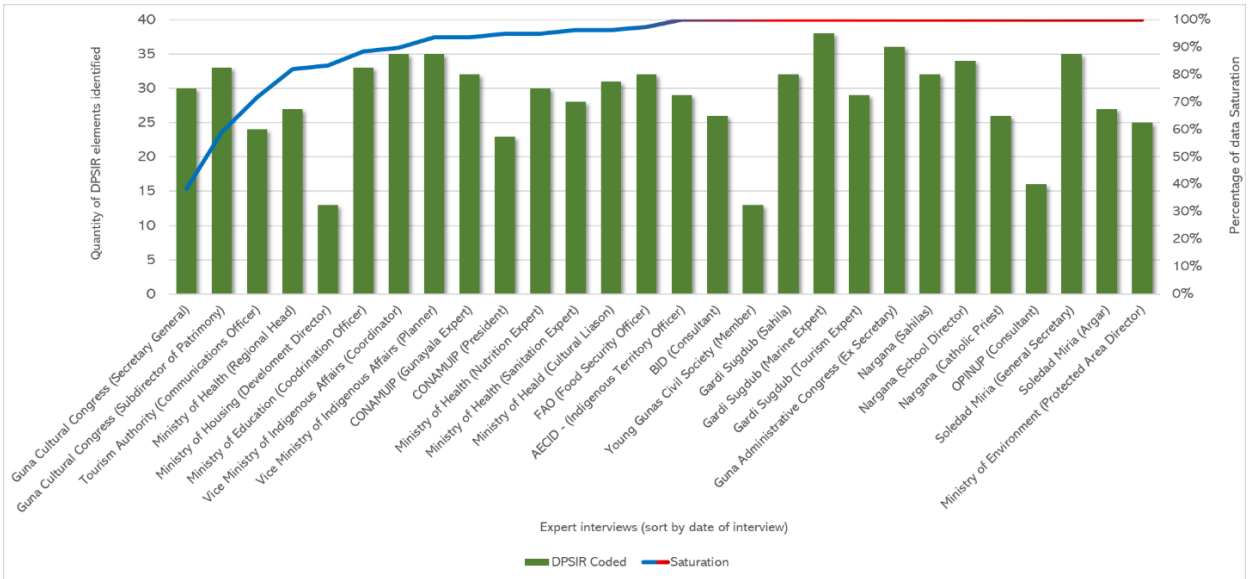

Figure 5 Content Analysis data saturation point for DPSIR elements

Table 4 Detailed characteristics of expert interviews

Type	Institution/Location	Role
Academic	Indigenous Community Office - University of Panama (OPINUP)	Consultant
Civil Society/NGO	Panama National Coordinator Indigenous Women (CONAMUIP)	Gunayala Member
Civil Society/NGO	Panama National Coordinator Indigenous Women (CONAMUIP)	President
Civil Society/NGO	Young Gunas Civil Society	Coordinator
Community Authority	Gardi Sugdub Community	Sagla
Community Authority	Nargana Community	Saglas
Community Authority	Soledad Miria Community	Arga (Sagla's interpreter)
Community Authority	Soledad Miria Community	General Secretary
Community Leader	Gardi Sugdub Community	Local Marine Expert
Community Leader	Gardi Sugdub Community	Local Researcher
Community Leader	Gardi Sugdub Community	Local Tourism Expert
Community Leader	Nargana Community	Catholic Church Priest
Community Leader	Nargana Community	Primary School Director
Community Leader	Soledad Miria Community	Head of Women Group
Development Agency	Inter-American Development Bank (IADB)	Consultant
Development Agency	Spanish Agency for International Development Cooperation (AECID)	Indigenous Territory Director
Development Agency	Spanish Agency for International Development Cooperation (AECID)	Indigenous Territory Officer
Gunayala Authority	Gunayala Cultural Congress	Secretary General
Gunayala Authority	Gunayala Cultural Congress	Subdirector of Patrimony
International Agency	Food and Agriculture Organization (FAO)	Food Security Officer
National Government	Ministry Education	Coordinator Officer
National Government	Ministry of Environment	Protected Area Director
National Government	Ministry of Health	Gunayala Cultural Liaison
National Government	Ministry of Health	Nutrition Officer
National Government	Ministry of Health	Regional Head
National Government	Ministry of Health	Sanitation Officer
National Government	Ministry of Housing	Director of Development
National Government	Panama Tourism Authority (ATP)	Communications Officer
National Government	Vice Ministry of Indigenous Affairs	National Coordinator
National Government	Vice Ministry of Indigenous Affairs	National Planning

The interview protocol consisted of multiple sections including: (1) general characteristics of respondents (i.e. age, education, livelihood activities), (2) stakeholder interactions, (3) local institutions and self-organization **(following Ostrom, 2009)**, (4) Guna's worldview, traditions, beliefs, and TK, (5) key resources in the Gunayala and their values **(Díaz et al., 2016; Pascual et al., 2017; following TEEB, 2010)**, and (6) key challenges due to Gunayala's current development trend. Results from the initial stakeholder analysis helped to identify additional relevant stakeholders, which were interviewed based on their relevance to Gunayala's development.

Each interview lasted on average one hour **(see Figure 1 "g")**. All interviews were conducted in Spanish, apart from two interviews that were conducted in gunagaya (Guna language). During these interviews, an interpreter familiar with the research provided simultaneous translation. All interviews were digitally recorded and transcribed to facilitate the coding for the content analysis. Coding was conducted manually using Excel as it allows for a consistent coding between interviews by programing custom functions and macros that keep track of similar references. Codes are defined based on interviewees responses and framed to achieve a balance between a general understanding of the issue (i.e. education challenges) and avoiding a granularity level where no patterns exits (i.e. lack of teachers, lack of books). The coding is conducted solely by the corresponding author to both ensure consistency between interviews and the ability to capture the nuances in Spanish.

The outcomes of the content analysis indicate the main development challenges and their trends over time. The individual development challenges are aggregated across four major categories and are represented in a dendrogram. The trends of these challenges are captured through 5 level Likert scale (1=degrading, 5=improving), and the consensus between respondents through a consensus value. This value denotes the level of agreement over these trends between interviewees, ranging from a value of one ("1") representing full consensus to a value of zero ("0") representing complete disagreement **(Tastle & Wierman, 2007)**. Consensus is estimated through the Likert scale from each interviewee and explains the distance between categories (or any ordinal scale) providing a value of dispersion among the group **(Tastle & Wierman, 2007)**.

The interactions between stakeholders are mapped using a Sankey chart to identify possible bottleneck and sources of delays/conflicts between Gunas and other institutions. In particular the study map three types of interactions between stakeholders, namely (a) funding flows (i.e. money that were either provided directly to the institution or indirectly through an intermediary agency or trust fund); (b) policy flows (i.e. regulations, sanctions, bans, and self-regulations of formal and informal institution); (c) service flows (i.e. consultancies, government-related social programs, health and education projects). A complementary matrix highlights the average quality of these interactions as perceived by the respondents, as well the source and recipient of each flow among stakeholders. The quality of interactions seeks to capture the

satisfaction level and collaboration effectiveness of such flows and is coded through a 3-level Likert scale (1=weak interaction, 2=neutral satisfaction, 3=strong interaction).

2.4.2 Household survey

Household surveys were conducted in three Gunayala islands **(Figure 3)**. The design of survey questions was informed by the expert interviews, and particularly by the content analysis outcomes (i.e. what proxy variables can be used to understand tradition, culture, and TK changes) **(see Figure 1 "j")**. The surveys contained questions about (a) respondent characteristics, (b) income and livelihood activities, (c) benefits derived from the SES, (d) traditional knowledge and practices.

Overall, 232 household surveys were conducted, capturing on average 14% of the target population in each island **(Table 1)**. The study targeted 4 distinct study groups divided across sex and age **(Table 5)**. This is because distinct values were expected, and value changes are linked to both age and gender. For example, based on expert interviews a more pronounced loss of traditional values was expected among the youth, and an expected responsibility to preserve traditional values through gender roles (i.e. women maintaining Guna culture through traditional clothing and traditional dishes) **(Guna Cultural Congress, personal communication, February 16, 2018)**.

Table 5 Total valid surveys by group and study site

Group/Site	Gardi Sugdub	Soledad Miria	Nargana	*Total*
Adult – Men	16	16	24	*56*
Adult – Women	20	16	24	*60*
Young – Men	20	16	24	*60*
Young – Women	16	16	24	*56*
Total	*72*	*64*	*96*	*232*

Age groups are divided between "adult" and "young", with the latter being closer to the concept of millennials. This group essentially reflects the generation that has been in closer and more frequent contact with western culture and values through the tourism generated by the better road access from the early 1990s. Hence, the study uses the threshold of "29 years old and below" to define the young age group. All respondents were above 18 years old to avoid triggering local community sensibilities about research targeting children.

To ensure the random sampling of each group, the study use satellite images of each community. Each household was assigned a unique number using QGIS version 3.4.4 that allowed us to run a random function in Excel to select both the household to visit and which of the 4 groups to survey **(Figure 6)**. In each household respondents were selected following a protocol to avoid any subjective decision from the

local enumerator (i.e. what to do in case of multiple possible viable interviewees). The surveys were conducted between March and April 2019 through local enumerators from each island. The enumerators were hired and trained at each island to mitigate concern regarding research motivations and generate trust among respondents and local authorities.

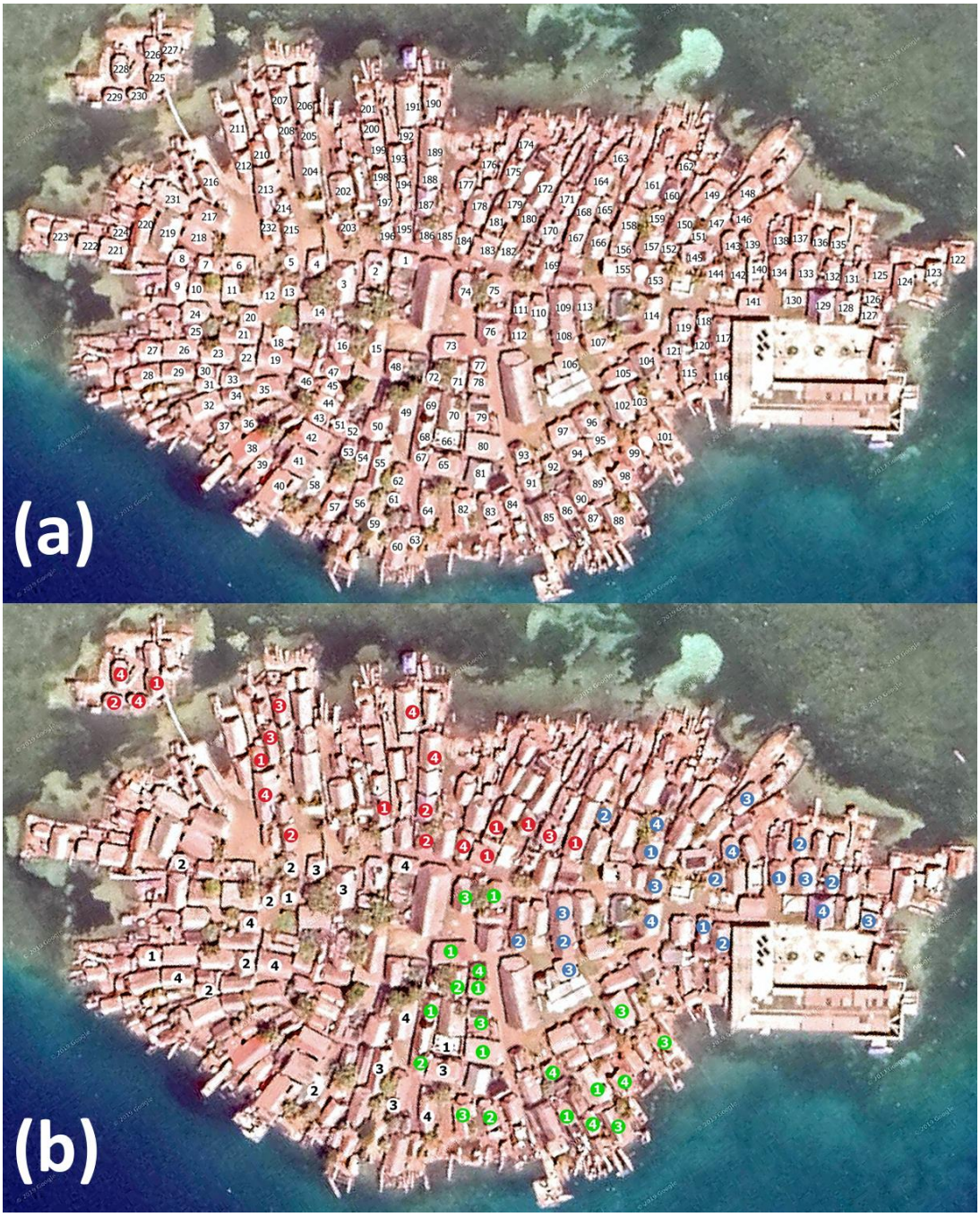

Figure 6 Sampling protocol for Soledad Miria, Gunayala
Note: (a) Initial identification of each available structure using QGIS, (b) Final sampling for each of the four groups (numbers identify sampling group, colors identify enumerator boundaries) using a random function in Excel. Source (Google Maps, 2019)

The main elements of the SES (and the associated ecosystem services) that are important to the local Gunas communities are identified through the expert interviews. The study group them in three main categories, namely geographical elements, natural resource elements, and cultural elements. The study elicits the perceived availability and trends of these elements relative to ongoing development in Gunayala through a 3-level Likert scale (1=Scarce, 2=Reduced, 3=Sufficient). The availability trend captures the expected future availability of each SES element if no further changes are introduced in the SES and was coded using a 5-level Likert scale (1=Improve, 2=Moderately improve, 3=Stable, 4=Moderately degrade, 5=Degrade. The overall trend for each SES component is calculated as the average of responses from the expert interviews.

The study elicits the multiple values associated with each of these SES elements for each study group following the distinction between bequest, instrumental, relational, intrinsic, existence, and option values **(Díaz et al., 2016; Pascual et al., 2017; TEEB, 2010).** These values were elicited through a multiple-choice question that contained the local interpretations of each value. These local interpretations were extracted from the expert interviews including experts from the Guna Cultural Congress and saglas (local chiefs). A 10-level Likert scale was used to elicit the importance of each SES element (1=Not important, 5=Neither important nor irrelevant, 10=Very important), with the values presented as the percentage of total respondent that perceived those values.

Finally, the study explores differences between groups to assess the loss of traditional values and changes in livelihoods activities. The study captures the exposure to non-local practices and the active engagement in traditional practices deemed as essential to preserve the Guna identity. These proxy indicators were identified from the expert interviews, with each respondent self-reporting their exposure to non-traditional elements (i.e. social media, tourist) through tailored 5-level Likert scales **(Table 6)**. The overall trend for each group for each value is calculated as the average of responses between all survey participants.

Table 6 Cultural practices variables used for the household survey

Indicator (Unit)	Variable	Description	Rationale
Travel to city (Year)	Frequency	Number of times respondent left community to visit outside Gunayala	A higher/more frequent interaction with the outside world influences development aspiration
Town Meeting (Month)	Frequency	Number of times in a month that respondent attends the local House of Congress	Participation in this meeting is a proxy of the traditional level of the local community. This daily meeting is the main venue of TK transmission, and the preservation of Guna traditions, worldview, beliefs, and culture
Media exposure (hrs./day)	Hours per day	Time spent following media (e.g. TV, cellphone, radio, internet)	Exposure to modern media is a key avenue of exposure to western values and often competes with interest/willingness to attend Town Meetings
Ceremony Knowledge (1-5)	5-level Likert scale	Range from 1=Unfamiliar to 5=Familiar	Knowledge of different traditional Guna ceremonies is inherently linked to Gunas culture. These ceremonies are also known as treaties, and include among others the celebration of girl adolescence, commemorating the dead, and spiritual purification.
Galus Knowledge (1-5)	5-level Likert scale	Range from 1=Unfamiliar to 5=Familiar	Galus are sacred places, objects or animals that can vary among communities. The presence of galus is traditionally passed from father to son and are integral elements of Guna culture.
Traditional medicine knowledge (1-5)	5-level Likert scale	Range from 1=Unfamiliar to 5=Familiar	Loss of traditional medicine knowledge suggests a shift towards modern medicine
una language use (1-5)	5-level Likert scale	Range from 1=Infrequent (a couple times per year) to 5=Frequent (every day)	Preserving the Guna Language is a key concern for the Gunas. Loss of language is associated with colonial oppression and the repression of culture and tradition. Western education is associated with the loss of traditional language and thus cultural identity
Interaction with foreigners (1-5)	5-level Likert scale	Range from 1=Infrequent (a couple times per year) to 5=frequent (every day)	Increased interaction with western tourists is a major avenue of exposure to non-Gunas values, and increases the possibility of dietary change and development aspirations
Community volunteering (1-5)	5-level Likert scale	Range from 1=Infrequent (a couple times per year) to 5=Frequent (every day)	Community is the basic social unit in Gunayala. The active participation in community activities (e.g. cleaning, community farming) reflects cultural cohesion and preservation
Exposure to politics (1-5)	5-level Likert scale	Range from 1=Infrequent (a couple times per year) to 5=Frequent (every day)	Exposure to non-Gunas political structures underpins other variables (e.g. community involvement) and can reflect a cultural shift between traditional lifestyle/ livelihoods to economy-based livelihoods (e.g. government social programs, political buy outs)

The comparisons between age groups, as well as by each of the 4 sampling groups were conducted through inferential statistics using SPSS version 23. The Mann-Whitney test was used for the age group comparison, and Kruskal-Wallis test for the 4-group comparison. Complementary comparisons between islands is provided to outline TK and value degradation (see "Study sites").

2.5 Gunayala Causal Analysis Methods

2.5.1 Analysis Tools:

Expert interviews were conducted between February and March of 2018. A total of 28 expert interviews were conducted across key stakeholders **(see Figure 1 "g")**. Questions were adapted avoiding academic specific terms. For instance, terms such as "key challenges", "main problems", and "relevant issues" were used to identify the impact component of the DPSIR. Once the "impact" was identified, probing questions to understand the sources (drivers and pressures) and responses were asked.

Community surveys were conducted to weight the importance of each DPSIR element identified from the expert interviews **(see section 2.4.1)**. The main tool to weight the relative importance from the community perspective was through a DCE. DCE is a tool that ask respondent to choose among their preferred scenario from a series of choice cards. The scenarios contain a set of attributes (i.e. development improvements, governance improvements, services improvements, etc.) with different options/levels for each attribute (i.e. better healthcare, higher education, stronger leaders, etc.) **(see section 2.5.3)**. There was a total of 5 different DCE, one for each DPSIR component (Drivers, pressure, etc.) assessing all 78 DPSIR element. Across all 5 DCE, a total of 144 choice cards were needed to be completed. To avoid respondent fatigue, each of the 5 DCE was split into four smaller surveys known as blocks **(see section 2.5.3)**. This allow four different respondents to provide the necessary information to complete one full DCE. Therefore, rather than one respondent answering 144 choice cards, each respondent was required to complete a more manageable 36 choice cards. A short pre-test was conducted a week prior to the survey among volunteer students from Gunayala studying at the University of Panama. Subsequent adjustment to the survey was done to accommodate clearer definitions, additional clarifications, and questions sequencing based on the student feedbacks.

2.5.2 Content Analysis

The boundaries for the main drivers, pressures, states, impacts, and responses relevant to overcome the sustainable challenges for the Guna SES were informed by the expert interviews **(see Figure 1 "h")**. The same interview protocol was follow across all interviews including 1) explanation of research goals and asking to limit their responses in regards to Gunayala SES, 2) asking same primary question and probing questions as needed, 3) aimed for an interview duration of approximately one hour to avoid result bias due to oversampling time by any actor, and 4) audio recording of the session to ensure an accurate account of the interview. A total of 28 interviews were conducted including actors from NGOs, international agencies, national authorities, Guna authorities, and community experts **(see Table 4)**. Interviewees were first asked

to identify what are the main challenge in Gunayala SES and subsequently identify what are the causes and effects of such challenges. Probing questions were asked until the full complete DPSIR system for the challenge was flush out. Once the full system was explained for that challenge, the process was repeated once again to capture a second key challenge system until no new challenges were deem important by the interviewee. A total of 97 of these sub-systems were identify at an average of 3.5 system per interviewee. Through a systematic content analysis two main outputs were produced from these challenges systems identified by the interviewee. First, a list of DPSIR elements for each of the DPSIR components. Second, a network that maps how each of these DPSIR elements interlink with each other. The coding was conducted manually using Excel since it allowed the setup of custom functions to ensure coding consistency. These custom functions provided a quick preview of past coding in similar cases as reference. The codes were terms frequently expressed during the interviews and were selected to achieve a balance that provides a general understanding of the issue without becoming too vague (i.e. instead of food security, more precise terms such as food access, utilization, and availability were used). Two separate coding was conducted. The first coding sought to capture the main DSPIR elements and collected metadata to understand the overall sentiment, trends, and the type of issue they represent. A total of 1,060 DPSIR elements were identified (having 78 unique elements) across all 97 DPSIR sub-system **(see Table 7)**. Results of this steps were summarized through tables containing a) the frequency in which the DPSIR element was mention within the 97 DPSIR sub-systems, b) the current trend measured as a five scale Likert (1=degrading, 2=somehow degrading, 3=same, 4=somehow improving, 5=improving), c) the consensus of this trend among the 97 DPSIR sub-system where a value of zero (“0”) represents complete disagreement and a value of one (“1”) represents full consensus **(Tastle & Wierman, 2007)**, and d) the level of uncertainties measure as the percentage of times where the DPSIR was identified but there is uncertainties regarding its trend. The second coding sought to map how each of the DPSIR elements link with each other across all 97 DPSIR sub-systems identified from the expert interviews. The metadata collected identifies for each DPSIR system the origin and destination of the link. A total of 1,550 links were identified across all 97 DPSIR sub-system **(see Table 8)**.

Table 7 DPSIR elements identified from content analysis (n=97 DPSIR sub-systems)

DPSIR component	Elements	Unique Elements
Drivers	188	15
Pressures	235	15
States	197	9
Impacts	275	24
Responses	165	15
Total	*1,060*	*78*

Table 8 Total number of links identified from content analysis (n=97 DPSIR sub-systems)

From	To	Total Links	Unique Links
Driver	Driver	27	15
Driver	Pressure	241	53
Pressure	Pressure	114	33
Pressure	State	254	54
State	Impact	279	44
State	State	97	17
Impact	Impact	106	39
Impact	Response	186	84
Response	Driver	33	17
Response	Pressure	155	61
Response	Response	58	30
Grand Total		*1,550*	*447*

2.5.3 Discrete Choice Experiment:

The DCE main goal is to rank the importance at community level each of the 78 DPSIR elements identified from the expert interviews **(see Figure 1 "j")**. The process followed 4 main steps. Step 1) organize all 78 DPSIR elements into 5 different DCE and determine the attributes and levels for each DCE. Step 2) develops the design of each DCE using the R package Support.CEs by crating the choice cards to be included in the surveys based on step 1 specifications. Step 3) relates to conducting the community survey to collect the DCE primary data. Step 4) conducts the analysis to obtain the estimates for each DPSIR element and calculates the marginal willingness to paid (MWTP) as a proxy to what are the most important elements of the DPSIR.

Step 1) organize each DCE (one for DPSIR component) in a structure that simplifies the understanding of each choice card. A total of five DCE were design (DCE 1= Drivers; DCE 2 = Pressures; DCE 3 = States; DCE 4 = Impacts; DCE 5 = Responses) to capture all 78 DPSIR elements. The design of each DCE exercise was built upon existing research that captured similar concepts of the DPSIR framework in this study **(see Table 9)**. Similar DPSIR elements (i.e. food availability, food utilization, food access) were grouped together to form an attribute (i.e. Food Security). These attributes were created based on the outcomes from the interviews and were based on DPSIR elements frequently discuss as interlinked concepts. Subsequently the DPSIR elements themselves became the levels to be estimated for each attribute **(see appendix 2)**. The balance between number of attributes and levels were setup to achieve a symmetrical design (all attributes have the same number of levels) since it helped to minimize the number of choice cards each respondent needed to answer based on an orthogonal design **(Grömping, 2018)**.

Table 9 Literature exploring similar DPSIR elements through DCE

DPSIR	Reference research	Concept captured
Drivers	**(Ferretti & Gandino, 2018)**	• measures people's preference in management type (private, public) and preferred functions for empty spaces (abandon area, recreational, etc.) based on drivers on changes
Pressures	**(Ward & Makhija, 2018)**	• measures risk exposure of key pressures in the system (chances that insurance/safety nets fail to pay people in case of droughts)
State	**(Bekele et al., 2018)**	• measures easy access/mobility issues of current SES state (how easy is for people to move around)
Impact	**(Oleson et al., 2015; Seeteram et al., 2018)**	• measures bequest values and social cohesion by asking how many generations should benefits exists and measure ES, biodiversity condition (species population, water conservation levels, etc.)
Responses	**(Niedermayr et al., 2018; Valasiuk & Klimkowska, 2018)**	• measures type of mechanisms to respond to water scarcity (having potable water with or without treatments; methods of removing shrubs)

Step 2) relies on Support.CEs package in R to define the number of choice cards, the content of the choice cards, and to split the DCE into 4 blocks. A full factorial design where all choice cards with all possible combinations of attributes and levels are presented to the respondents are often not feasible to conduct in the real world **(Grömping, 2018)**. For this study a total of 274,688 choice cards would have been required to conduct a full factorial design based on the specifications from step 1 **(see Table 10)**. Therefore, DCE often relies on orthogonal design to reduce the number of experiments while providing the ability to estimate the main effects estimated with precision **(Holmes et al., 2017; Walker et al., 2018)**. Furthermore, a four-block design was selected to reduce the respondent fatigue risk and an overall decrease of response quality. A four-block design allows to split the total number of choice cards into smaller "blocks" and having different respondent to fill out one of the blocks. Subsequently, all blocks are merged to obtain the complete DCE. Finally, the rotation.design function from the Support.CEs package was used to generate the orthogonal design for each of the DCE and reduce the number of experiments **(see Table 10)** as well to produce the choice cards.

Table 10 DCE designs. Number of choice cards that respondents need to answer per design

	Full Factorial	Orthogonal design	Per Block
DCE 1: Drivers	4,096	32	8
DCE 2: Pressures	4,096	32	8
DCE 3: States	256	16	4
DCE 4: Impacts	262,144	32	8
DCE 5: Responses	4,096	32	8
Total	*274,688*	*144*	*36*

Step 3) determines the protocols to conduct the DCE. The definitions of all 78 DPSIR elements were included in the questionnaire to help respondents to understand the meaning of each element **(see appendix 2)**. Icons were created with a brief legend representing each of the 78 DPSIR elements to simplify each choice card. A guide sheet with definitions, legends, and icons were printed out and made available to respondent for their reference during the DCE section of the survey **(see appendix 3)**. Respondent sampling size was designed targeting to have at least 5 respondents for each DCE block for each of the 4 sampling groups **(see Table 11)**. It is important to highlight that sample size in DCE are different than number of respondents. Sample size is equal to the number of respondents multiplied by the number of choice cards they completed. However, to capture a representative portion of the population and to account for invalid responses approximately 270 respondents were asked to complete the DCE representing roughly 12% of the population **(see Table 11)**.

Table 11 Total sampling per study site by sampling group and DCE block

	Gardi Sugdub	Soledad Miria	Nargana	*Total*
Adult Population	*563*	*459*	*690*	*1,712*
% sampled	16%	21%	12%	*16%*
Adult – Men	*23*	*26*	*22*	*71*
Block 1	7	6	6	*19*
Block 2	6	6	5	*17*
Block 3	5	8	6	*19*
Block 4	5	6	5	*16*
Adult – Women	*23*	*24*	*20*	*67*
Block 1	5	6	5	*16*
Block 2	6	6	5	*17*
Block 3	7	6	5	*18*
Block 4	5	6	5	*16*
Young – Men	*23*	*24*	*20*	*67*
Block 1	5	6	5	*16*
Block 2	5	6	5	*16*
Block 3	8	6	5	*19*
Block 4	5	6	5	*16*
Young – Women	*21*	*24*	*20*	*65*
Block 1	5	6	5	*16*
Block 2	5	6	5	*16*
Block 3	6	6	5	*17*
Block 4	5	6	5	*16*
Total	*90*	*98*	*82*	*270*

The survey was design to allow respondent to take a break between each of the five DCE. Overall, the questionnaire consisted of eight modules **(see Figure 7)**. The first three modules captured the respondent general characteristics, the erosion of traditional practices and knowledge (module designed based on the outputs from the expert interviews of local and regional Guna authorities), and the income sources. Next, each of the DCE were conducted in sequence (first the drivers DCE, then the pressures DEC, etc.). Within each exercise, the two main ranking tools (Likert and DCE) were conducted, starting with the Likert ranking. The Likert ranking tool served multiple purposes in the survey protocol. First, it allowed respondents to familiarize themselves with the concepts through the guiding materials containing the explanations and icons developed for each DPSIR element. This in turn help to make the next ranking tool (the DCE) easier to complete. Second, it provided a logical/conceptual break between exercises where the enumerators hired and trained locally to conduct the surveys were instructed to pause the interview, produce the printed materials (a laminated copy of the guiding material, **see appendix 3**) and explain concepts as needed.

Figure 7 Community survey design showing key thematic modules and their sequence

Invalid surveys were identified and removed from the final analysis. Invalid responses were validated based on a series of checkpoint mechanisms to identify biases including:

- bias alternative selection: fail if respondent selected only one alternative (1, 2 or 3) for all the choice cards
- ratio of selected alternative: fail if respondent selected more than 90% the same alternative (1, 2 or 3)
- irregular completion time: fail if respondent completed the survey in less than 10 minutes
- warm globe effect: fail if respondent answer a set of control questions showing motivation is only as an emotional reward of giving
- punishment vote: fail if respondent answer a set of control questions showing motivation is to protest current leadership
- control choice cards: fail if respondent selected an illogical alternative within the control choice card in the survey (i.e. selecting an alternative that provides the same benefits but at a higher price)

Surveys that showed “bias alternative selection” were automatically removed from the analysis. Surveys that failed only one of the remaining biases checkpoints were kept while surveys that failed two or more of the checkpoints were removed. During the survey validation process the balance between blocks was also considered. Since a full DCE depends on having a complete dataset from all four-blocks created in step 2 it translated on removing lower quality surveys in order to balance the blocks (have a 1:1 ratio of each block, i.e. if there is only 4 valid surveys from block 1, even if blocks 2, 3 and 4 contains 5 valid surveys, one will be removed from blocks 2, 3 and 4 to have 4 surveys in each block). A total of 232 valid surveys remained after removing invalid responses and balancing the blocks for each sampling group at each study site **(see Table 5)**.

Step 4) uses the mixed logit model (MIXL) from the gml package in R to obtain the estimates from the outcome of step 3 **(Sarrias & Daziano, 2017)**. MIXL is a frequently used extension of multinomial logit models based on random utility maximization **(equation 1).** This utility accounts for unobserved preference heterogeneity from the choice attributes and respondent characteristics **(McFadden & Train, 2000; Sarrias & Daziano, 2017)**. The random utility of respondent i alternative j in choice occasion t is:

$$\boldsymbol{U_{ijt} = x_{ijt}\beta_i + \varepsilon_{ijt}}, \quad (1)$$

where x_{ijt} are observed variables for the alternative attributes, β_i is a vector of coefficients of the variables representing the respondent preference, and ε_{ijt} is the error term. While conditional logit model is frequently use, they perform better under scenarios where the choice is a function of the alternatives, while the MIXL performs better when the choice is a function to the characteristics of the respondents **(Hoffman & Duncan, 1988; Sarrias & Daziano, 2017)**. The MIXL models performed better compared to the results from the conditional logit model from the Support.CEs package **(see Table 12)**. The outcomes from the analysis allowed to estimate the marginal willingness to paid (MWTP). To estimate the MWTP a "willingness to paid" attribute was added into each choice card **(see Figure 8)**. The levels for this attribute was set at 0, 10, 25, and 35 USD. These values were selected since it roughly represents a range that approximate the cost for 1 adult to eat for 1 week. To calculate the MWTP the estimate of the DPSIR element is divided by the estimate of the willingness to paid attribute added in the DCE **(Aizaki, 2012; Sarrias & Daziano, 2017)**.

Table 12 Maximized log-likelihood between Mixed Model and Conditional Logit Model (CL)

DCE	Total		Nargana		Soledad Miria		Gardi Sugdub	
	Mixed	CL	Mixed	CL	Mixed	CL	Mixed	CL
Drivers	-1876.3	-1892.0	-509.2	-511.8	-739.0	-744.3	-565.4	-572.2
Pressures	-1911.9	-1912.0	-525.7	-525.7	-747.3	-747.3	-568.2	-568.2
States	-866.3	-866.4	-223.0	-224.3	-349.3	-349.9	-238.3	-239.2
Impacts	-1888.5	-1888.6	-523.5	-523.5	-717.4	-717.4	-566.9	-566.9
Responses	-1909.5	-1918.9	-526.4	-530.4	-749.0	-749.0	-579.2	-589.1

Note: (higher values=better)

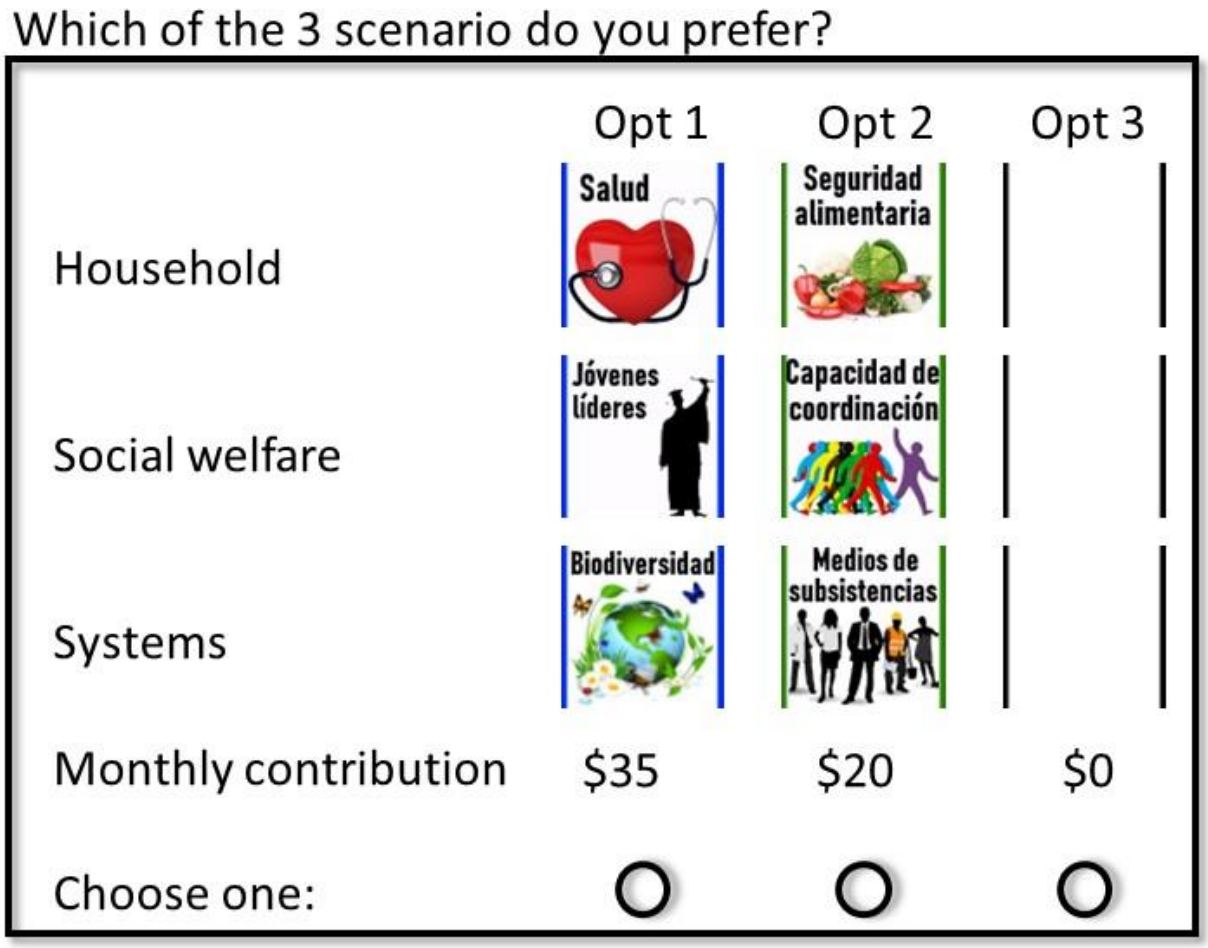

Figure 8 Sample of choice card for the States DCE

2.5.4 DPSIR Elements Likert Ranking

A second ranking tool was included in the surveys to elicit the priorities for each of the 78 DPSIR elements at community level **(see Figure 1 "j")**. A 10 scale Likert was added, and respondent were free to rank each DPSIR element independent from each other. While DCE simulate better real-life choices where tradeoffs need to be made (DCE achieve this by forcing respondent to choose only one of the alternatives presented), the Likert ranking has the potential to capture the respondent ideal alternatives. The responses from the Likert were subsequently averaged and a consensus value between respondents was estimated. The consensus value explains the distance between categories (or any ordinal scale) providing a value of dispersion among the group **(Tastle & Wierman, 2007)**. This value denotes the level of agreement over the average rank for each DPSIR element between interviewees, ranging from a value of one ("1") representing full consensus to a value of zero ("0") representing complete disagreement **(Tastle & Wierman, 2007)**.

2.5.5 *Network Centrality Analysis*

Network centrality measurements have the ability to identify critical nodes (in this study network nodes represents each of the 78 DPSIR elements) **(see Figure 1 "o")**. The foundations to conduct the network analysis comes from two primary data sources. First, the 97 sub-systems obtained as an outcome from the content analysis. Second, the MWTP values from all 78 DPSIR elements obtained from the DCE conducted at the community level. The first step of the network analysis merged all 97 DPSIR sub-systems into one network that contains Gunayala SES sustainable challenges. Each of the sub-system acted as part of a bigger system and added upon the other sub-systems (by adding additional no-identified links from other actors). An initial assessment of which nodes are relevant can be obtain from this merging through an in-degree analysis (in-degree of a given nodes is equal to the number of other nodes pointing at him). However, the value of this research is the use of a prestige rank centrality analysis where two sources of information can be combined to capture a multi-stakeholder perspective (the mapping of a network from interviews and the ranking of each node by the community). The prestige rank of a node takes into account the prestige/prominence of the nodes pointing at him. In this study, the prominence of a node was capture through the MWTP from the DCE conducted at the community level. The prestige rank for node i is equal to the sum of the prominence P from all nodes j from the set of directed links E in the network pointing at node i **(see equation 2)**.

$$\boldsymbol{R_i} = \sum_{(\boldsymbol{j},\boldsymbol{i})\in \boldsymbol{E}} \boldsymbol{P_j} \qquad (2)$$

The network was created using the open source network analysis and visualization package Gephi version 0.9.2 and the prestige rank was calculated through the "Prestige Plugin" version 1.0.0 available as an optional extension **(Bastian et al., 2009)**. The prestige plugin extension produces two outputs including the prestige rank as the sum of the prestige and a normalize version of the prestige ranks' minimum and maximum. This study presents the normalized version since the objective is to identify relative rank distances between nodes rather than the absolute value.

Summarized tables were created for each of the DPSIR components to facilitate the interpretation of the results within the components. While the page rank centrality results are standardized across all components in the network, the summarized table allows to standardize the results in isolation (i.e. see how the DPSIR element "food access" rank within the impacts component rather than across the entire network ranking). These summarized tables code each of the elements within each DPSIR component between low, medium, and high priority. The coding is bases on the page rank centrality value and classify each DPSIR element based on the tertile they are located. The tertiles for each DPSIR component is calculated by diving in three equal ranges the prestige rank based on the highest and lowest value in the DPSIR component.

2.5.6 SDG Interlinkages

This study found the "Impacts" component from the DPSIR framework contains a close interconnection with the SDGs **(see Figure 1 "I")**. A follow up content analysis was conducted to map each of the 275 impacts from the 97 DPSIR sub-systems **(see Table 7)** to the relevant SDG targets **(UN General Assembly, 2015)**. The coding was conducted manually **(see section 2.5.2)** and the linkages was determined by the context in which the impact was referred on a case per case basis. For instance, the impact "increased conflicts/violence" from one sub-system referring to corruption from authorities will be linked to targets 16.3 (promote the rule of law) and 16.6 (promote accountable and transparent institutions), while from another sub-system referring to the issues related to drugs will be linked to target 3.5 (strengthen the prevention and treatment of substance abuse). Furthermore, local concepts that encompass a series of expected outcomes, and where there was no direct translation into a single SDG target, a group of SDG targets was mapped to those impacts. For instance, the impact "leadership erosion" was mapped to target 11.4 (safeguard world heritage), target 12.2 (sustainable management of resources), target 14.2 (protect marine and coastal ecosystems), and target 15.1 (ensure conservation, restoration and sustainable use of terrestrial ecosystems). A total of 657 targets were identified having 53 of them unique representing a coverage of 31% of the 169 SDG targets **(see Table 13)**.

Table 13 List of targets related to key impacts across Gunayala SES

SDGs	Targets	Unique Targets	Target Coverage
SDG 1	11	1	1 of 7 (14%)
SDG 2	166	6	6 of 8 (75%)
SDG 3	70	9	9 of 13 (69%)
SDG 4	74	4	4 of 10 (40%)
SDG 5	17	2	2 of 9 (22%)
SDG 6	21	4	4 of 8 (50%)
SDG 7	10	2	2 of 5 (40%)
SDG 8	6	2	2 of 12 (17%)
SDG 9	7	1	1 of 8 (13%)
SDG 10	1	1	1 of 10 (10%)
SDG 11	76	4	4 of 10 (40%)
SDG 12	33	3	3 of 11 (27%)
SDG 13	7	1	1 of 5 (20%)
SDG 14	83	5	5 of 10 (50%)
SDG 15	9	1	1 of 12 (8%)
SDG 16	52	4	4 of 12 (33%)
SDG 17	14	3	3 of 19 (16%)
Total	*657*	*1*	*53 of 169 (31%)*

After identifying the related SDG targets relevant to each of the DPSIR impacts, the study proceeded interlinking the targets based on the network that contains Gunayala SES sustainable challenges **(see section 2.5.5)**. There are three types of SDG targets interlinkages **(see Figure 9)**. The "within interlinks" refers to targets linked due to impacts having multiple SDG targets. The "direct interlinks" refers to impacts linked due to their parents (impacts) interlinked together. The "indirect interlinks" refers to targets linked due their grandparents (states) interlinked together.

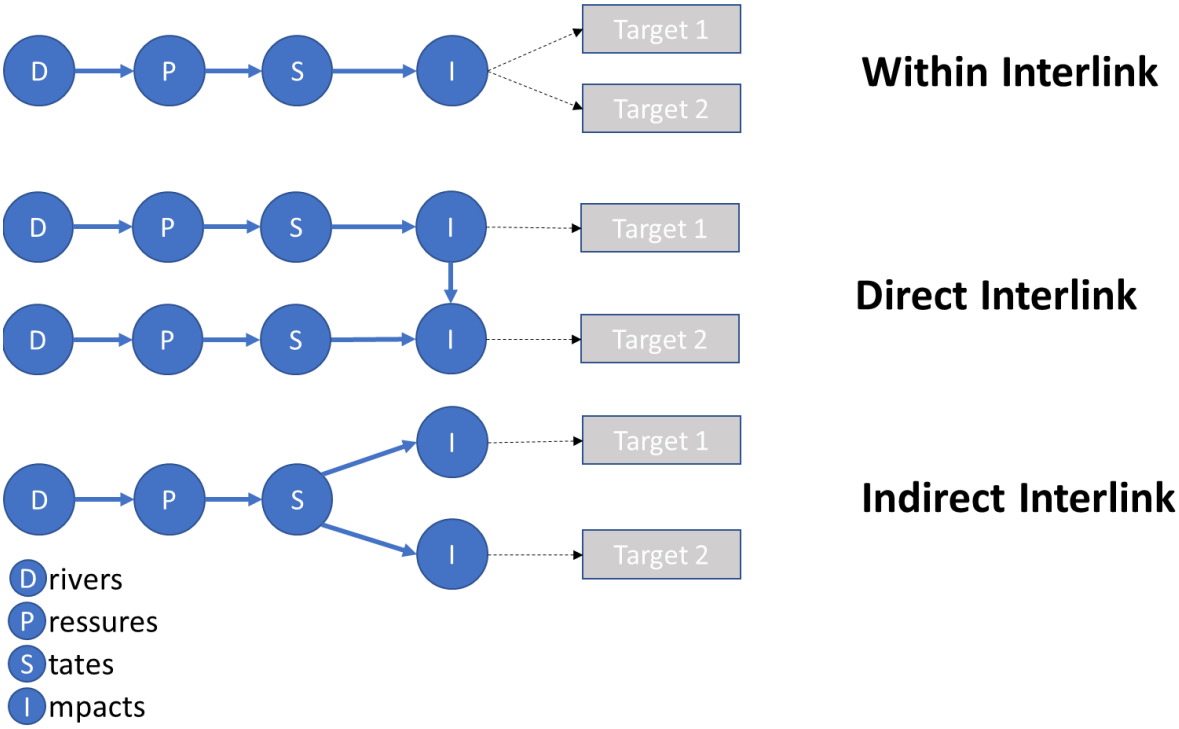

Figure 9 Types of SDG targets interlinkages methods

A total of 1,615 links were identified through this method **(see Table 14)**. Given the complexities of calculating each of the interlinkages and to avoid human errors, the process to identify each type of linkages was perform through Access database manager through a series of SQL queries **(see appendix 4)**. The outcome from Access was programmed to produces a duplicate of each interlink type to express the bi-directional nature of the linkages (i.e. link A to B, as well as B to A). This duplicate interlinks was needed to develop figures, however for analysis purposes the duplicate version is not considered.

Table 14 Total number of SDG targets links by type of interlinkages

Type of Interlink	Number of Interlinks	Unique Interlinks
Within	760	92
Direct	522	235
Indirect	333	146
Total	*1,615*	*394*

Chapter III: Existing Research Analysis[3]

3.1 Chapter Analysis Approach

This chapter systematic review explores patterns in the peer-reviewed literature related to the integration of multiple values in coastal/marine SES in indigenous settings **(see Figure 1)**. The study extracts metadata from 109 papers across five domains: 1) general study characteristics, 2) transdisciplinarity, 3) methodology, 4) SES elements (and their relationships), and 5) values. The study uses latent class analysis, descriptive statistics, and different visualization tools to elicit, synthesise and highlight the identified research patterns. This analysis attempts to understand how different values have been articulated, captured, and integrated in indigenous coastal and marine SES. The study identifies how different studies of indigenous people in marine and coastal ecosystem has been approached within the peer-reviewed literature, and what have been the challenges, barriers, and strategies that researchers and practitioners have encountered. The study extracts, analyses, and visualizes metadata from 109 published studies **(section 2.3)** to identify (a) general research characteristics **(section 3.2.1)**, (b) main research approaches **(Section 3.2.2)**, (c) transdisciplinarity **(section 3.2.3)**, (d) methodologies **(section 3.2.4)**, (e) relationships between the main SES elements **(Section 3.2.5)**, and (f) elicited values **(section 3.2.6)**. The study synthesises this information to identify the strengths and limitations of current approaches at the interface of values and coastal/marine ecosystem services in indigenous settings **(section 3.3.1 and section 3.3.2)**. The study outlines some proposals for the effective cross-fertilisation between approaches **(section 3.3.4)** and the limitations of the current systematic review **(section 3.3.3)**.

3.2 Results

3.2.1 General Characteristics

Most of the reviewed studies (68%) were conducted in developed countries (e.g. Australia, Canada, United States, New Zealand) while the remaining were distributed in 18 developing countries or regions **(see appendix 5, in "Location")**.

Figure 10 and **Figure 11** reveal two main concentrations of studies. The first is in Canada's west coast, British Columbia among First Nation people. These studies mainly cover issues related to indigenous rights, and management and access to marine resources with high cultural value such as abalone *(Haliotis kamtschatkana)*, sea otters *(Enhydra lutris)*, and clams *(Prototthaca staminea, Saxidomus gigantea, Venerupis philippinarum)* **(Augustine & Dearden, 2014; Levine et al., 2017; Marlor, 2010; Menzies, 2010; Sloan, 2004)**. The second cluster is in the Torres Strait, North of Australia focusing on Torres Strait Islanders and Australian aboriginals. These studies mainly cover issues concerning commercial fisheries

and marine resources with high economic value such as rock lobster *(Panulirus ornatus)* **(Hutton et al., 2016; Lalancette, 2017; van Putten et al., 2013)**, and the protection of culturally significant species such as dolphins *(Orcaella heinsohni, Sousa sp., Tursiops sp.)*, dugongs *(Dugong dugon)*, and sea turtles *(Chelonia mydas, Natator depressus)* **(J. R. a Butler et al., 2012; Fuentes et al., 2015; Grech et al., 2014; Nursey-Bray et al., 2010)**.

Interestingly, **Figure 10** suggests that there are few studies in coastal countries with large indigenous populations[4] such as China, India, Indonesia, Venezuela, Mexico, Philippines, Vietnam, and Kenya. **Figure 11** suggests that the two main clusters of studies are conducted in countries with higher indigenous land right recognition such as Canada, Papua New Guinea and, to some extent, Australia. Some countries such as India, Venezuela, United States, and Chile with large population of indigenous people have low land recognition and little research conducted in indigenous marine/costal SES.

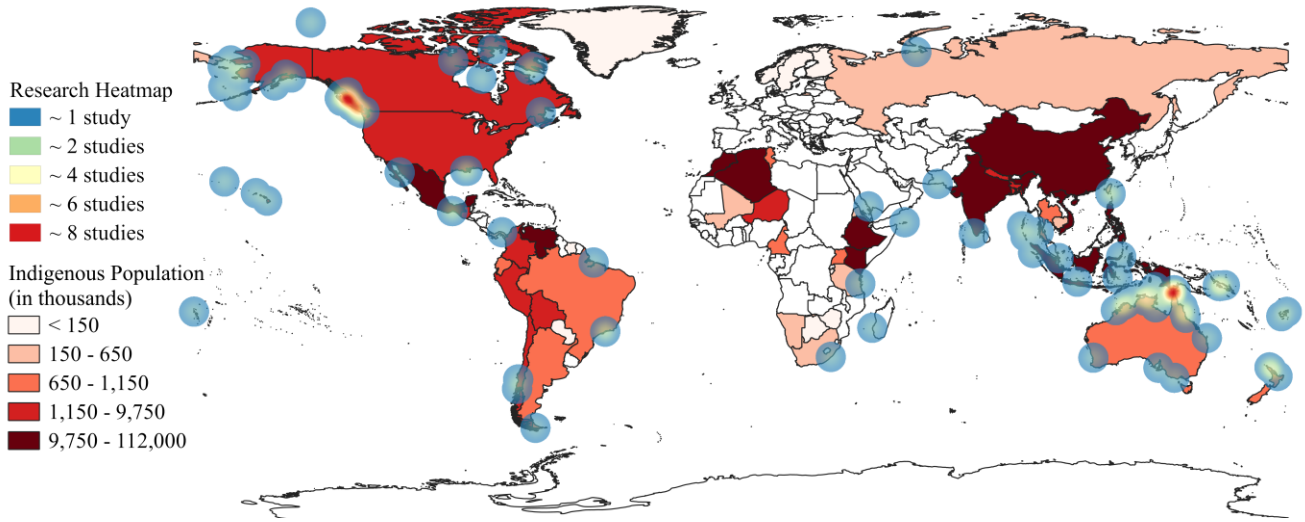

Figure 10 Heatmap of reviewed studies sites and population of indigenous people by country.

Note: The upper and lower limits of population brackets are set up to distribute equal numbers of countries within each level. For more detail on the percentage of indigenous population relative to the country population refer to ***appendix 6***

[4] Despite the general lack of detailed information about the spatial distribution of indigenous people settlements globally (whether inland or in coastal areas), there are some available general population estimates **(Dubertret and Alden Wily, 2015)**.

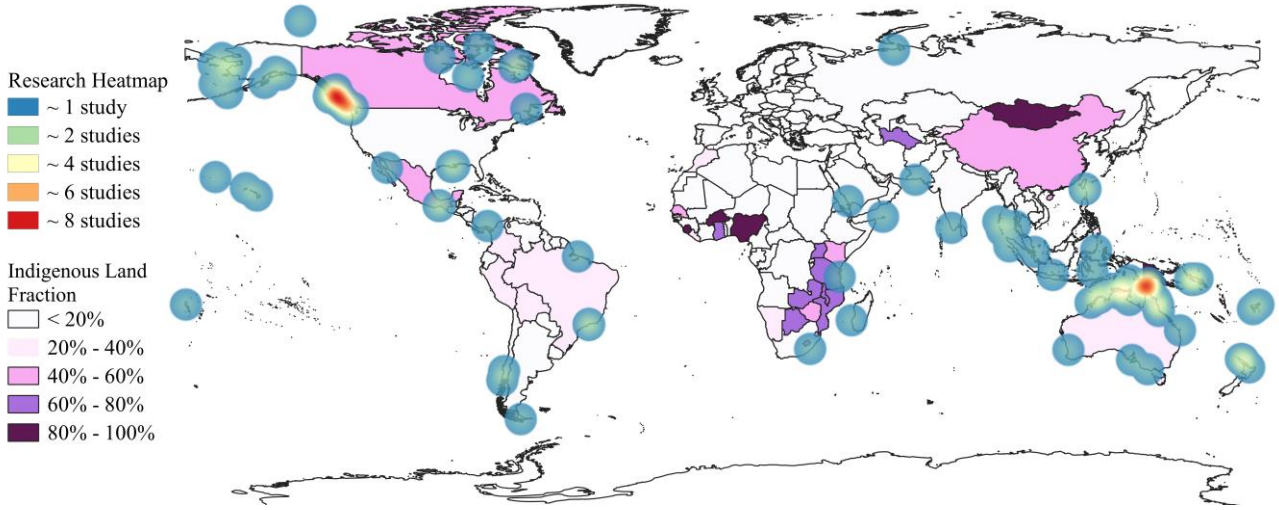

Figure 11 Heatmap of reviewed studies sites and recognized indigenous land ownership by country.

Note: Indigenous land fraction represents the recognized indigenous land mass area compared to the countries' total land mass

3.2.2 Latent Classes: Contextual and Causal research approaches

The LCA identifies two latent classes that fit the best solution that carry the lowest BIC. Class 1 contains 55% of the studies and Class 2 the remainder 45% **(see Table 15)**. The sensitivity analysis suggests that the two latent classes are a good model, with an overall accuracy of 99% **(see Table 16)**. While not all variables within the LCA showed a distinctive pattern between the two classes **(see Figure 12)**, some interesting results emerge. Class 1 is characterized by studies that contextualize indigenous issues, focusing mostly on descriptive research questions and qualitative research. These studies frequently aim to raise awareness about the relationship between indigenous people and coastal/marine ecosystems. These include, among others, studies that seek to recapture traditional understanding of coastal/marine systems, and methods and values of ecosystem services preserved through customary practices, oral history, and archaeological evidence, with the aim of addressing present challenges such as urban development, marine resource management, and indigenous rights **(McMillan & Prosper, 2016; Roberts et al., 2016; Saleh, 2004; Suluk & Blakney, 2009)**.

Table 15 Latent Class Analysis fitness tests

	Fit for 2 classes	Fit for 3 classes	Fit for 4 classes	Fit for 5 classes
Maximum log-likelihood	-938.469	-906.6571	-884.5837	-870.2498
AIC	1962.938	1943.314	1943.167	1958.5
BIC	2078.666	2118.252	2177.315	2251.857
Estimated class shares	Class 1: 56% Class 2: 44%	Class 1: 42% Class 2: 29% Class 3: 29%	Class 1: 28% Class 2: 29% Class 3: 14% Class 4: 29%	Class 1: 17% Class 2: 18% Class 3: 11% Class 4: 25% Class 5: 29%
Predicted class membership	Class 1: 55% Class 2: 45%	Class 1: 42% Class 2: 29% Class 3: 29%	Class 1: 29% Class 2: 28% Class 3: 14% Class 4: 29%	Class 1: 17% Class 2: 18% Class 3: 12% Class 4: 24% Class 5: 29%

Table 16 Sensitivity, specificity, and accuracy of LCA model

	Percentage	Qty	Analysis Results
Class 1			
Estimated cases	56%	61	
Predicted cases	55%	60	
Sensitivity			***100%***
Class 2			
Estimated cases	44%	48	
Predicted cases	45%	49	
Specificity			***98%***
Overall Accuracy			***99%***

Note: *"Sensitivity" captures the true positive cases of actual predicted class 1 studies that were accurately estimated by the LCA model; "Specificity" captures the true negative cases of actual predicted class 2 studies that were accurately estimated by the LCA model*

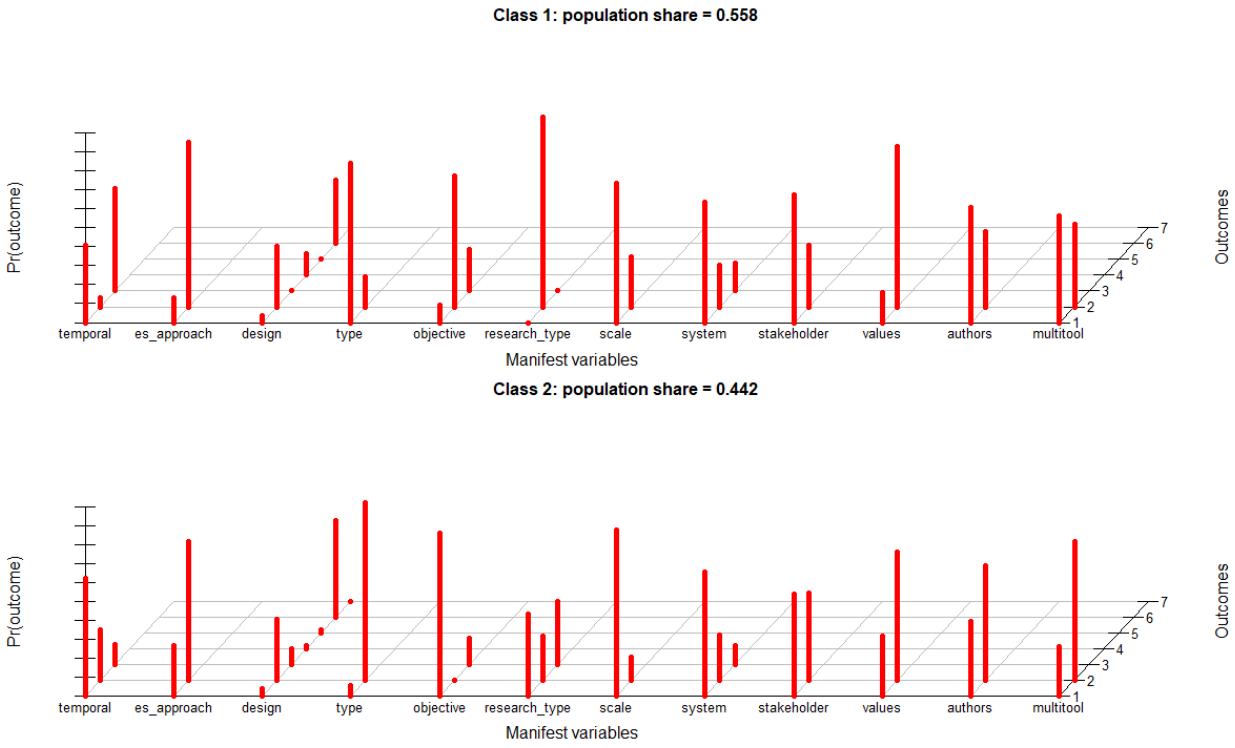

Figure 12 Likelihood for each research characteristics by research class
Note: "y" axis represents the probability for any given option; "z" axis represents the different options ***(for details see Table 3)****.*

On the other hand, Class 2 studies seek to explain the causal flow between system pressures, their impact on the SES, and people's responses. It contains studies that address exploratory research questions using quantitative, qualitative, and mixed-method research approaches. Some of the main research themes include mapping and assessing fisheries supply chains and how they affect the SES on issues such coastal pollution and marine resource management **(J. R. A. Butler et al., 2013; Hutton et al., 2016)**. Many of these studies found ways to integrate ILK and modern scientific techniques such as remote sensing to assess potential conflicts between different stakeholders **(Espinoza-Tenorio et al., 2013; Moore et al., 2017)**, identify suitable protected areas **(Ban et al., 2008, 2009)**, and determine the value of adaptation measures against climate change **(Hoverman & Ayre, 2012; Laidler et al., 2011)**.

Considering their unique set of characteristics, for the remainder of this study, studies within latent Class 1 will be referred as *"contextual research"* and studies within latent Class 2 as *"causal research"*. The overall academic influence of these studies seems to be growing, as not only the number of relevant studies increases in the last few years, but they are also being published in higher impact journals **(see Figure 13)**. Even though *contextual research* studies are more prevalent, they tend to be published in lower impact journals and have few articles that are highly cited. On the other hand, *causal research* tends to be published in higher impact journals and have, on average, higher citation rates.

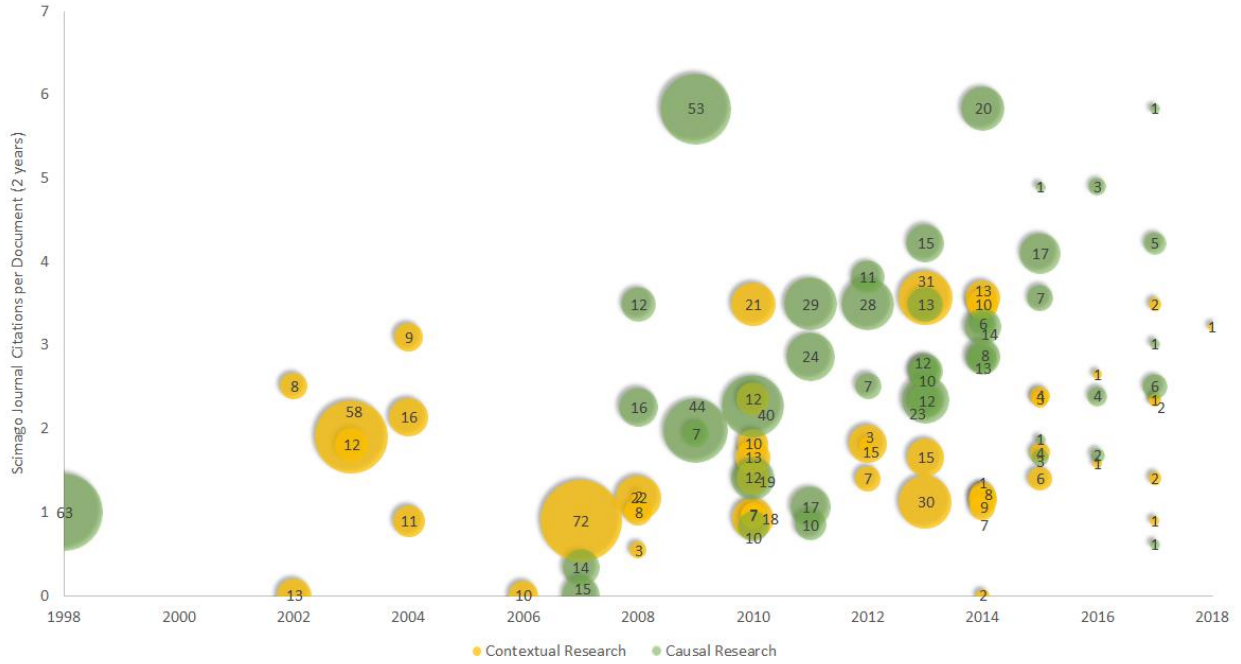

Figure 13 Journal citations per document for the last 2 years and number of citations for each reviewed study.
Note: Size of the bubbles represents the number of citations as of June 2018.

3.2.3 Transdisciplinarity

There is an increasing trend towards a broader representation and collaboration between academic disciplines and fields in studies related to coastal/marine SES in indigenous settings **(Figure 14)**. Initially studies came from just a few fields within the environmental, agricultural, and biological sciences such as oceanography, environmental sciences, and management and policy studies. Currently studies come from a plethora of different academic disciplines and fields through academic fields such as computer sciences, economics, biochemistry, arts and humanities, and pharmacology, among others **(see appendix 7)**.

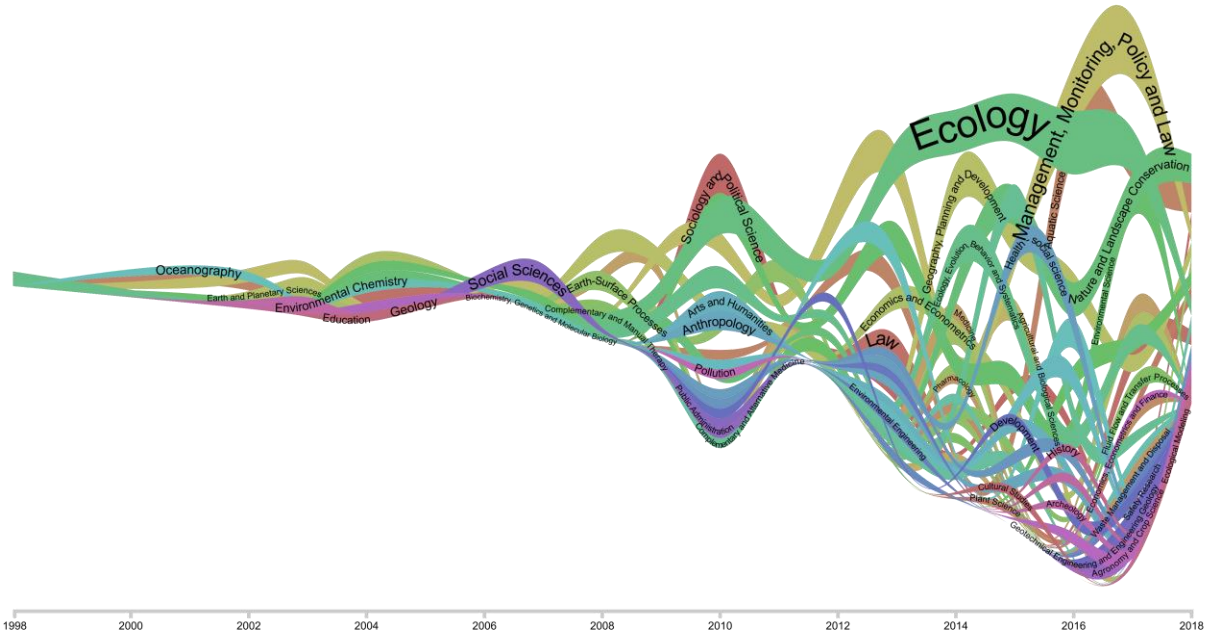

Figure 14 Evolution of the main academic fields of the reviewed studies.
*Note: For a full list refer to **appendix 7**.*

Figure 15 outlines the types of institutions engaged in this type of research and presents in detail the authors' cross-collaboration within (and between) institutions. In a sense **Figure 15** provides a snapshot of the stakeholders directly involved in the conceptualisation, design, and execution of the reviewed studies. Distinct patterns emerge when comparing between research classes. Most *contextual research* studies are predominately produced within academia compared to other types of institutions. Most of the collaborations tend to be between academic institutions from different countries **(Figure 15)**, and only in a few studies are indigenous community members integrated actively in the research team **(McMillan & Prosper, 2016; Roberts et al., 2016; Suluk & Blakney, 2009)**. In contrast, authors from *causal research* studies tend to be more open to collaborations with multiple non-academic institutions such as research institutes and indigenous group agencies (e.g. traditional institutions in charge of local marine resource management) **(J. R. A. Butler et al., 2013; Fuentes et al., 2015; Gratani et al., 2011)**. However, interestingly, there seems to be less collaboration with actual indigenous community members within *causal research* studies, compared to *contextual research* studies.

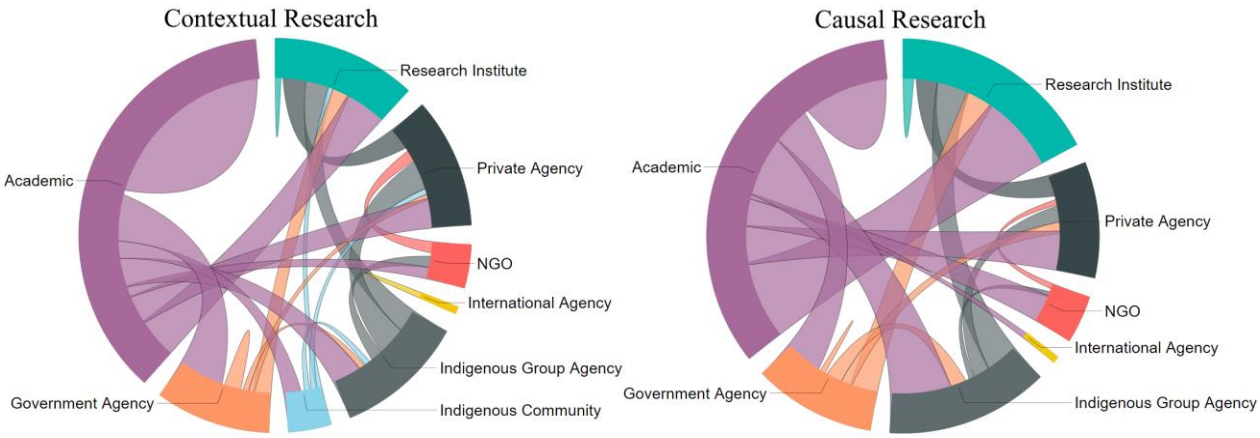

Figure 15 Collaboration between authors' institutions by research classes.
Note: The "arcs" represent the frequency of authors' institutions that participated in the study; "links" between the arcs shows the collaboration between authors' intuitions to produce each study. Links that start and end within the same arc represent collaboration between the same type of institution from different countries

The level of stakeholders' integration also varies between research classes. Despite a lack of *causal research* studies in the early 2000s (the study found only 1 study from 1998), they tend to integrate more stakeholders (and at a higher proportion of studies) compared to *contextual research* **(Figure 16)**. Furthermore, even though indigenous communities are the most frequently integrated stakeholders in both classes, there seems to be a different level of contribution to the actual research. C*ausal research* studies tend to integrate more meaningfully the input of indigenous people than *contextual research*. Higher integration of indigenous communities through co-design approaches is observed in the *causal research* class (10% of all studies) rather than the *contextual research* class (5% of all studies). This also applies for general public participation through co-design, discussions and consultations **(see appendix 5, in "Indigenous People Integration")**.

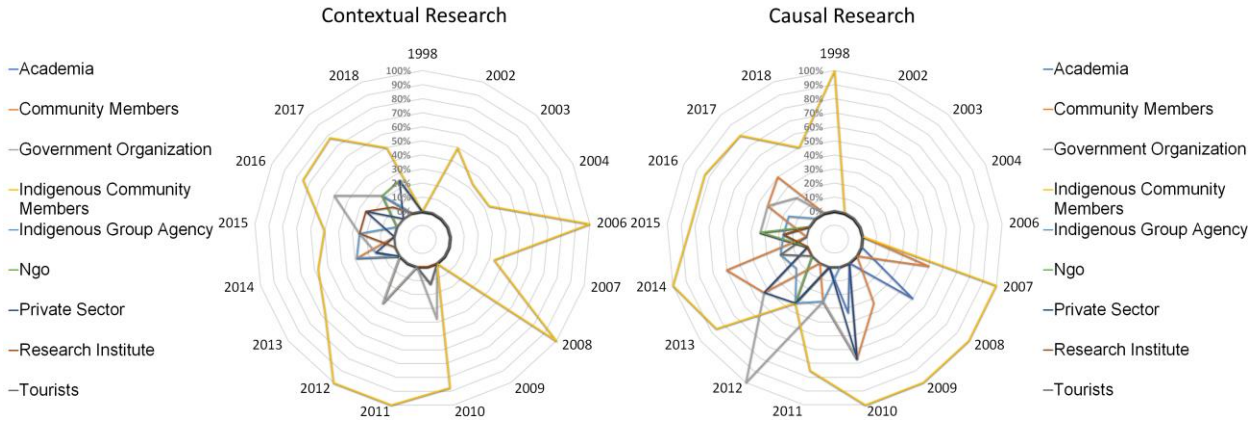

Figure 16 Stakeholder integration within the reviewed studies by research class.
Note: Main axis represent the percentage of studies that includes a given stakeholder within a specific year

3.2.4 *Methodologies*

A closer look of the data collection tools, analytical methods, and theoretical frameworks used in each study also identified distinct patterns between research classes. **Figure 17** clearly shows the differences and similarities between the types of tools, methods, and frameworks used within each research class. Overall, while it seems that both research classes implement the same type of data collection tools, a closer examination revealed that *causal research* studies tend to use multiple types of data collection tools in their studies **(see Table 17, in "Data Collection Tool")**. Furthermore, *causal research* studies tend to use more frequently multiple tools to collect primary data (e.g. questionnaires complemented with focus group discussions) (73% of studies) than *contextual research* studies (43% of studies) **(see appendix 5, in "Multi Tools")**.

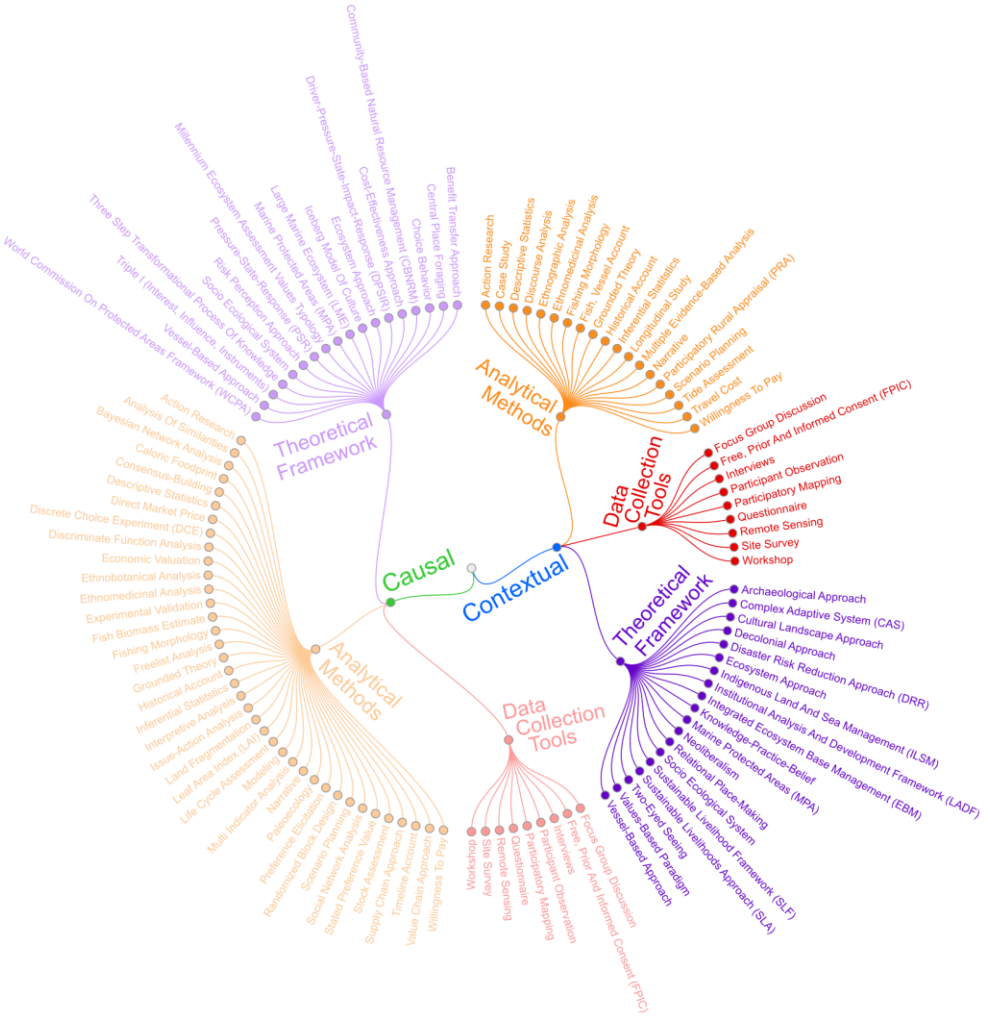

*Figure 17 Data collection tools, analytical methods, and theoretical frameworks by research class. Note: For a full list refer to **Table 17***

Table 17 Methodologies of the reviewed studies

	Contextual Research		Causal Research		Total	
Data Collection Tools (full list)						
Interviews	*39*	*65%*	*35*	*71%*	*74*	*68%*
Site Survey	*9*	*15%*	*15*	*31%*	*24*	*22%*
Participant Observation	*14*	*23%*	*9*	*18%*	*23*	*21%*
Workshop	*8*	*13%*	*13*	*27%*	*21*	*19%*
Questionnaire	*4*	*7%*	*14*	*29%*	*18*	*17%*
Remote Sensing	*2*	*3%*	*14*	*29%*	*16*	*15%*
Free, Prior and Informed Consent (FPIC)	*5*	*8%*	*8*	*16%*	*13*	*12%*
Participatory Mapping	*2*	*3%*	*11*	*22%*	*13*	*12%*
Focus Group Discussion	*2*	*3%*	*10*	*20%*	*12*	*11%*
Analytical Methods (top 15)						
Narrative	46	77%	10	20%	56	51%
Descriptive Statistics	11	18%	35	71%	46	42%
Historical Account	14	23%	2	4%	16	15%
Inferential Statistics	1	2%	10	20%	11	10%
Ethnographic Analysis	6	10%	0	0%	6	6%
Scenario Planning	2	3%	3	6%	5	5%
Action Research	1	2%	3	6%	4	4%
Case Study	3	5%	0	0%	3	3%
Grounded Theory	2	3%	1	2%	3	3%
Willingness to Pay	1	2%	2	4%	3	3%
Ethnobotanical Analysis	0	0%	3	6%	3	3%
Direct Market Price	0	0%	3	6%	3	3%
Ethnomedicinal Analysis	1	2%	1	2%	2	2%
Fishing Morphology	1	2%	1	2%	2	2%
Discrete Choice Experiment (DCE)	0	0%	2	4%	2	2%
Theoretical Frameworks (top 15)						
Marine Protected Areas (MPA)	3	5%	7	14%	10	9%
Socio Ecological System	2	3%	3	6%	5	5%
Archaeological Approach	3	5%	0	0%	3	3%
Vessel-Based Approach	1	2%	2	4%	3	3%
Decolonial Approach	2	3%	0	0%	2	2%
Ecosystem Approach	1	2%	1	2%	2	2%
Cultural Landscape Approach	1	2%	0	0%	1	1%
Two-Eyed Seeing	1	2%	0	0%	1	1%
Values-Based Paradigm	1	2%	0	0%	1	1%
Knowledge-Practice-Belief	1	2%	0	0%	1	1%
Relational Place-Making	1	2%	0	0%	1	1%
DPSIR	0	0%	1	2%	1	1%
Choice Behavior	0	0%	1	2%	1	1%
Cost-Effectiveness Approach	0	0%	1	2%	1	1%
Pressure-State-Response (PSR)	0	0%	1	2%	1	1%

The biggest differences between the research classes relates to the analytical methods used. In total the study identified 38 different types of analytical methods used in *causal research* studies, which is more than double the 18 methods identified in *contextual research* studies **(Figure 17)**. Furthermore, the study found different methodological preferences between research classes. Narrative analysis is by far the most frequent analytical method in *contextual research* (77% of studies), while in *causal research* descriptive statistics is the most frequent analytical method (71% of studies) **(see Table 17, in "Analytical Methods")**.

On the contrary there are subtler differences in the use of theoretical frameworks between research classes. Interestingly, the main differences between classes lie in the objective of the adopted theoretical frameworks rather than the number of frameworks used or the frequency of their adoption. Overall *contextual research* studies tend to adopt theoretical frameworks based on anthropological and ethnographical approaches (e.g. two-eyed seeing, values-based approach, decolonial approach) that aim to understand the different aspects of coastal/marine SES in indigenous settings **(Augustine & Dearden, 2014; Kronmüller et al., 2017; McMillan & Prosper, 2016)**. On the other hand, *causal research* studies tend to adopt theoretical frameworks that seek to explain relationships for an observed phenomenon that affects these coastal/marine SES (e.g. pressure-state-response framework, DPSIR, choice behaviour approach) **(Espinoza-Tenorio et al., 2013; Gunn et al., 2010; Oleson et al., 2015) (see Table 17, in "Theoretical Frameworks")**.

3.2.5 Conceptual mapping of the main SES elements and their relationships

The study identified key DPSIR elements and the relationship for each study, aggregate the results for all studies, and produce a conceptual map of the linkages between the DPSIR elements. From this point onwards, when the word "map/mapping" is use in the context of SES and DPSIR elements, this refer to the conceptual mapping of the system.

Figure 7 depicts the relationship between the different DPSIR elements as extracted from the reviewed studies and illustrates the complexity of coastal/marine SES in indigenous settings. While some caution should be paid when combining the results of all studies, very revealing causal relationship emerge between DPSIR elements. In particular underlying economic drivers combined with policy instruments (that often have a lagging effect), tend to give rise to pressures related to poor resource management and habitat destruction pressures **(Allamel, 2016; Marlor, 2010) (see Figure 7, drivers and pressures columns)**. These pressures can have a substantial effect in coastal/marine SES, affecting negatively biodiversity **(Lyver et al., 2015; Stephenson et al., 2014)**, ecosystem services **(Preece et al., 2016; Zander & Garnett, 2011)**, and the wellbeing of indigenous communities **(Brooks & Bartley, 2016; Espinoza-Tenorio et al., 2013) (see Figure 7, states column)**. This often manifests through the loss of cultural values **(McMillan & Prosper, 2016; Preece et al., 2016)** and culturally significant marine species **(Jackson et al., 2015; Liu,**

2017), among others **(see Figure 7, impacts column)**. The most common responses include the call for adopting integrated approaches to respond to the economic, social and cultural needs of indigenous communities considering their distinct values, ILK, and worldviews **(Brooks & Bartley, 2016; Espinoza-Tenorio et al., 2013; Setti et al., 2016)** **(see Figure 7, responses columns)**.

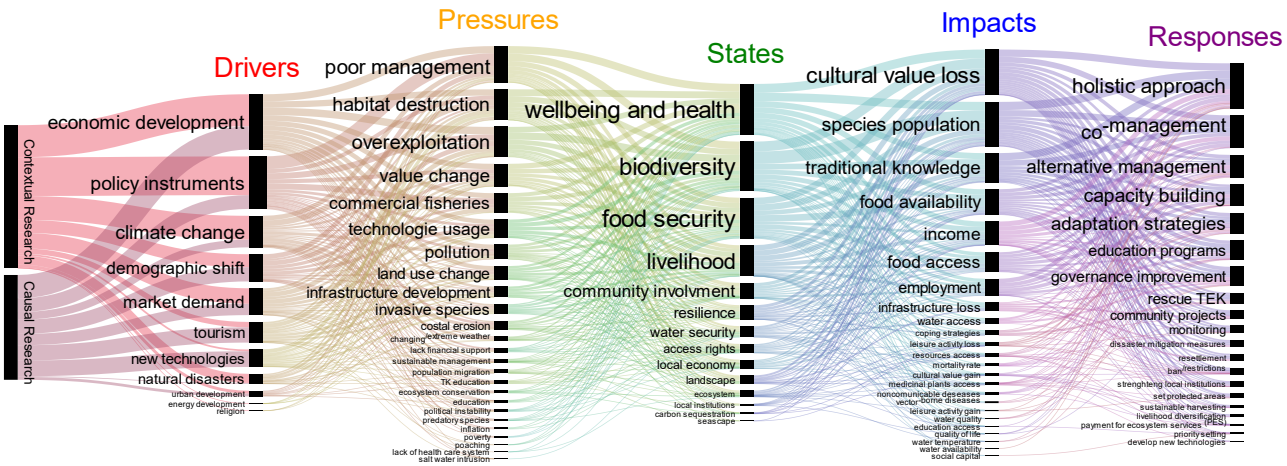

Figure 18 Relationship between DPSIR elements within marine/coastal SES in indigenous settings for both research classes.

Note: The width of lines represents the frequency of this element as identified in the reviewed studies. Elements are aggregated from contextual and causal research studies. For a full list refer to ***appendix 8***

To identify patterns between research classes the study compares the three most frequent variables for each DPSIR element between studies. Overall, *causal research* studies tend to identify more often Drivers and Responses that have a favourable effect to the SES, such as the capacity of policy instruments and new technologies to improve the SES **(Carothers, 2013; Joyce & Satterfield, 2010)** **(see appendix 8, in "Drivers")**. The most notable difference however is observed in the trend of the DPSIR responses. *Causal research* studies often identify that integrated responses can protect marine areas and endangered species **(Ban et al., 2009; Gunn et al., 2010)**, while *contextual research* studies show that the effectiveness of integrated approaches declines when policy instruments are designed to meet market demands **(Raymond-Yakoubian et al., 2017; Turner et al., 2013)** **(Figure 19)**.

		Total			Contextual Research			Causal Research		
		Trend	Consensus	Uncertain	Trend	Consensus	Uncertain	Trend	Consensus	Uncertain
Drivers										
Economic Development	(n=47/23/24)	2.2	0.8	40%	2.1	0.8	26%	2.4	0.7	54%
Policy Instruments	(n=37/24/13)	2.4	0.7	24%	2.4	0.7	13%	2.6	0.7	46%
Climate Change	(n=31/18/13)	1.9	0.9	26%	1.8	0.9	28%	1.9	0.9	23%
Pressures										
Habitat Destruction	(n=38/20/18)	1.7	0.8	8%	1.6	0.8	3%	1.9	0.8	5%
Poor Management	(n=36/26/10)	2.1	0.8	6%	2.1	0.7	3%	2.0	0.8	3%
Overexploitation	(n=35/16/19)	1.8	0.9	9%	1.7	0.8	3%	1.8	0.9	6%
States										
Biodiversity	(n=55/25/30)	2.1	0.8	15%	1.9	0.8	5%	2.2	0.8	9%
Wellbeing And Health	(n=53/32/21)	2.2	0.8	15%	2.2	0.8	8%	2.1	0.8	8%
Livelihood	(n=33/17/16)	2.6	0.6	24%	2.4	0.7	9%	2.8	0.5	15%
Impacts										
Species Population	(n=53/23/30)	2.1	0.8	15%	1.8	0.8	6%	2.3	0.7	9%
Cultural Value Loss	(n=50/30/20)	1.9	0.9	6%	1.8	0.9	4%	2.0	1.0	2%
Traditional Knowledge	(n=32/20/12)	2.2	0.7	9%	2.3	0.7	6%	2.1	0.8	3%
Responses										
Holistic Approach	(n=39/22/17)	2.9	0.5	67%	2.3	0.6	38%	3.7	0.8	28%
Alternative Management	(n=24/15/9)	3.9	0.5	71%	3.6	0.4	42%	4.5	0.8	29%
Co-Management	(n=23/17/6)	2.2	0.4	78%	1.5	0.8	65%	2.7	0.2	13%

= significant degradation	< 0.2	< 20%
= moderate degradation	0.2 - 0.4	20% - 40%
= remain the same	0.4 - 0.6	40% - 60%
= moderate improvement	0.6 - 0.8	60% - 80%
= significant improvement	≥ 0.8	≥ 80%

Figure 19 Top three variables for each DPSIR element by research class.

Note: Parentheses represent the number of papers that studied each variable (total/contextual/causal); Trends are based on an average of the results elicited from each individual study; Consensus (of the trend) is based on the level of agreement between studies. Uncertainty is based on the percentage of studies that identifies the variable without clear trend. For a full list refer to ***appendix 8***

However, the type of Impact (either positive or negative), follows a similar pattern between research classes **(see appendix 9)**. For example, the results show that most responses in both research classes are perceived having a positive feedback to the marine SES **(see appendix 9, in "Responses")**.

3.2.6 Values and valuation techniques

Figure 20 shows the values elicited in the reviewed studies, the ecosystem services they are attached to, and the valuation methods. Instrumental values are the most commonly elicited values, representing 50% of the values captured in the reviewed studies. Instrumental values are mostly attached to provisioning services such as food and raw materials **(Huntington et al., 2013; Roberts et al., 2016)**. Relational values account for 30% of the captured value and are mostly related to cultural services linked to spiritual needs **(Kikiloi et al., 2017; McMillan & Prosper, 2016)**. Bequest values represent 13% of all values captured and are mostly attached to supporting ecosystem services related to the maintenance of genetic diversity **(Lyver et al., 2015; Oleson et al., 2015)**. Intrinsic, existence and option values are captured in much fewer studies **(Figure 20)**.

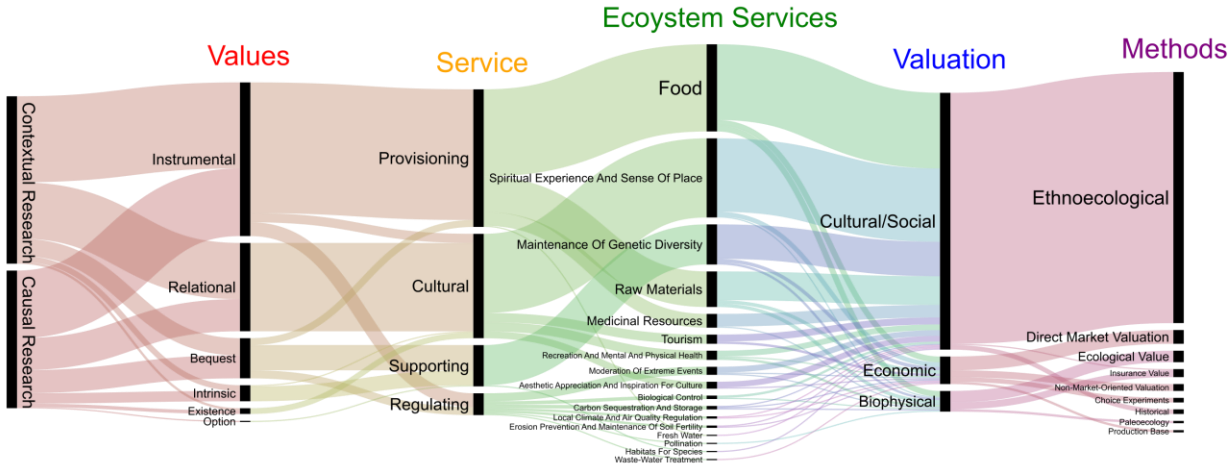

Figure 20 Values and valuation methods for coastal/marine ecosystem service for both research classes. Note: For a full list of ecosystem services refer to ***Figure 21***

The most common valuation methods are cultural/social approaches used in 84% of the cases, mostly using ethnoecological tools. Economic and biophysical methods are also employed (e.g. direct market valuation, non-market valuation, choice experiment) but only in 16% of the cases. When comparing research classes, *contextual research* studies overwhelmingly tend to capture more than one value representing 85% of studies compared to 67% of *causal research* studies **(see appendix 5, in "Multi Value")**.

Figure 21 shows that most studies have identified that coastal/marine ecosystem services in indigenous settings are either declining or have an uncertain future. Studies from both research classes suggest declines on the instrumental value of food-related provisioning services due to overexploitation **(Cullen et al., 2007; Eckert et al., 2018)**, habitat destruction **(Lauer & Aswani, 2010; Oleson et al., 2015)**, and poor marine resource management **(Gauvreau et al., 2017; Robards & Lovecraft, 2010)**. Similarly loss of relational values has been linked to the loss of cultural ecosystem services triggered by the decline of culturally significant species **(Menzies, 2010; Sloan, 2004)** and the degradation of landscape/seascape elements **(Kronmüller et al., 2017; Vaughan & Ardoin, 2014)**. On the other hand the effects to regulating services with bequest values remains mostly uncertain **(Preece et al., 2016; Zander & Garnett, 2011)**.

Value	Services type	Services	Total			Contextual Research			Causal Research		
			Trend	Consensus	Uncertain	Trend	Consensus	Uncertain	Trend	Consensus	Uncertain
Bequest	Provisioning	Raw Materials (n=6/3/3)	1.5	0.8	33%	1.0	1.0	33%	2.0	1.0	33%
Bequest	Regulating	Carbon Sequestration And Storage (n=3/1/2)	2.0	1.0	67%			100%	2.0	1.0	50%
Bequest	Regulating	Erosion Prevention And Maintenance Of Soil Fertility (n=1/0/1)			100%			0%			100%
Bequest	Regulating	Local Climate And Air Quality Regulation (n=2/1/1)			100%			100%			100%
Bequest	Regulating	Moderation Of Extreme Events (n=1/1/0)	3.0	1.0	0%	3.0	1.0	0%			0%
Bequest	Supporting	Maintenance Of Genetic Diversity (n=22/9/13)	2.3	0.7	23%	2.1	0.7	22%	2.4	0.7	23%
Existence	Cultural	Aesthetic Appreciation And Inspiration For Culture, Art And Design (n=5/2/3)	2.3	0.6	20%	2.5	0.3	0%	2.0	1.0	33%
Instrumental	Cultural	Tourism (n=8/4/4)	3.0	0.6	25%	3.3	0.6	25%	2.7	0.6	25%
Instrumental	Provisioning	Food (n=76/43/33)	2.1	0.8	33%	2.1	0.7	26%	2.3	0.8	42%
Instrumental	Provisioning	Fresh Water (n=1/1/0)	1.0	1.0	0%	1.0	1.0	0%			0%
Instrumental	Provisioning	Medicinal Resources (n=12/7/5)	2.3	0.5	25%	2.2	0.3	29%	2.5	0.7	20%
Instrumental	Provisioning	Raw Materials (n=25/16/9)	2.4	0.7	36%	2.3	0.8	25%	2.8	0.7	56%
Instrumental	Regulating	Biological Control (n=3/1/2)	4.0	1.0	33%	4.0	1.0	0%	4.0	1.0	50%
Instrumental	Regulating	Erosion Prevention And Maintenance Of Soil Fertility (n=1/1/0)	1.0	1.0	0%	1.0	1.0	0%			0%
Instrumental	Regulating	Moderation Of Extreme Events (n=6/1/5)	3.0	0.6	33%	4.0	1.0	0%	2.7	0.6	40%
Instrumental	Regulating	Pollination (n=1/1/0)			100%			100%			0%
Instrumental	Regulating	Waste-Water Treatment (n=1/0/1)			100%			0%			100%
Intrinsic	Cultural	Aesthetic Appreciation And Inspiration For Culture, Art And Design (n=1/0/1)	4.0	1.0	0%			0%	4.0	1.0	0%
Intrinsic	Supporting	Maintenance Of Genetic Diversity (n=13/5/8)	2.7	0.6	54%	3.0	0.6	60%	2.5	0.6	50%
Option	Supporting	Habitats For Species (n=1/0/1)	2.0	1.0	0%			0%	2.0	1.0	0%
Relational	Cultural	Recreation And Mental And Physical Health (n=8/4/4)	2.2	0.7	25%	1.7	0.8	25%	2.7	0.6	25%
Relational	Cultural	Spiritual Experience And Sense Of Place (n=69/45/24)	2.3	0.7	35%	2.2	0.6	33%	2.4	0.7	38%

= significant degradation	< 0.2	< 20%
= moderate degradation	0.2 - 0.4	20% - 40%
= remain the same	0.4 - 0.6	40% - 60%
= moderate improvement	0.6 - 0.8	60% - 80%
= significant improvement	≥ 0.8	≥ 80%

Figure 21 Types of values related to each ecosystem service by research class.

Note: Parentheses represent the number of papers that studied each ecosystem services (total/contextual/causal); Trends are based on an average of the results elicited from each individual study; Consensus (of the trend) is based on the level of agreement between studies. Uncertainty is based on the percentage of studies that identifies the variable without clear trend.

3.3 Discussion

3.3.1 Strengths and weaknesses of contextual research approaches

Contextual *research* studies have so far been more successful in integrating multiple values and diverse knowledge systems for the study of coastal/marine SES in indigenous settings. The ethno-ecological approaches that are predominant in these studies facilitate the collaboration of academics with indigenous and local communities, allowing the identification of a wide(r) range of values. The qualitative focus of *contextual research* studies allows for a relative comprehensive understanding of phenomena in such coastal/marine SES, by identifying key relevant elements within the SES, their linkages, and their impacts. In a sense the study identifies three strengths of *contextual research* approaches to study coastal/marine SES in indigenous settings: (a) direct collaboration with ILK holders, (b) multi-value orientation, (c) comprehensive conceptual mapping of coastal/marine SES.

Direct collaboration with ILK holders: Contextual *research* studies tend to include more often extensive direct collaboration between academics and community members (as co-authors and active partners) (*see section 3.2.3*). This direct collaboration enriches the perspective of academic studies and allows for a more holistic understanding of pertinent issues in coastal/marine SES. It does not only provide a first-hand account from actors involved in the issues being explored, but also ensures that the points of view of indigenous people are not set aside or overshadowed/dominated by modern science perspectives and western values. This type of direct collaboration becomes essential when addressing politically-charged issues such as indigenous rights, and conflicts between indigenous people and governments over marine resources **(McMillan & Prosper, 2016)**.

Multi-value orientation: *Contextual research* studies also tend to ***adopt*** more often a multi-value approach. In particular, the study identified a multi-value perspective in 85% of *contextual research* studies, compared to 67% of *causal research* studies **(see Section 3.2.6)**. The values and benefits that indigenous people receive from coastal/marine SES are often attached to specific marine products that have instrumental value (i.e. provisioning services related to food) and relational value that connect them with their environment (e.g. series of cultural services related to spiritual/religious functions and traditional lifestyle, among others) **(Augustine & Dearden, 2014; Berkes et al., 2007; Menzies, 2010; Sloan, 2004; Turner, 2003)**. Moreover, these perceived values by indigenous communities are not only attached to marine species, but also include landscape and seascapes elements such as springs, wetlands, rocks, and forests that elevate these areas as sacred sites of high cultural significance. Such landscape and seascape elements can have very different values to indigenous communities including instrumental value (e.g. provide directly food or income from tourism); bequest value (e.g. assets for future generations), intrinsic value (e.g. supporting services for the maintenance of genetic diversity), and relational values (e.g. provide cultural services that satisfy spiritual and recreational needs) **(Harto, 2017; McNiven, 2004; Petheram et al., 2015; Walter & Hamilton, 2014)**.

Comprehensive conceptual mapping of coastal/marine SES: Due to their multiple value perspective, *contextual research* studies are usually better suited to identify and explain effectively complex interactions within coastal/marine SES compared to *causal research* studies **(see section 3.2.5 and 3.2.6)**. For example *contextual research* studies have considered drivers of SES change such as religion **(Tang & Tang, 2010)** and pressures that impact traditional institutions **(Begossi, 2014; King, 2004; Suluk & Blakney, 2009; Tang & Tang, 2010)**. The erosion of traditional education systems that increase the risk of losing ILK, attachment to the landscape/seascape, traditional values, and culture **(Austin et al., 2017; Matsumoto et al., 2014; Saleh, 2004)**. *Contextual research* studies have also explored possible mitigation options to unsustainable commercial fisheries based on ILK practices **(Lepofsky & Caldwell, 2013; Menzies, 2010; Thurstan et al., 2018)**.

However, due to the generally descriptive approach of *contextual research* studies as a result of their overreliance on narrative analysis methods **(see Section 3.2.4)**, they often neglect other important aspects related to the integration of ILK practices and indigenous values. On the one hand *contextual research* approaches rely on direct collaboration with ILK holders to capture indigenous perspectives comprehensively (see above), but on the other hand they might miss the perspectives of other important stakeholders. Furthermore, while qualitative methods are fit for identifying multiple pressures within coastal/marine SES, these techniques by themselves are not enough to prioritize the effects of different pressures within the SES. Considering the above, *contextual research* approaches have essentially three weaknesses: *1) issue-orientation, 2) stakeholder imbalance, and 3) relevance ambiguity*.

Issue-orientation: Generally speaking, the ethnographic frameworks used in *contextual research* studies can help develop a comprehensive narrative by describing the issues that indigenous people located in coastal/marine SES face. However, such studies often conclude after describing the issue, without exploring viable solutions and implementation methods **(Dunlap, 2018; Suluk & Blakney, 2009)**. In this regard these studies are issue-oriented, rather than solution-oriented. While neither research class shows high levels of indigenous knowledge integration at the co-design level, there are some differences between research classes. C*ontextual research* studies exhibit a lower degree of knowledge integration compared to *causal research* studies (5% and 10% of studies respectively), implying that the role of indigenous communities is often limited to being information providers ***(see appendix 5, in "Indigenous People Integration")***. This reinforces the notion that since these *contextual research* studies mainly aim to describe phenomena within coastal/marine SES, co-design components become less crucial. Thus although *contextual research* provides comprehensive analyses by capturing conflicts from indigenous communities' perspectives, values, ILK, worldviews, belief, and traditional livelihood systems, they are often devoid of any clear solution pathway **(Clifton & Majors, 2012; Dunlap, 2018)**.

Stakeholder imbalance: A high proportion ***of*** *contextual research* studies involve indigenous community members through multiple research tools **(see section 3.2.3)** **(Austin et al., 2017; Carter, 2010; O'Neill et al., 2012)**. However, the inclusion of other relevant stakeholders is considerably lower compared to *causal research* studies **(Ashaletha & Immanuel, 2008; McDonald et al., 2008)**. Although specific research objectives and perspectives of *contextual research* approaches might justify this trend, some studies implement participatory research tools such as workshops with participant selection within a homogenous group without including other key actors **(Petheram et al., 2015; Raymond-Yakoubian et al., 2017)**. While this enables researchers to focus on targeted groups, it might introduce biases in the study outcome, as the perspective of one stakeholder group is overrepresented. For example several *contextual research* studies have sought to explore indigenous marine resource management or the protection of endangered species in coastal/marine SES considering only the perspective of local communities **(Gauvreau et al., 2017; Lepofsky & Caldwell, 2013; Liu, 2017; Matsumoto et al., 2014)**. While this helps to bring indigenous perspective and ILK to the forefront, the lack of integration of the voices of other key stakeholders (e.g. private sector actors from commercial fisheries or tourism, government agencies) the line between advocacy and research becomes blurred.

Relevance ambiguity: A key ***strength*** of *contextual research* is the ability to provide a comprehensive conceptual mapping of coastal/marine SES. However, this does not necessarily translate into a better understanding of the coastal/marine SES **(Dunlap, 2018; Kikiloi et al., 2017; King, 2004)**. Identifying an extensive list of drivers and pressures within a SES can expand our perspective but can also introduce confusion. Providing a lengthy list of drivers and pressures without a proper explanation of their linkages,

priorities or effects to the SES might divert the study focus to less relevant factors. Often *contextual research* studies that tackle five or more pressures to coastal/marine SES (e.g. climate change, overexploitation, coastal erosion, pollution, commercial fishing) often end up being inconclusive of what is most relevant **(Allamel, 2016; Jackson et al., 2015; O'Neill et al., 2012; Turner et al., 2013)**. This broad net of causal factors that *contextual research* is capable of casting can introduce noise into the research, reducing its ability to provide specific outcomes.

3.3.2 Strengths and weaknesses of causal research approaches

A key feature of *causal research* studies is their use of an extensive array of quantitative and qualitative research methodologies **(see section 3.2.4)** **(Grech et al., 2014; Hoverman & Ayre, 2012; Laidler et al., 2011)**. In contrast to *contextual research* approaches that rely mainly on a few qualitative methods, *causal research* approaches often incorporate a plethora of quantitative methods. Furthermore, there is higher degree of integration between modern scientific techniques and ILK **(see Section 3.2.3)**. Indigenous people are often more than merely information providers, as they often co-design research elements and shape significantly the research outcomes. Moreover, when collaborative methods are employed, *causal research* studies frequently rely on stakeholders from multiple sectors, rather than focusing only on indigenous communities. Overall *causal research* approaches have three main research strengths: *1) rich methodological portfolio, 2) knowledge system integration, and 3) stakeholder balance*.

Rich methodological portfolio: *Causal research* approaches have gradually adopted a series of innovative techniques from the social sciences. This in turn provides new and interesting options to researchers and practitioners to facilitate the integration of modern science and ILK systems. For example, discrete choice experiments are used to capture the willingness to pay among indigenous communities and capture bequest values that have been difficult to quantify in the past **(Oleson et al., 2015)**. Bayesian network analysis is used to create scenarios that estimate how government policies affects coastal/marine SES in indigenous settings **(van Putten et al., 2013)**. Different direct market valuation techniques are used to capture use and non-use values of ecosystem services, and to measure the social, ecological, and biological values of marine/coastal ecosystems **(Evseev et al., 2018; Hutton et al., 2016)**.

Knowledge system integration: The ***contribution*** of indigenous people to modern scientific techniques has gradually allowed *causal research* studies move from studies about ILK, to studies with ILK **(Tengö et al., 2017)**. One example is the integration of ILK with remote sensing to identify the location of use and non-use ecosystems services, thus highlighting possible source of conflicts during the implementation of new coastal/marine resource management programs **(Ban et al., 2008, 2009; Moore et al., 2017)**. These integrated techniques also enable the management of marine protected areas with lifelong experiences of indigenous communities that can provide historical baseline, knowledge on biodiversity, species distributions, and breeding areas **(Bethel et al., 2011; Eckert et al., 2018; Espinoza-Tenorio et**

al., 2013). Such approaches can enhance the integration of knowledge systems, which is now identified as a key priority area for ecosystem services research (Pascual et al., 2017).

Stakeholder balance: *Causal research* studies tend to integrate more frequently multiple stakeholders such as indigenous communities, NGOs, government agencies, private sector, and academia **(see Figure 16)**. This often translates into more productive collaboration that reduces frictions and increases the trust between the different actors (Hiwasaki et al., 2015; Hoverman & Ayre, 2012). Such tighter collaborations can also promote resource and knowledge sharing and produces cultural relevant solutions. For example multi-stakeholder workshops combined with community mapping techniques have produce relevant coping strategies in coastal/marine SES for climate-related hazards such as droughts and sea ice melting (Hiwasaki et al., 2015; Hoverman & Ayre, 2012; Laidler et al., 2011).

However, the general focus of *causal research* studies on assessing a phenomenon can have some trade-offs related to the research scope. As discussed on the previous section *contextual research* studies tend to rely on methodologies that cast a wide net to comprehensively identify the different elements within a system **(see section 3.3.1)**. On the other hand, *causal research* studies usually attempt to explore thoroughly few key drives and impact in the studied coastal/marine SES. Essentially, this approach of quality over quantity leads to some compromises. The focus on few variables often means overlooking the multiple values that indigenous people attach to ecosystem services in coastal/marine SES. Furthermore, the attempt to introduce economic valuation methods for non-material benefits often involves the use of proxy variables that do not necessarily capture properly the perceived values of indigenous people. Essentially *causal research* approaches have three main weaknesses as *1) solution-oriented, 2) limited values captured, 3) compromised proxies*.

Solution-oriented: There is a clear demand to produce robust and quantifiable evidence for practitioners and policymakers to facilitate the sustainable management of coastal and marine SES (Díaz et al., 2018; Grech et al., 2014; Tengö et al., 2017). However, often, there are trade-offs when attempting to satisfy such demands in indigenous coastal and marine settings. Tools that have a limited capability to capture the intricacies of the issues at hand (e.g. simple maps, indices, economic assessments) often omit the full context within which those results should be interpreted. For example, *causal research* studies have used remote sensing and participatory mapping to assess endangered species abundance and distribution to set up species protection programs (Ferguson et al., 1998; Grech et al., 2014), but have also tended to overlook the drivers and pressures behind those changes. Ethnobotanic approaches based on detailed inventories and use assessment of medicinal plant among indigenous communities can help assess the instrumental value attached to these plants, but also omit non-material benefits such as cultural or bequest values (Noman et al., 2013; Peter et al., 2014).

Limited values captured: Following from the above there is often an articulated preference to use well-established economic valuation methods that are easily understood and accepted by practitioners and policymakers (Díaz et al., 2016; P Kumar et al., 2010). Such studies often attempt to merge different epistemological approaches hoping to capture all values that indigenous people receive from ecosystem services relying on methods that are only capable of quantifying few values. This often results in valuations that over-represent values from modern scientific approaches (mostly instrumental values), further undermining other values that indigenous communities ascribe to coastal/marine SES. For example, studies with complex SES that includes bequest and relational values often focus only on instrumental values to quantify/elicit ecosystem services **(Cullen et al., 2007; Hutton et al., 2016; Preece et al., 2016)**.

Compromised proxies: *There* are often compromises in the selection of variables as inputs for models within *causal research* studies. *Causal research* studies often attempt to capture a wide range of social and cultural values using generic variables such as employment as a proxy indicator to social values of marine systems, or commodities as representative of cultural significant resources to assess cultural values of ecosystem services **(Evseev et al., 2018; Hutton et al., 2016)**. These compromises happen due to various reasons such as data and knowledge gaps (Ban et al., 2009; P Kumar et al., 2010). While these proxies might indeed represent a part of the social and cultural benefits derived from coastal/marine SES, by no means they represent the full spectrum of benefits they perceived from ecosystem services. In fact, one might argue that these compromises perpetuate the marginalization of the full range of values making more acceptable to focus on instrumental values rather than measuring “elusive” non-material values.

3.3.3 Existing Indigenous studies limitations

Despite its robust findings, the systematic review has some limitations including the (a) selection of keywords, (b) non-inclusion of grey literature, (c) inability to classify a priori studies in research classes solely based on their research characteristics.

Regarding (a), even though this systematic review considered a wide range of keywords, it was not possible to include all possible keywords related to indigenous contexts around the world. For example, in some indigenous settings very specific keywords become relevant (e.g. mobs in Australia) **(Pannell, 2005; Pickerill, 2009)**. Conversely, in other contexts very generic terms become relevant (e.g. small-scale fishers in Sub-Sahara Africa) **(Jacquet et al., 2010; Mills et al., 2011)**. In the former case, adding all specialised terms is not practically feasible, meaning that selective additions might result in the over-representation of specific indigenous contexts, thus biasing the results by disproportionally considering literature from specific indigenous settings. Furthermore, adding generic terms increases the difficulty of understanding whether the study reflects indigenous areas. For example, not all small-scale fishery communities in Sub-Sahara Africa are indigenous, and this is not always clarified in the methodological section of the specific studies. The study went through an iterative process of refining all search terms based on prevailing and commonly

accepted terminology. The selected keywords are robust enough to elicit the main literature patterns. However, due to keyword selection some studies might have been omitted. This sensitivity to keyword selection is a recurring criticism of systematic reviews **(Berrang-Ford et al., 2015; MacLure, 2005)**, and needs to be taken into consideration when using the results of this study.

Regarding (b), the study constrained the analysis to peer-reviewed studies, omitting grey literature. This was a conscious decision to allow for the reproducibility of the results, as the search engines used for this systematic review (i.e., Scopus, Web of Science) do not contain grey literature. In order to add grey literature in this analysis the study would have had to resort to subjective additions that would have compromised the reproducibility, which is an essential requirement of systematic reviews. However, the study cites relevant grey literature in the Introduction and Discussion to improve both the framing of the study, as well put its key findings into perspective.

Regarding (c) our protocol can only determine the class in which a specific study belongs only after the methodologies, tools, and objectives have been reviewed and classified. In other worlds it is not possible to predict whether a specific study adopts a causal or a contextual research approach. Therefore, the it falls on the critical capacity of the respective researchers to both characterize their research and implement the cross-fertilisation recommendations **(see section 4.3)**.

3.3.4 Contextual and causal research future orientations

Both research classes can play a constructive role in overcoming knowledge integration barriers in indigenous coastal and marine SES. While slow, some advances have been made towards bridging the unequal footing between modern science and ILK in such SES **(Michel & Gayton, 2002; TEBTEBBA, 2008; Vierros et al., 2010)**. For example, *contextual research* studies have developed frameworks that assess both cultural and biophysical impacts, balancing in the process modern science and ILK goals **(Raymond-Yakoubian et al., 2017; Scherrer & Doohan, 2011)**. Furthermore, the use of context-sensitive methods such as discourse analysis has helped in identifying the sources of technical gaps in *contextual research* studies **(Nursey-Bray et al., 2010)**. Meanwhile, *causal research* studies have developed frameworks and protocols that deal with structural barriers related to the lack of guidance on how ILK should be integrated with scientific knowledge **(Carter, 2010)**. *Causal research* studies have also addressed perception barriers, by showing, for example, the similar results of scientific and community-based approaches when developing marine protected areas **(Ban et al., 2009)**.

At the same time there are many cases of effective knowledge integration designs **(Beltrán, 2000; Ference Weicker & Company Ltd., 2009; Jonas et al., 2012; Stevens et al., 2016)**. For instance, some contextual research studies have used collaborative tools such as workshop that have allowed best practices to be shared, boosted trust between stakeholders, and produced robust programme designs to

address both biodiversity conservation and indigenous community needs **(Matsumoto et al., 2014; Walter & Hamilton, 2014)**. Co-management approaches during programmes design not only helps in increasing marine biodiversity, but also empowers indigenous communities and reduces ILK loss/erosion **(Indian and Northen Canada Affairs, 2003; Memon et al., 2003; National Oceans Office, 2002; Stephenson et al., 2014)**. Furthermore, causal research studies have exceled at combining ILK with modern tools such as remote sensing to create well-rounded management plans that integrate the perspectives of indigenous communities **(Ban et al., 2009; Lauer & Aswani, 2010)**.

Considering the above this study finds that both research classes have their merits and can play a constructive role in integrating different knowledge systems and multi-value perspectives to achieve the sustainable management of marine and coastal resources in indigenous settings. In a way, through their distinctive research characteristics, strengths and weaknesses, *contextual research* and *causal research* approaches complement each other.

On the one hand*, contextual research* studies can provide the theoretical foundations and map the coastal/marine SES identifying multiple elements of these systems. These studies essentially can help to lay the research agenda about how to approach issues related to coastal/marine SES in indigenous settings. On the other hand, c*ausal research* studies can explore the effect of these drivers and pressure within SES and produce outcomes that facilitate the assessment of key issues. *Causal research* studies can thus play a crucial role for the effective design and implementation of policies, plans, and programmes by government agencies and traditional local authorities alike. While not many studies presently attempt to simultaneously map and assess comprehensively issues in indigenous coastal/marine SES, it would be impractical to make a call for all future research to do so. Possibly except for large-scale projects that have the support of multiple stakeholders, research outcomes would likely be subpar if such ambitious goals are set in individual studies constrained by budget and expertise.

However, with some adjustments it might be possible to increase the synergies between *contextual research* and *causal research* approaches. The cross-fertilization between these approaches could accelerate the integration of ILK and multiple values, and produce research that is both relevant and exhaustive.

On the one hand, *contextual research* approaches should capitalize on their ability to provide a comprehensive view of complex coastal/marine SES. This includes the multiple perceived values and the different elements that interact within such SES. In a way, this means that *contextual research* approaches have the potential to act as a pathfinder and create a roadmap where future studies should focus. Therefore, their role should go beyond that of merely presenting the system “as is”, but attempt to consciously integrate

different methodologies to highlight what is relevant in such SES. In other words, they should seek to address the *relevance ambiguity* weakness discussed above **(see section 3.3.1)**.

On the other hand, *causal research* approaches need to acknowledge that economic valuation has, so far, only captured values based on dominant western value perceptions. In this sense, the direct implementation of such studies conducted in non-indigenous settings is not necessarily relevant (or even appropriate) in indigenous settings. A "copy and repeat" process might fail to address the aspirations and values of indigenous people, as well as incorporate their unique worldviews and beliefs. There should be conscious efforts to push the present boundaries of direct economic valuation to develop novel methods to elicit such values in indigenous coastal/marine SES.

Adopting a transdisciplinary mindset **(see section 3.2.3)** can facilitate the effective cross-fertilization between research types. Still, more can be done at a "grassroot" research level, where active multi-partner engagement is not always possible. First, scholars should identify whether and how the specific study should/could contribute to this cross-fertilization. Subsequently they should seek to understand the role that the specific research can play in this contextual-causal research relationship. Following this introspective self-assessment, research protocols and outputs should:
a) deliver instructions of where follow-up research should focus, provide a clear vision of SES interactions, and delineate the mechanisms that comes into play (for contextual research studies);
b) move beyond using previous studies as merely providing background context and take advantage of the initial groundwork produced by *contextual research* to implement novel research tools that will advance existing knowledge by incrementally building upon other studies (for causal research studies).

Finally, even though contextual research relies more heavily on qualitative tools and causal research on quantitative tools, each approach does not rely solely on such tools. Thus, when cross-fertilising we need to keep in mind some of the underlying debates about how the types of data, methods, purposes, and paradigms boundaries between quantitative and qualitative methods have become blurred. This, however, should not diminish the merit of mix-and-matching the arsenal of tools from both methodological approaches **(Borland, 2001; Morgan, 2018)**; but rather emphasise how seemingly the strengths of diverse methods can be integrated **(Morgan, 2018; Sandelowski, 2014)**. In any case, as outlined in ***section 1.4.1***, it is important to carefully consider the specific indigenous community contexts when designing such research **(Pascual et al., 2017; Spoon, 2014)**.

3.3.5 New Findings Summary

The approach to classify existing studies based on similar characteristics through the LCA yield 2 main key findings, namely:

1. A fragmented knowledge sources. The knowledge generated by the contextual research rarely trickle down towards causal research studies. We can observe that often quantitative research pursues methodological robust tools without considering the full context of the case study. Such background understanding of the case study becomes relevant among indigenous people studies given the complex SES, distinct worldviews, and customary practices and knowledge.

2. Sustainability science have a role to play within the intersection point between contextual and causal research. On the one hand, contextual research often seeks to pursue a problem oriented research, trying to understand the context of the issue, the causes, and the different perspective. On the other hand, causal research often seeks to pursue a solutions oriented research, trying to identify key issues and propose the most effective solutions based on empirical data collection. While both approaches contribute to the broader academic discussion, the goal of sustainability science is to contribute to address what has been known as wicket problems that spam across complex systems in pursue to address real-world problems and contribute towards a sustainable development. Therefore, studies located at the intersect of contextual and causal research can both approach these issues in a holistic and pragmatic way these real-world issues.

Chapter IV: Gunayala Contextual Analysis

The content of this chapter is planned to be publish and will be released five years after the publication date of this version.

Chapter V: Gunayala Causal Analysis

The content of this chapter is planned to be publish and will be released five years after the publication date of this version.

Chapter VI: Study Dissemination

6.1 Value Dashboard

Figure 53 provides a sample of the interactive dashboard that will be made available to the public to share the outcomes of this study. In summary, the dashboard provides an in-depth information of the main aspects of the Gunayala SES elements covered in this study, including the outcomes of the expert interviews and household surveys across all sampling groups. It can be used to show a breakdown of the multiple perceived values associated with each SES element, their current availability, and trend. Recognizing that different stakeholders might need to break down results under different views, the dashboard provides multiple filtering capabilities to customize the results based on specific needs. The dashboard can provide and insight on differences in the relational bonds between human and non-human objects among the Guna **(see section 1.3.1)**. Results shows that across different sampling groups (by age and gender) the perceived benefits and values for non-human objects remains similar. While there is evidence of traditional practices and values erosion **(see section 4.2.4, and section 5.2.3)**, their worldview regarding their bond with their SES remains similar.

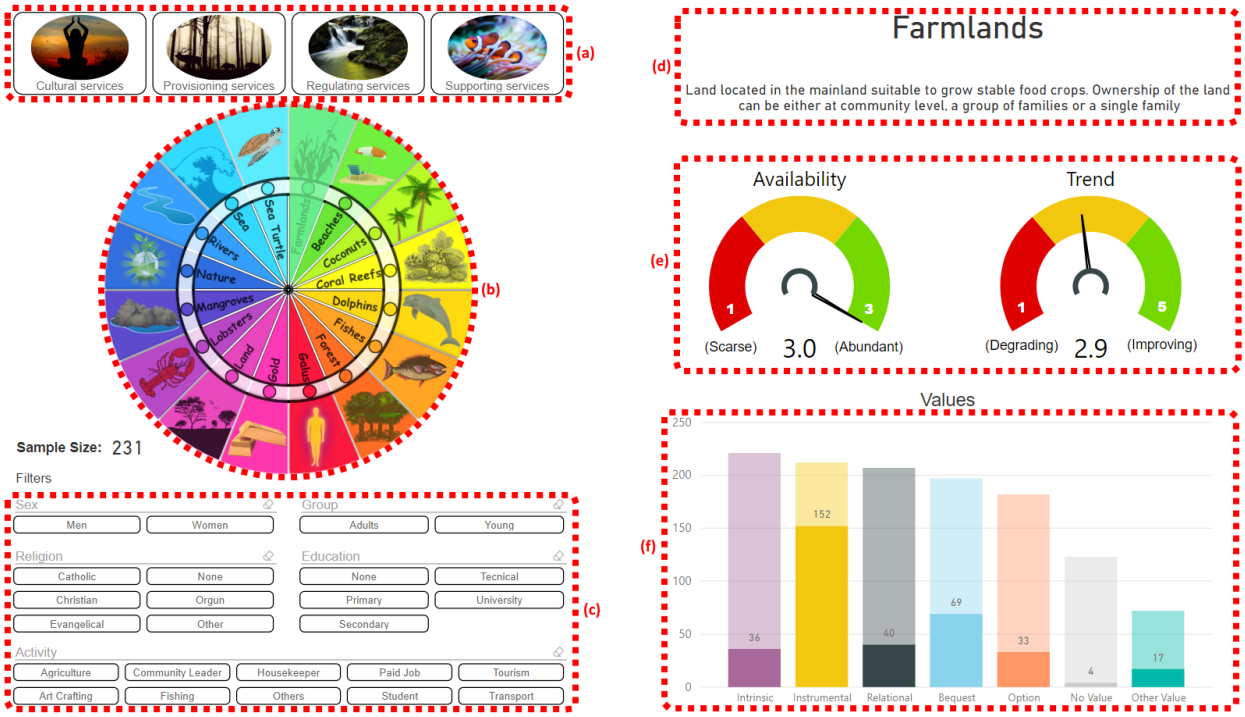

Figure 53 Overview of Gunayala key resources dashboard

Note: (a) filter option by Ecosystem Services provided; (b) selection wheel of key resources in Gunayala; (c) multiple filtering options that will affect the rest of the dashboard; (d) brief description of the resource selected; (e) gauge conveying the condition of the selected resource(s); (f) type of values perceived by the selected group/resource(s)

6.2 SDG Dashboard

The research outcomes can be framed under the broader discussion of SDGs **(see section 5.2.5)**. The results from a bottom-up approach can identify the SDG targets involve in Gunayala's SES, how they interlink, and what impacts are included **(Figure 54)**. The dashboard was designed to provide an in depth understanding on what SDGs are being affected (either in positive or constraining way). Acknowledging that funding agencies often follows institution wide mandates to focus efforts on specific SDGs based on the institutions aims **(see section 7.3.2)**, the SDG dashboard provides a pathway to key stakeholders to target related funding. While addressing SDG 1 (No Poverty) receives ample attention among governments and funding agencies, issues related to climate change are often neglected. However, through the dashboard there is a clear pathway on how programs targeting on strengthening community resilience against climate change can indeed reinforce the achievement of poverty reduction through target 1.5 (reduce the vulnerability against extreme events and others social, economic, and environmental shocks).

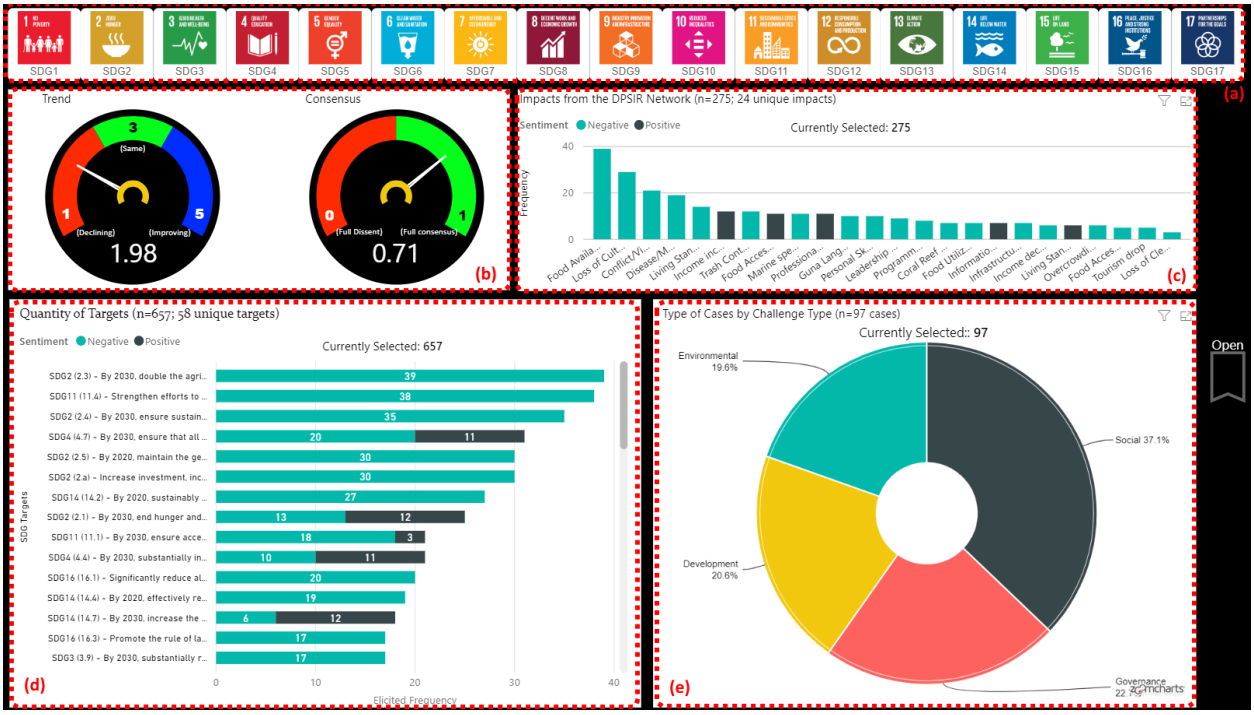

Figure 54 Overview of SDG Interlinkage Dashboard

Note: (a) display SDGs being affected and to filter the dashboard by SDGs; (b) detail of selected Guna SES impacts; (c) display impacts and filter the dashboard by impact; (d) display list of related SDG targets based on dashboard filters and filters the dashboard by SDG targets; (e) display the type of challenges in Guna SES based on dashboard filters and filters the dashboard by type of challenge

6.3 DPSIR Dashboard

Guna SES is compose of multiple sub-systems closely interconnected and constantly influencing each other **(see section 5.3.1)**. This complex network of drivers, impacts, and responses pose a challenge to effectively organize the vast amount of information into knowledge. Furthermore, while this study focusses on key research questions **(see section 1.5)**, unique needs of a diverse field of stakeholders might fall outside the scope of the research. However, dynamic dashboards can provide a pathway for key actors to dig out valuable insights that might be otherwise bury among the collected information. **Figure 55** shows the latest version of the develop dashboard to convey how different DPSIR elements connect to each other. Flexible filtering options allow users to narrow down the search scope of the SES and expose the interlinkages between them. The information is display with the purpose of showcasing what are they main concerns of the Guna people, the sentiment behind each component, and the trend.

Figure 55 Overview of Guna SES DPSIR summary

Note: (a) filtering option by sampling group for the dashboard; (b) word cloud of the DPSIR elements of Guna SES; (c) list of DPSIR elements sorted by importance (high to low) based on its prestige rank; (d) word cloud summary pop-up for the selected DPSIR element showing trend, sentiment, description, and rank

Chapter VII: Synthesis and Policy Implication

7.1 Synthesis of Result

7.1.1 Existing results conclusions

There are significant challenges in managing coastal and marine SES (and the ecosystem services they provide) in indigenous settings and integrating related values and knowledge systems. Our systematic literature review identifies the trends and gaps in the current peer-review literature at the interface of values and ecosystem services in coastal and marine social-ecological systems (SES) in indigenous settings. In particular, the chapter identify two distinctive research classes, which are refer to as contextual and causal research, each with its unique strengths and weaknesses.

Rather than categorising such research within the confines of qualitative, quantitative, and mixed methods, it is much more useful to acknowledge their distinct contribution and approaches in the current research landscape. This distinction has a greater potential to provide a clearer and more streamline pathway towards knowledge and value integration, without necessarily compromising research rigor.

Overall, the study found that *contextual research* studies represent a higher proportion of the current studies. These studies are mainly concerned with presenting the context of changes in indigenous costal/marine SES. *Causal research* studies, on the other hand, tend to assess the impacts of these changes in SES, and what causes them. The integration of perspectives from multiple stakeholders is more frequent in *causal research* studies. Furthermore, causal research studies have a richer methodological portfolio, with twice as many different techniques identified compared to *contextual research* studies. On the other hand, *contextual research* studies are more adept in developing comprehensive conceptual maps of coastal/marine SES and eliciting the multiple values attached to their ecosystem services.

Considering their different strengths and weaknesses, cross-fertilization and collaboration between these distinct research approaches will be indispensable in advancing the integration of the different knowledge systems and multiple values encountered in indigenous coastal/marine SES. *Contextual research* studies can act as pathfinders of important research foci in these contexts, and *causal research* studies can push the methodological boundaries to study more deeply these research priorities. There is great merit in further exploring the development of a framework(s) that can facilitate the cross-fertilization between these research classes at the grassroot research level**.**

This chapter identified two new main findings, namely 1) A fragmented knowledge sources between contextual and causal research each pursuing distinct objectives; 2) sustainability science have a role to play within the intersection point between contextual and causal research.

7.1.2 Gunayala contextual analysis conclusions

The Gunas are at a crossroad where today they must decide the future they want. On the one hand they have perceived the benefits of stronger interactions with the external world (i.e. access to education, new income options, improved health care), but on the other hand they have experienced an array of social problems (i.e. drugs, non-communicable diseases, loss of cultural identity). The increased interaction with the outside world over the last 20 years has triggered rapid changes in Gunas' values and the broader SES. These new values emphasize on capital accumulation and consumerism, and are often at odds with traditional worldviews, beliefs, and traditions. There have been undoubtedly improvements across the region due to infrastructure development, access to education, livelihood diversification, and better healthcare, which have empowered the younger generation. Such improvements are welcome by the Gunas but expanding these achievements without losing their cultural identity remains a priority for them.

The local chiefs are struggling to balance a development agenda and maintain the SES, amidst perceived leadership decline in local and regional institutions as protectors of Guna identity. The gradual disuse of the local language in favor of Spanish, the decline of traditional ceremonies, the change of values in the younger generations, and the loss of traditional medicine practices are all among the main Gunas concerns. The local chiefs are expected to lead community projects that strengthen social cohesion and preserve important traditional ceremonies, while regional chiefs are expected to steer Gunayala's development during this transition period and preserve their worldview and beliefs. However, there is an emerging perception that the traditional institutions currently lack the capacity to respond to these challenges proactively and in a timely manner. For example, the absence of stable funding sources that are independent to the national government, and the shortage of trained Gunas able to secure and implement programmes sponsored by international agencies are among the challenges that the current governance structure has to overcome.

Currently there is no clear blueprint to accomplish development aspiration of the Gunas and at the same time preserve cultural identify and the broader SES. Nevertheless, identifying and acknowledging the perspective of the Gunas, opening inclusive channels of communications between key development actors, and understanding Gunas values, concerns, and what they perceive as tradeoffs, can help foster a development path that is in accordance to their needs, balancing development and the preservation of their identity.

This chapter identified six new findings, namely 1) there are four thematic areas of concern regarding the sustainable development of Gunayala; 2) there is a limited chance of local communities to capitalize on international funding sources; 3) development agencies funding often force communities to pursue available agencies objectives rather than community needs; 4) not all interaction with the national

government are perceived negatively; 5) there is statistically significance change of livelihood activities occurring in Gunayala; 6) while traditional knowledge and practices has been eroded, their worldview and strong relational connection remains similar between young and adult Gunas.

7.1.3 Gunayala causal analysis conclusions

The complexities of multiple development aspirations, challenges, and perceptions begins to unravel when Gunayala's SES are studied as a whole rather than the sums of its parts. This chapter seeks to unravel how different sub-systems affect and interact with each other. The results show that the livelihood transition sub-system has trickle down generating a chain effect across Gunayala's food security sub-system and constantly reshaping the value sub-system among the Gunas. This value sub-system in turn has become the main agent of change in regard to Guna identity degradation and the main cause of concern among local and regional chiefs and the local communities. This concern is consistent across multiple levels in Gunayala structure. Regional and local chiefs have recognized the issue as critical and putting efforts to reverse the degrading trend of value erosion. The Gunayala 2025 action plan that sets a 10-year plan to guide the development plans for the region emphasis on preserving the Guna beliefs and worldviews. At community level, the Gunas recognize the tradeoffs between development and loss of traditional practices and knowledge

Further evidence of the struggle that local communities are facing regarding the balance between ripping the benefits of development (increase of living standard, better healthcare, education, etc.) and preserving their culture, traditions, and identity can be found when comparing priority results base on two different tools. Outcomes from a ranking experiment using a ten scale Likert provided respondent the freedom to rank their priorities without any restriction, thus allowing them to portray their perfect scenario. Under this condition respondent (both adult and young Gunas) rank the cultural loss as their main concern and priority. However, the results from a second experiment using DCE, where prioritizations are embedded using choice cards over the same variables and the same sampling groups show a sharp drop in relevance of the cultural loss. Instead the result shows that when forced to prioritize, issues such as healthcare and education take a more prominent importance over the side effect of cultural degradation. Similar to the tragedy of the commons, the results show how individuals behave contrary to their own beliefs in a finite pool of priorities.

This chapter identified six new findings, namely 1) a total of 78 DPSIR elements were found as the main components of Gunayala's SES regarding their main development challenges; 2) cultural erosion is a tradeoff to improve basic needs; 3) the increase of violence and petty crimes in Gunayala is rising and a growing concern among Guna authorities and local communities; 4) there are 3 key sub-system within Gunayala SES that are highly interconnected; 5) food production decay is the primary mechanism of traditional knowledge and practice erosion; 6) unintended consequences of nationwide social programmes

further contributes towards the cultural erosion in Gunayala; 7) there are multiple pathways in which SDGs can be achieve.

7.2 Research Key Findings

This study sought to unravel the current Guna SES amid the ongoing socioeconomic changes through a series of research questions **(see section 1.5)**. The research outcomes addressing these questions captures the main highlights of the research, namely:

(a) Fragmented academic landscape among indigenous SES research were knowledge obtain from contextual studies do not trickle down to causal studies

A systematic analysis revealed that current studies mainly focus either on highly qualitative, problem-oriented research (contextual studies) or highly quantitative, solution-oriented research (causal studies), each with their unique strengths and weaknesses **(see section 3.3)**. While each research type fulfills critical roles in the academic landscape **(see section 7.1.1)**, sustainability science seeks to solve "wicked-problems" that greatly benefit from merging both approaches.

(b) There is a strong convergence in the region development priorities as Guna perspective and aspirations are integrated. However, when Guna sovereignty is threaten there are political, social, and developmental break in the system

Expert interviews, community surveys, and regional strategic plans reveals that development priorities are mostly aligned at ground level. These priorities revolve around the concept of improving the governance system and leadership, healthcare, education, and basic services (i.e. freshwater access) while preserving their sovereignty, culture, and traditions **(see Figure 48)**. The mid-management level, National Ministries (i.e. Health, Education, Environment) have learned to align Gunayala's agenda with the national government agenda. However, most conflicts arise at higher political levels when agendas from a western perspective fails to understand Guna's concerns **(see section 5.2.1)**.

(c) The lack of resources (human and technical knowledge) disproportionally affects remote Guna communities with specific needs

Multiple institutional challenges lead to a reactive approach to the emerging issues in Gunayala. These includes poor programme executions that do not involve local actors, cumbersome processes that limits local community access to international development funds, and limited resources from Guna instructions **(see section 4.3.2)**. While processes to handle, approve, and develop large projects at regional level are in place and mostly functional, the same is not true to handle local projects at community level leaving few options for their development **(see section 4.2.1)**.

(d) New generations of Gunas (below 30 years) are shifting from traditional subsistence livelihoods (agriculture, fishing, traditional medicine) into economic base activities (tourism, doctor)

Similar to other indigenous case studies, the transition from a subsistence base livelihood into a capital accumulation society has triggered a cascading effect throughout Guna society in detriment to their traditional SES **(see section 5.3.2)**. There is a statistical significant difference of younger Gunas depending on economic based livelihood activities compared to older generations **(see section 4.2.3)**. Moreover, older generations cease to fulfill their role of TK teacher to children under the new livelihood paradigm **(see section 4.3.1)**. National policies disconnected from the context of Guna culture further erodes their traditional SES **(see section 4.2.3)**.

(e) Erosion of traditional practices and values has been the tradeoff for a living standard improvement (better healthcare, education, access to information) among the new generations of Gunas

While Guna's traditional SES relies on a relational bond between human and non-human entities that underline the nature of what means to be Guna **(see section 1.3.1)**, expert interviews with sahilas and regional leaders flush out proxy indicators that showcase such bonds **(see section 2.4.2)**. The integration of this Guna definition of traditional value erosion confirmed the concerns raised by the expert interviews. The results at community level shows the erosion of Guna TK and traditional practices among young Gunas **(see section 4.2.4)**.

(f) While there are clear evidence of traditional practices and values erosion among the new generations of Gunas, their worldview showcased as their traditional bond with their SES remains similar to older generations of Gunas (above 30 years)

While most evidence points towards a change of Guna core values and traditional practices specially among young Gunas **(see findings "d" and "e")**, the relational bonds and perceived values (instrumental, bequest, relational, intrinsic, option) with their SES remains mostly similar across sampling groups **(see section 4.2.4 and section 6.1)**. This apparent dichotomy can be explained as the ongoing struggle of the Guna people to balance development aspirations and Guna identity preservation **(see section 5.2.3)**.

(g) Gunayala SES amid the rapid socioeconomic changes consist of three sub-system closely interconnected with each other (livelihood, food security, social wellbeing) that are constantly interacting, affecting, and changing their overall SES

The value of capturing the different development challenges as part of a whole system is that it helps to study the phenomena beyond isolated issues. Three main sub-system can be highlighted within Gunayala's SES, namely a livelihood transition, a food security, and a social wellbeing sub-system **(see section 5.3)**. Each of these sub-systems interacts (both positive and negatively) with each other that

subsequently lead to the current SES. Impacts such as food insecurity, poor basic services, and cultural erosion are issues that actively affect each other **(see section 7.1.3)**.

(h) There are strong synergies between SDGs in Gunayala SES showing there are multiple direct and indirect paths towards achieving a sustainable Guna community (SDG 11)

Each development impact in Gunayala's SES can be mapped to specifics SDG targets. Extrapolating the mapped network analysis allowed this study to produce a bottom-up approach capable not only to identify the main SDG involve in Gunayala's development, but also how they reinforce and constrains the achievement of each other. A comprehensive knowledge of direct and indirect attainment of SDGs can inform key stakeholders of alternative paths to achieve SDGs that can benefit remote communities **(see section 4.2.2)**. While results show expected strong synergies among key SDGs (reducing hunger, good health, and education), its noteworthy to see the scares presence of the critical SDG 17 (partnerships) across Gunayala's SES **(see section 5.2.5)**.

7.3 Policy Recommendations

7.3.1 Policy recommendations for National Government

Intervention into Gunayala's affairs ought to be planned and executed at State level rather than at government level. The ongoing relations between the Panamanian government and the Guna institutions are at odds **(see section 7.2 "b")**. The uncertainties that new governments bring under new political cycles translates into mistrust and cautious attitudes from the Gunas. Simple copy/paste policies that are enacted across the country as political party campaign does not necessarily translates effectively among indigenous populations **(see section 7.2 "d")**. The unintended consequence of a constant change of political stance with the Guna people it's a failure to understand the complex development aspirations of the Gunas **(see section 7.2 "f")**.

There have been significant advances to close the gap between indigenous institutions and the national government. Representative of Gunayala in the legislative branch and the creation of a Vice Ministry of Indigenous Affairs dedicated to advance the development of the region have been well received **(see section 1.3.1)**. However, the lack resources (both human and capital) translates into little changes in Gunayala. Therefore, to catalyze an effective and long-lasting change in the region the national government should promote an approach shift. This change will involve:

- **Create a State level institution of indigenous affairs.** The most trusted government agency in Panama is the Panama Canal Authority (ACP). This institution is in charge of administrating all aspects related to the Panama Canal operation. The unique structure, the independent budget allocation, and the administrative autonomy of the ACP play a key role on the stability and reliability of the institution unaffected by partisan influences from political parties. This can help overcome the current mistrust that Guna people have towards the national government

"we have always had tensions with the Panamanian government, with the president… they are always trying to intimidate us, [take away] our rights…" **(Guna Administrative Congress Ex secretary, personal communication, February 12, 2018)**. Promoting a national government institution in which the Guna people can trust, a structure similar to the ACP can be implemented *"the congress is working much better now, they have they own structure and regulate independently, like the Panama canal"* **(Vice Ministry of Indigenous Affair, personal communication, February 20, 2018)**. The implementation can be done through the existing government institution, the Vice Ministry of Indigenous Affair, which was created through the National decree No.64 on September 20, 2013. This Ministry can duplicate a similar administrative and funding structure as the ACP and execute development programs in indigenous communities based on long term plans rather than the everchanging ambitions of political parties at every political cycle

7.3.2 Recommendations for international agencies

The allocation, access, and disbursement of development funds should incorporate processes that pursue the equitable development across Guna communities. While in theory any community have the equal opportunity to access a myriad of fund across different international agencies, in practices the odds to successfully execute local community projects are poor **(see section 7.2 "c")**. The local institutions ran by the community chiefs known as sahilas often lack the capacity and resources to handle basic safeguards from international agencies to ensure a transparent and an accountable development of these projects **(see section 4.2.1)**.

Remote communities that fall outside of the scope of regional development programs have few options of securing funds and following the international standards for basic check and balances **(see section 7.2 "h")**. Moreover, specific needs of local communities might divert from regional initiatives **(see section 4.2.1)**. As such, international donors, development agencies, and financial institutions should be more understanding of the limited capabilities of individual communities and become more receptive of the distinct needs of each community. Some changes that can contribute to the equitable development of remote communities includes:

- **Flexible internal protocols to address community main priorities**. A common request from international agencies call for the inclusion of experience organizations to monitor the development and management of projects. While more developed communities might have the structure to comply with such conditions, smaller underdeveloped communities that need it the most do not *"the money was approved months ago, but they [japan embassy] ask to work through an experience organization to disburse the funds…"* **(OPINUP Officer, personal communication, March 15, 2019)**. Moreover, institutions that can serve as guarantors of these projects are already thin out and need to focus their resources on higher impact

developments, while small local NGOs are not up to the standards of donor agencies. A flexible protocol targeting small projects in remote communities that on a case by case basis can forgo with the most "complex" conditions for such communities can rapidly even up the development in Gunayala. The implementation can be done with the help of the Guna institutions, where working commissions can act as guarantors of the project, while local communities members are in charge of managing and executing the project.

- **Broader interpretation of SDG.** Since its inception, the SDGs were envisioned as a set of complementary targets meant to reinforce each other. However, after four years since the SDG have officially came into force there is no clear pathway on how interlinked SDG should be handled. A step towards acknowledging the complex linkages between SDG targets will be for international funding agencies to allocate funding based on a broader interpretation of SDGs (including other SDG that reinforce targeted SDG) rather than its narrow understanding (only the targets within the targeted SDG) *"…well, there are priority zones where we put more attention, such as addressing multi-poverty, at the end, government decides their priorities…"* **(Inter-American Development Bank Consultant, personal communication, March 2, 2018)**. The implementation can be done through partnerships with think tanks, academic institution, and Guna work commissions to holistically identify the impacts (both direct and indirect) of each project.

7.3.3 Policy recommendations for Guna Institutions

Local policies, regulations, and initiatives must proactively address the needs of communities rather than reactively solve the string of emerging issues. Under the rapid socioeconomic changes where traditional values and practices are been eroded **(see section 7.2 "e")**, communities are concerned about the capabilities of local institutions to address their needs **(see section 7.2 "c")**. There is a lack of transparency on how regional revenue obtained from the tourism industry are allocated in Gunayala **(see section 4.2.2)**. Moreover, community leaders are hoping for higher involvement of both Cultural and Administrative Congresses to guide them on this period of rapid changes and cultural erosion, while community members are expecting for stronger local chiefs to address their basic needs **(see section 7.2 "g")**.

Moreover, the speed in which new issues arises are much faster than the lax pace in which new policies and approval of new projects are enacted. The Guna governance system while is extremely effective and inclusive among indigenous groups **(see section 1.3)**, is a slow system that requires multiple gatherings at multiple levels. The difficult access and remote locations of the communities further increases the complexities to conduct such gatherings **(see section 2.2)**. A lack of a reliable cellphone network across the entire region further stresses the system **(see section 4.2.1)**. As such, the current governance structure can greatly benefit from institutional changes targeted to speed up their process, overcome technical

barriers, and respond to the communities clamor of proactive addressing the emerging undesirable effects of current development trends. This change includes:

- **Decentralize policy enactment.** Currently the Guna General Congress where regional and local chiefs gather to discuss pressing issues across Gunayala convenes in regular session twice per year (with extraordinary sessions on a per need basis). Over these sessions working groups are created as needed to respond to Gunayala's emerging issues. These working groups eventually reports back to the next General Congress session to make their recommendations and continue the discussion on the way forward. While the system ensures a comprehensive discussion, it also involves redundant steps and logistical challenges *"the problem is efficiency, [Guna Congress] their structure, they don't have communication coverage beyond 15 km, they don't have mobility [between islands], it's extremely expensive, so they have challenges to make decisions, such barriers should be easy to solve if you can speed up the decision making process, the coordination…"* **(Inter-American Development Bank Consultant, personal communication, March 2, 2018)**. The implementation of a decentralized Guna institution with the inclusion of truly independent branches that can act and implement initiatives and policies on behalf of the Congress can vastly reduce the turnover time of regional programs. Current regional saglas can be assigned as head of the working groups and make implementation decision within a set of parameters of the working group scope. Check and balances to monitor the direction that each working group is taking can be set up to ensure that initiatives taken are align to the will of the General Guna Congress.

However, certain conditions must be preserved in order for this recommendation to be successfully implemented. Among the key pre-conditions is to ensure that local institutions have the capacity to organize their people and manage both productive and human resources. This pre-condition has been proven so far, the unique governance system of the Gunas has been recognized as highly organized **(see section 1.21.3)** not only at regional level *"what makes easy to develop [Gunayala] it's how organize they are, their internal organization, they are a well-organized people"* **(Regional Head Ministry of Health, personal communication, February 19, 2018)**, but also at community level "they have a governance system in place, when we arrive, we coordinate with them, because they already have the community organized, we [the Ministry of Housing] just need to do our part…" **(Ministry of Housing National Director of Development, personal communication, February 19, 2018)**. This self-organization system of the Gunas has led to bolster self-sufficiency among their people, capable of regulating complex commercial activities, while protecting their intellectual properties such as their traditional art form known as *molas "…other communities don't have it [highly organized community], this is an example that must be embraced as a good practice, because I have seen many indigenous groups in South America, begging on the streets, you won't see any member of the Guna community begging in Panama, at most you will see them selling*

molas, but they are part of an authorized network of sellers, they even have an mobile app…" **(AECID, personal communication, March 2, 2018)**.

It is noteworthy to mention that the inclusion of decentralized special offices to address rising social challenges in Gunayala has the potential to generate some unintended side effects. The de-layering of Guna institutions translates into not having every single initiative conducted in Gunayala thoroughly discuss among the Gunas (from regional and local leaders to every community member across all 49 communities). While this can improve the response time of Guna local and regional leaders, the potential tradeoff is to further erode the local community participation due to a sense of de-attachment or responsibility transfer. Further studies need to be conducted to develop comprehensive risk management plans to identify the best balance in accordance to Guna expectations (where this research can contribute) where a range of issues can be safely address thought this independent offices without alienating the active participation of the Guna people.

7.4 Study Limitations and Future Research

7.4.1 Research limitations

The study sought to capture the perspective of all the key actors involve in Gunayala's development. The perspective of the national government, Guna institutions, and international agencies were capture through expert interviews. On the other hand, the perspective of local communities was capture through questionnaires. However, this study acknowledges some limitations in the attempt to gather the perspective of a larger sampling, this includes:

- **Limited spread within each international agency organization.** While the study covered a wide diversity of agencies (development banks, United Nations agency, foreign country development agency, NGOs, etc.), it was only able to identify one of each in most cases. Attempts were conducted to increase the coverage, however door to door visits, snowball sampling results, and local partners (OPINUP) expertise, did not lead to further actors to cover.
- **Limited selected islands as study site.** Only one island was selected per sampling target status (development stage vs. tradition preservation). While 11 out of 49 Guna communities are located in the coastal area (mainland), only islands were selected in this study. Given the exponential cost of adding one island in the study (in contrast to a lower cost to sample more people per island) and the limited budget availability, this study focused only on islands (where the majority of the communities are located) and only one per sampling target status.
- **Lack of community level validation.** The study recognizes the value of cross-validation of data, methods, and outputs. A third field work was originally planned (contingent to additional grant access) to validate and disseminate the outcomes of the study among key actors for Gunayala's development. However, due to a lack of budget an alternative medium of information dissemination is used in this research. A series of dynamic dashboards were

developed to share the research findings and will be made available to the public via a website rdamlam.wordpress.com/gunayala/

7.4.2 Future studies

This study explored the ongoing challenges that Guna people is facing amid the rapid socioeconomic changes occurring in Gunayala. The main research interest was to understand how these changes affected their SES, worldviews, traditional practices, and values. However, the methodological approach of combining a contextual research using expert interviews to conduct a content analysis, and a causal research using a discrete choice experiment can be easily adapted to explore in-depth specific aspects of Guna's SES. For instance, a dedicated study to understand the Guna livelihood transition sub-systems can follow a similar mix method approach as this study. The Sustainable Livelihood Framework (SLF) could replace the DPSIR framework in order to capture the nuances of how the five livelihood assets (human, social, natural, physical, and financial) interact, affect, and change each other. The SLF could be used to design the interview protocols, conduct the coding of the content analysis, and map a network that can serve as the foundation for a prestige rank analysis as this study applied. Furthermore, other ranking tools could be used to identify at community level what are their key priorities. A mix of reveal or stated preference tools could be used to validate these priorities.

At a broader scope, sustainability science research can benefit on building upon research that seek to blur the line between problem oriented and solution oriented research such as this study. The capacity to understand the full context of the issue, the perspective of the main actors involved, and the use flexible frameworks capable of capturing a diverse set of value systems are undoubtedly advantageous to studies targeting indigenous communities. Moreover, a seamless integration of quantitative tools that seek to identify multiple paths towards solving the sustainability challenges provides indigenous communities with an invaluable knowledge than can empower their local institutions to take an active role for their development and the resources to plan, decide, and control their future.

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Appendix

Appendix 1: List of indigenous people in marine and coastal ecosystem studies

Literature included for the analysis ordered by year/author (full reference format available at the end of the document)

Year	Authors	Title
2018	Dunlap A	The 'solution' is now the 'problem:' wind energy, colonization and the 'genocide-ecocide nexus' in the Isthmus of Tehuantepec, Oaxaca
2018	Eckert LE, Ban NC et al.	Diving back in time: Extending historical baselines for yelloweye rockfish with Indigenous knowledge
2018	Evseev A V., Krasovskaya TM et al.	New look at territories of traditional nature use – traditional nature management lands at the coastal zone of the Ice Silk Road: a case study for the Russian Arctic
2018	Jenkins A, Horwitz P et al.	My island home: place-based integration of conservation and public health in Oceania
2018	Movono A, Dahles H et al.	Fijian culture and the environment: a focus on the ecological and social interconnectedness of tourism development
2018	Thurstan RH, Brittain Z et al.	Aboriginal uses of seaweeds in temperate Australia: an archival assessment
2017	Austin BJ, Vigilante T et al.	The Uunguu Monitoring and Evaluation Committee: Intercultural Governance of a Land and Sea Management Programme in the Kimberley, Australia
2017	García C, and Vasconcelos R	The beauty and the beast: Endemic mutualistic interactions promote community -based conservation on Socotra Island (Yemen)
2017	Gauvreau AM, Lepofsky D et al.	"Everything revolves around the herring": The Heiltsuk–herring relationship through time
2017	Harto S	Community empowerment through the development of tourism village (A case study: Tourism village of Penyengat island, Tanjung Pinang, Riau Islands)
2017	Kikiloi K, Friedlander AM et al.	Papahānaumokuākea: Integrating Culture in the Design and Management of one of the World's Largest Marine Protected Areas
2017	Kronmüller E, Atallah DG et al.	Exploring indigenous perspectives of an environmental disaster: Culture and place as interrelated resources for remembrance of the 1960 mega-earthquake in Chile
2017	Lalancette A	Creeping in? Neoliberalism, indigenous realities and tropical rock lobster (kaiar) management in Torres Strait, Australia
2017	Levine J, Muthukrishna M et al.	Sea otters, social justice, and ecosystem-service perceptions in Clayoquot Sound, Canada
2017	Liu T-M	Unexpected threat from conservation to endangered species: reflections from the front-line staff on sea turtle conservation
2017	McMillen H, Ticktin T et al.	The future is behind us: traditional ecological knowledge and resilience over time on Hawai'i Island

2017	Moore SA, Brown G et al.	Identifying conflict potential in a coastal and marine environment using participatory mapping
2017	Raymond-Yakoubian J, Raymond-Yakoubian B et al.	The incorporation of traditional knowledge into Alaska federal fisheries management
2017	Rocha TT, Tavares-Martins ACC et al.	Traditional populations in environmentally protected areas: an ethnobotanical study in the Soure Marine Extractive Reserve of Brazil
2017	Watts P, Koutouki K et al.	Inuit food security in canada: arctic marine ethnoecology
2016	Allamel F	The Houma Indians' battle against the ocean
2016	Brooks JJ, and Bartley KA	What is a Meaningful Role? Accounting for Culture in Fish and Wildlife Management in Rural Alaska
2016	Frid A, McGreer M et al.	Rockfish size and age: The crossroads of spatial protection, central place fisheries and indigenous rights
2016	Hutton T, van Putten EI et al.	Trade-offs in transitions between indigenous and commercial fishing sectors: the Torres Strait tropical rock lobster fishery
2016	Lyons C, Carothers C et al.	A tale of two communities: Using relational place-making to examine fisheries policy in the Pribilof Island communities of St. George and St. Paul, Alaska
2016	McMillan LJ, and Prosper K	Remobilizing netukulimk: indigenous cultural and spiritual connections with resource stewardship and fisheries management in Atlantic Canada
2016	Patankar V, D'Souza E et al.	For traditional island communities in the Nicobar archipelago, complete no-go areas are the most effective form of marine management
2016	Preece LD, van Oosterzee P et al.	Ecosystem service valuation reinforces world class value of Cape York Peninsula's ecosystems but environment and indigenous people lose out
2016	Roberts A, Mollenmans A et al.	"They Planned Their Calendar… They Set Up Ready for What They Wanted to Feed the Tribe": A First-Stage Analysis of Narungga Fish Traps on Yorke Peninsula, South Australia
2016	Setti AFF, Ribeiro H et al.	Governance and the promotion of sustainable and Healthy territories: The experience of bocaina, Brazil
2015	Bhatia P, and Chugh A	Role of marine bioprospecting contracts in developing access and benefit sharing mechanism for marine traditional knowledge holders in the pharmaceutical industry
2015	Cullis-Suzuki S, Wyllie-Echeverria S et al.	Tending the meadows of the sea: A disturbance experiment based on traditional indigenous harvesting of Zostera marina L. (Zosteraceae) the southern region of Canada's west coast
2015	Fuentes MMPB, Blackwood J et al.	A decision framework for prioritizing multiple management actions for threatened marine megafauna
2015	Hiwasaki L, Luna E et al.	Local and indigenous knowledge on climate-related hazards of coastal and small island communities in Southeast Asia
2015	Jackson M V., Kennett R et al.	Developing collaborative marine turtle monitoring in the Kimberley region of northern Australia

2015	Lyver POB, Wilmshurst JM et al.	Looking back for the future: Local knowledge and palaeoecology inform biocultural restoration of coastal ecosystems in New Zealand
2015	Narchi NE, Aguilar-Rosas LE et al.	An ethnomedicinal study of the Seri people; a group of hunter-gatherers and fishers native to the Sonoran Desert
2015	Oleson KLL, Barnes M et al.	Cultural bequest values for ecosystem service flows among indigenous fishers: A discrete choice experiment validated with mixed methods
2015	Outeiro L, Gajardo C et al.	Framing local ecological knowledge to value marine ecosystem services for the customary sea tenure of aboriginal communities in southern Chile
2015	Petheram L, Stacey N et al.	Future sea changes: Indigenous women's preferences for adaptation to climate change on South Goulburn Island, Northern Territory (Australia)
2014	Aswani S, and Lauer M	Indigenous people's detection of rapid ecological change
2014	Augustine S, and Dearden P	Changing paradigms in marine and coastal conservation: A case study of clam gardens in the Southern Gulf Islands, Canada
2014	Begossi A	Ecological, cultural, and economic approaches to managing artisanal fisheries
2014	Golden AS, Naisilsisili W et al.	Combining natural history collections with fisher knowledge for community-based conservation in Fiji
2014	Grech A, Parra GJ et al.	Local assessments of marine mammals in cross-cultural environments
2014	Matsumoto GI, Needham C et al.	A collaborative and mutually beneficial tribal marine science workshop format for tribal natural resource professionals, marine educators, and researchers
2014	McNamara KE, and Prasad SS	Coping with extreme weather: Communities in Fiji and Vanuatu share their experiences and knowledge
2014	Peter EL, Rumisha SF et al.	Ethno-medicinal knowledge and plants traditionally used to treat anemia in Tanzania: A cross sectional survey
2014	Stephenson J, Berkes F et al.	Biocultural conservation of marine ecosystems: Examples from New Zealand and Canada
2014	Syafwina	Recognizing Indigenous Knowledge for Disaster Management: Smong, Early Warning System from Simeulue Island, Aceh
2014	Vaughan MB, and Ardoin NM	The implications of differing tourist/resident perceptions for community-based resource management: a Hawaiian coastal resource area study
2014	Walter RK, and Hamilton RJ	A cultural landscape approach to community-based conservation in Solomon Islands
2013	Butler JRA, Gunn R et al.	A Value Chain Analysis of ghost nets in the Arafura Sea: Identifying trans-boundary stakeholders, intervention points and livelihood trade-offs
2013	Carothers C	A survey of US halibut IFQ holders: Market participation, attitudes, and impacts
2013	Cochran P, Huntington OH et al.	Indigenous frameworks for observing and responding to climate change in Alaska

2013	Espinoza-Tenorio A, Wolff M et al.	Using traditional ecological knowledge to improve holistic fisheries management: Transdisciplinary modeling of a lagoon ecosystem of Southern Mexico
2013	Fall JA, Braem NS et al.	Continuity and change in subsistence harvests in five Bering Sea communities: Akutan, Emmonak, Savoonga, St. Paul, and Togiak
2013	Huntington HP, Braem NM et al.	Local and traditional knowledge regarding the Bering Sea ecosystem: Selected results from five indigenous communities
2013	Lepofsky D, and Caldwell M	Indigenous marine resource management on the northwest coast of North America
2013	Noman A, Hussain I et al.	Ethnobotanical studies of potential wild medicinal plants of Ormara, Gawadar, Pakistan
2013	Turner NJ, Berkes F et al.	Blundering Intruders: Extraneous Impacts on Two Indigenous Food Systems
2013	van Putten I, Lalancette A et al.	A Bayesian model of factors influencing indigenous participation in the Torres Strait tropical rocklobster fishery
2012	Butler JR a, Tawake A et al.	Integrating traditional ecological knowledge and fisheries management in the torres strait, Australia:The catalytic role of turtles and dugong as cultural keystone species
2012	Clifton J, and Majors C	Culture, Conservation, and Conflict: Perspectives on Marine Protection Among the Bajau of Southeast Asia
2012	Grice AC, Cassady J et al.	Indigenous and non-Indigenous knowledge and values combine to support management of Nywaigi lands in the Queensland coastal tropics
2012	Heck N, Dearden P et al.	Insights into marine conservation efforts in temperate regions: Marine protected areas on Canada's West Coast
2012	Hoverman S, and Ayre M	Methods and approaches to support Indigenous water planning: An example from the Tiwi Islands, Northern Territory, Australia
2012	O'Neill C, Green D et al.	How to make climate change research relevant for Indigenous communities in Torres Strait, Australia
2011	Bethel MB, Brien LF et al.	Blending geospatial technology and traditional ecological knowledge to enhance restoration decision-support processes in coastal Louisiana
2011	Gratani M, Butler JRA et al.	Is validation of indigenous ecological knowledge a disrespectful process? a case study of traditional fishing poisons and invasive fish management from the wet tropics, Australia
2011	Laidler GJ, Hirose T et al.	Evaluating the Floe Edge Service: How well can SAR imagery address Inuit community concerns around sea ice change and travel safety?
2011	Scherrer P, and Doohan K	Capturing intangible cultural impacts of tourism on aboriginal land in Australia's kimberley region
2011	Zander KK, and Garnett ST	The economic value of environmental services on indigenous-held lands in Australia
2010	Carter J	Displacing Indigenous Cultural Landscapes: the Naturalistic Gaze at Fraser Island World Heritage Area
2010	Dicken ML	Socio-economic aspects of boat-based ecotourism during the sardine run within the pondoland marine protected area, South Africa

2010	Gunn R, Hardesty BD et al.	Tackling 'ghost nets': Local solutions to a global issue in northern Australia
2010	Jones R, Rigg C et al.	Haida marine planning: First nations as a partner in marine conservation
2010	Joyce AL, and Satterfield TA	Shellfish aquaculture and First Nations' sovereignty: The quest for sustainable development in contested sea space
2010	Lauer M, and Aswani S	Indigenous Knowledge and Long-term Ecological Change: Detection, Interpretation, and Responses to Changing Ecological Conditions in Pacific Island Communities
2010	Marlor C	Bureaucracy, Democracy and Exclusion: Why Indigenous Knowledge Holders Have a Hard Time Being Taken Seriously
2010	Menzies C	Dm sibilhaa'nm da laxyuubm Gitxaała: Picking Abalone in Gitxaała Territory
2010	Nursey-Bray M, Marsh H et al.	Exploring discourses in environmental decision making: An indigenous hunting case study
2010	Robards MD, and Lovecraft AL	Evaluating Comanagement for Social-Ecological fit: Indigenous priorities and agency mandates for Pacific Walrus
2010	Tang C-P, and Tang S-Y	Institutional adaptation and community-based conservation of natural resources: The cases of the Tao and Atayal in Taiwan
2009	BAN NC, PICARD CR et al.	Comparing and Integrating Community-Based and Science-Based Approaches to Prioritizing Marine Areas for Protection
2009	Haggan N, Jackson GD et al.	Salmon and Eulachon in Ecosystem Space and Time: A Plea for Wider Collaboration and Data Integration
2009	Hoehn S, and Thapa B	Attitudes and perceptions of indigenous fishermen towards marine resource management in Kuna Yala, Panama
2009	McAdoo BG, Moore A et al.	Indigenous knowledge and the near field population response during the 2007 Solomon Islands tsunami
2008	Suluk TK, and Blakney SL	Scope of ethnofisheries and sustainable marine fisheries management in India
2008	Ashaletha S, and Immanuel S	Moving toward spatial solutions in marine conservation with indigenous communities
2008	Ban NC, Picard C et al.	Thinking outside the framework: Equitable research partnerships for environmental research in Australia
2008	Carter JL	The green frog and desalination: A Nyungar metaphor for the (mis-)management of water resources, Swan coastal plain, western Australia
2008	McDonald E, Coldrick B et al.	Indigenous payment for environmental service (PES) opportunities in the Northern Territory: negotiating with customs
2008	Muller S	Land claims and resistance to the management of harvester activities in Nunavut
2007	Arango X, Rozzi R et al.	Discovery and implementation of Magellanic woodpecker (Campephilus magellanicus) as an emblematic species: A biocultural approach for conservation in Cape Horn Biosphere Reserve
2007	Babidge S, Greer S et al.	Management speak: Indigenous knowledge and bureaucratic engagement

2007	Berkes F, Berkes MK et al.	Collaborative integrated management in Canada's North: The role of local and traditional knowledge and community-based monitoring
2007	Clarke P	Marine living resources, biodiversity conservation and self-determination in the Torres Strait - A regional case study in natural resource dispute resolution
2007	Cullen LC, Pretty J et al.	Links between local ecological knowledge and wealth in indigenous communities of Indonesia: Implications for conservation of marine resources
2006	Arunotai N	Moken traditional knowledge: An unrecognised form of natural resources management and conservation
2004	King L	Competing knowledge systems in the management of fish and forests in the Pacific Northwest
2004	McNiven I	Learning from tradition: the planning of residential neighborhoods in a changing world
2004	Saleh MAE	Northern Abalone: Using an invertebrate to focus marine conservation ideas and values
2003	Sloan NA	Saltwater People: spiritscapes, maritime rituals and the archaeology of Australian indigenous seascapes
2003	Memon PA, Sheeran B et al.	Strategies for rebuilding closer links between local indigenous communities and their customary fisheries in Aotearoa/New Zealand
2003	Turner NJ	The ethnobotany of edible seaweed (Porphyra abbottae and related species; Rhodophyta: Bangiales) and its use by First Nations on the Pacific Coast of Canada
2002	Miraglia RA	The cultural and behavioral impact of the Exxon Valdez oil spill on the native peoples of Prince William sound, Alaska
2002	Stenlund P	Lessons in regional cooperation from the arctic
1998	Ferguson MAD, Williamson RG et al.	Inuit knowledge of long-term changes in a population of arctic tundra caribou

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Appendix 2: Discrete choice experiment definitions

Discrete choice experiment 1: Drivers

Attribute	Levels	Description
Development problems	⇒ Education	Formal education system ran by the national government, following a "western" curriculum, seeking to develop professionals in social and hard sciences field.
	⇒ New technologies	Arrival in the last decades of mass communication medias, including satellite TV, smartphones, and internet.
	⇒ Tourism	Growth of the tourism sector within the region triggered by improved road access since early 2000's
External influence problems	⇒ National governance	Relations between the national government and the Guna general congress across multiple issues including access and autonomy of to the region, mega-projects development, etc.
	⇒ National political system	Influence of political parties from the national political system within the local communities in Gunayala
	⇒ Western influence	Foreign influences in Gunayala's lifestyle including diet change (bottled water, soft drinks, alcohol), traditions, practices (watching soap operas, etc.)
Governance problems	⇒ Justice-legal instruments	Formal justice systems and legal instruments that will allows to tackle new arising social issues (petty theft, household conflicts, illicit activities, etc.)
	⇒ Local governance	Strength of local authorities (known as saglas) that will allow a good governance system within each community
	⇒ Regional governance	Strength of the regional authorities (known as sagladummagan) that will allow a good governance across the entire Gunayala region
Island problems	⇒ Climate change	Effects of the changing weather patterns and extreme events (often seen as a natural process of nature to cleanse itself) within the communities and their livelihood activities
	⇒ Population growth	Increase in the population density in the communities driven mostly due to the lack of space within the islands, leading to extended families living within the same household
	⇒ Remote location	Access challenges across multiple aspects in the region. Gunayala is located in a remote area with only one road access (often inaccessible during rainy season due to the rugged nature of the road). Limited communication (cellphone towers) and electrification access in most communities.
Value problems	⇒ Economic interest	Switch from a traditional subsistence lifestyle to an economic driven livelihood seeking to improve basic life quality needs
	⇒ Guna belief system	Traditional knowledge system that guided the Gunas including traditional medicine, ceremonies, treaties (traditional practices for special events), local knowledge, customary laws, etc.
	⇒ Religion	Effect of nontraditional religion in the communities (such as Christian, Mormon, Evangelist, etc.)

Discrete choice experiment 2: Pressures

Attribute	Levels	Description
Development	⇒ Infrastructure development	Projects to develop/improve infrastructure in Gunayala including freshwater pipelines, healthcare facilities, sanitation, etc.
	⇒ Technology usage	Spread of new technologies in Gunayala such as solar panels, cellphone towers, and access to internet
	⇒ Transport/access barriers	Transport challenges between islands due to limited access to few transportation methods (mainly outboard motorboats) and access barriers to Gunayala due to the remote location with only one road access (often inaccessible during heavy rains) to transport goods between Gunayala and the city.
Environmental	⇒ Changing/extreme weather	Change on the frequency, duration, and strength of storms rendering transportation between island and to the mainline impossible; and damaging community infrastructure (damage pipelines, floods, etc.)
	⇒ Marine destruction / overexploitation	Overfishing of seafoods such as lobster and destruction of key marine habitats such as coral reefs
	⇒ Pollution	Increase production of trash (plastic bottles, bags, and cans) and water pollutant (such as diesel fuel from outboard motors)
Governance problems	⇒ Comarcal-national relations	Interaction between national government and the regional authorities of Gunayala (general Guna congress)
	⇒ Lack of funding resources	Resource mobilization in the development of new projects across Guna's communities
	⇒ Poor management	Ineffective administration of resources (human and monetary) from regional leaders (general Guna congress) and local leaders (saglas)
Self-improvement	⇒ Food production	Development of food systems in the region of traditional food items
	⇒ Personal development	Development of human capital through capacity building using either formal (schools, workshops, trainings) or traditional methods (knowledge transmit ion from father to son)
	⇒ Population migration	Migration of younger Guna population to the cities searching for better job opportunities, higher education (college, universities), higher living standard (access to technologies, electrification, etc.)
Social welfare	⇒ Healthcare access barriers	Difficulties to transport and store healthcare supplies and challenges of remote communities to access healthcare centers within Gunayala
	⇒ Illegal activities	Surge of illegal activities from illicit substances across the borders (including Gunayala, panama, and Colombia) sometimes involving Guna's community members
	⇒ Values change	Loss of traditional Guna values including traditional ceremonies, treaties (traditional practices for special events), traditional medicine, beliefs, worldviews, social practices (such as community farm, harvest, cleaning, etc.) and being replaced with "westernized" values focusing on an economic based lifestyle

Discrete choice experiment 3: States

Attribute	Levels	Description
Household	⇒ Food insecurity	Availability, access, utilization, and stability of food items
	⇒ Health and sanitation	Quality, availability, and access of proper healthcare systems, improved freshwater, and sanitation
	⇒ Household diet	Type and quality of consumed food within the households
Social welfare	⇒ Authorities coordination capacity	Capacity of regional authorities (general Guna congress) and local authorities (saglas) to administer and coordinate the development of Guna's communities
	⇒ Community involvement	Participation of community work (such as the farming committee)
	⇒ Younger generations engagement	Participation of younger generations in community activities
Systems	⇒ Biodiversity	Diversity of marine species, flora and fauna across Gunayala
	⇒ Livelihood	Activities engaged by the community for their subsistence and development
	⇒ Wellbeing	Life quality including social, physical, mental, and spiritual health.

Discrete choice experiment 4: Impacts

Attribute	Levels	Description
Development priorities	⇒ Infrastructure damage	Damage to physical infrastructures in the communities including water pipelines (that provides fresh water supply from the coast to the islands), flooding, etc.
	⇒ Programme collapse/delays	Key project delays that seeks to provide infrastructure to satisfy community needs such as healthcare, education, fresh water supply, sanitation, etc.
	⇒ Tourism drop	Decrease in tourism flow in the region
Environmental priorities	⇒ Contamination / health drop	Contamination across the island and coastal areas from new sources of pollutant such as plastic bottles, batteries, diesel (from outboard motors), trash from larger ships sailing in the region, etc. this increases the risk of disease outbreaks.
	⇒ Coral reef loss	Loss of coral reefs due to its extraction mainly use as landfill or coastal barriers within the communities
	⇒ Marine species decrease	Decrease availability of key marine species such as lobster and sea turtles. often communities are force to sail farther away and/or dive deeper to find those species.
Food production priorities	⇒ Food access loss	Difficulties to physically reach the areas where food is available. storms can make impossible for communities to reach farmlands in the coast or allow ships with supplies to reach the islands. heavy rains will stop the road access supply chain from the capital into to the region
	⇒ Food availability loss	Loss of traditional native food crops in the region that leads to the loss of traditional food items necessary for traditional ceremonies and social bonding (corn crops and traditional preparations of corn based fermented drinks)
	⇒ Food utilization loss	Diet change from traditional dishes consisting mostly of tubers, fish, coconuts (such as tulemasi) in favor to faster, convenient, and often cheaper fast food items and snacks (such as French fries, burgers, soft drinks, coffee, etc.)
Gains priorities	⇒ Income increase	Purchase power increase at household level from new sources of income earnings within the communities including tourism (transport, guide, selling food, souvenirs, etc.), government social programmes, new jobs types from the government (teachers, police, community leaders, etc.)
	⇒ Living standard increase	Improvement on basic needs such as access to healthcare, improved drinking water sources, and education
	⇒ Professional skill gain	Formal education either through national school system, workshops, technical trainings or vocational schools. obtaining skills that will allow access to paid jobs within or outside Gunayala
Guna values priorities	⇒ Guna language loss	Decrease in the daily usage of the Guna language in the communities, specially within younger generations and people educated within the formal national education curriculum that only focus on Spanish and English language
	⇒ Leadership erosion	Loss of interest within younger generations to actively drive community engagement, preserve Guna's identity, and continue with traditional activities and ceremonies. lack of enforcement of local leaders "saglas" to preserve the Guna culture, traditions, and livelihood in favor of an economic based lifestyle
	⇒ Loss of culture	Loss of traditional practices such as ceremonies, treaties (traditional practices for special events), and traditional medicine. loss of daily attendance to the "house of congress"

		where the community gather at the community center to discuss matters relevant to the community and Gunayala, as well as a venue to transmit/reinforce Guna's beliefs/worldviews through songs by the local leaders "saglas"
Improve access priorities	⇒ Food access increase	Access to new food types that are convenient with longer shelf life such as canned tuna/meat, bottled water, soft drinks, frozen food (burgers, French fries, etc.)
	⇒ Information access increase	Access to national/international news, entertainment, and general content from multiple sources such as satellite tv, radio, internet, and smartphones
	⇒ Loss of clean water	Loss of access to improved drinking water sources often caused by damaged pipelines between the islands and the mainland
Social welfare priorities	⇒ Conflict/violence increase	Increase of conflicts within the island (such as fights, petty theft) and within the region (conflict due to illicit substance trade)
	⇒ Disease/mortality increase	Increase in health issues due to poor nutrition, lack of safe drinking water sources, healthcare access that can lead to disease outbreaks, increase in non-communicable diseases (such as diabetes), and an increased mortality rate
	⇒ Overcrowding	Increase in the population density within the communities due to the lack of land in the islands leading to large extended families within the same roof. this leads to concerns about privacy and increase of intra-household conflicts
Tradeoffs	⇒ Income decrease	Loss of access to new income sources from tourism, formal jobs (either part time or full-time jobs) or from national social programmes
	⇒ Living standard decrease	Loss of basic needs such as access to healthcare, improved drinking water sources, and education. loss of regulating and cultural ecosystem services such as increase in pollution from plastic bottles, contaminated waters with outboard motor fuel, etc.
	⇒ Personal skill loss	Loss of traditional skills that was often pass from generation to generation (from father/mother to son/daughter) including fishing, agriculture, traditional crafting (art, baskets, etc.), food insecurity coping strategies, and traditional food preparations

Discrete choice experiment 5: Responses

Attribute	Levels	Description
Collaborations	⇒ FPIC	Follow the free, prior and informed consent (FPIC), the right that pertains to indigenous peoples and is recognized in the united nations declaration on the rights of indigenous peoples across all projects within Gunayala
	⇒ Harmonize wester-traditional system	Find solutions that balance the "western" concepts of development and the worldviews/beliefs of Guna's people
	⇒ Programme co-design	Equal collaboration between national government, regional authorities (Guna general congress), local leaders (saglas), and communities in the development of new projects
New approaches	⇒ Alternative management	Develop innovative ways to administer natural resources in the region where communities are actively involved in the management and monitoring of new projects
	⇒ Diversify livelihood activities	Develop new income sources such as eco-tourism, cultural tourism (tourism focus on sharing Guna's culture, values, and traditional lifestyle), permanent local jobs, etc.
	⇒ Relocation	Relocation of communities and livelihood activities to the mainland across Gunayala coastline
Programmes	⇒ Capacity building	Roll out technical training programmes and workshops to build up Gunayala's capacity to cope with their development challenges
	⇒ Education programmes	Update school curriculum through an Intercultural Bilingual Education (EBI Guna) that will strengthen local food production, health and nutrition, native language and values, and leadership
	⇒ Recover ilk	Invest and develop programmes that seek to rescue/preserve Guna's traditional knowledge and customs
Restrictions	⇒ Informal autoregulation	Implement informal regulation (such as temporal harvest ban on specific species during mating seasons) within communities through informal institutions
	⇒ Recycling	Develop recycling programmes targeting products that can be sold out (aluminum cans, glass bottle, etc.) and will minimize the trash pollution in the communities
	⇒ Sanctions	Implement sanctions, punishments, fines, and coercive actions to enforce local and regional regulations
Strengthen institutions	⇒ Formal comarcal regulation system	Increase the involvement of the regional authorities (general Guna congress) in matters related to the management of natural resources, preservation of Guna's traditions, enforcement of regional regulations, traditional food item production, etc.
	⇒ Local regulation system	Increase the involvement of the local authorities (sagla) in matters related to the management of natural resources, preservation of Guna's traditions, enforcement of local and regional regulations, traditional food item production, etc.
	⇒ Strengthen leadership system	Strengthen the leadership of local authorities and engagement of younger generations in matters related to the community welfare

Appendix 3: DPSIR elements printed guide

Drivers Spanish guide:

EJERCICIO 1 - Grupo de factores que influencian el desarrollo en tu comunidad y su entorno		
Desarrollo		Sistema educativo formal para el desarrollo de profesionales en diversas ramas
		Nuevas tecnologías como teléfonos celulares e internet dentro de las comunidades
		Actividades turísticas en la región
Influencia Externa		Relaciones con el gobierno nacional de Panamá en diversos aspectos de colaboración
		Participación de partidos políticos dentro de las comunidades
		Influencias externas como cambio de dietas (coca cola, etc.) y de costumbres (telenovelas, etc.) en Guna Yala
Gobernanza		Administrar a través de leyes y regulaciones las actividades diarias dentro de las comunidades
		Fortaleza de autoridades locales (sahilas) para una buena administración de las comunidades
		Fortaleza de los Congresos Generales para la buena administración de Guna Yala
Retos		Efectos del cambio climático como tormentas e inundaciones en la vida diaria dentro de las comunidades
		Efectos de sobrepoblación dentro de la comunidad, como falta de espacio para construir nuevas casas
		Retos de comunicación y acceso de trasporte marina y terrestre entre las comunidades y tierra firme
		Crecimiento económico en las comunidades para el mejoramiento de la calidad de vida
Valores		Conocimientos ancestrales y tradiciones Gunas como medicina tradicional, uso de tratados, ceremonias, etc.
		Rol e influencia de religiones latinas en las comunidades

Pressures Spanish guide:

		EJERCICIO 2 - Efectos como consecuencia del desarrollo en tu comunidad
Desarrollo		Proyectos para desarrollar infraestructuras como instalaciones de salud, tuberías de agua potable, sanidad, etc.
		La propagación de nuevas tecnologías como celulares, paneles solares, tv, internet, etc. en las comunidades
		Medios de transporte entre las islas, tierra firme y comercio marino dentro de las comunidades
Medio Ambiente		Cambio en la frecuencia, duración y fuerza de tormentas afectando las comunidades (transporte, inundaciones)
		Sobreexplotación de especies como langostas, tortugas, etc., y sobre extracción de corales para rellenos
		Polución de basura dentro de las islas y derrame de diésel/gasolina en las costas
Gobernanza		Relación existente entre el Congreso Administrativo y el Gobierno Nacional y su efecto en la región de Guna Yala
		Escasez de fondos para desarrollar nuevos proyectos en beneficio de las comunidades
		Deficiencia en la administración por parte de los lideres ya sea del congreso o los líderes de la comunidad
Bienestar Personal		Desarrollo de la agricultura para la producción local de alimentos autóctonos
		Mejoramiento de las capacidades personales a través de entrenamientos o educación formal superior
		Migración de la población de las islas hacia la capital en busca de mejor educación o trabajo
Bienestar Social		Facilidad de acceder a centros de salud y disponibilidad de insumos de salud
		Aparición de actividades ilegales y conflictos dentro de las comunidades
		Perdida de los valores tradicionales Gunas (ceremonias, medicina, etc.) siendo reemplazado por valores latinas

States Spanish guide:

EJERCICIO 3 - Aspectos/facetas de la tu comunidad y su entorno		
Hogar		Disponibilidad de alimentos y su estabilidad durante el año dentro del hogar
		La calidad de servicios de salud, saneamiento y accesos a agua potable dentro del hogar
		La calidad de alimentación que existe en los hogares dentro de la comunidad
Bienestar Social		Capacidad de las autoridades y líderes locales para coordinar el desarrollar en la comunidad
		Participación en trabajos comunitarios (comisión de agricultura, comisión de ornato y aseo, etc.)
		Participación de los jóvenes en las actividades de la comunidad para su desarrollo
		Diversidad de la fauna y flora dentro de la región de Guna Yala
Sistemas		Trabajos o actividades (turismo, pesca, etc.) para adquirir los recursos para la subsistencia dentro del hogar
		Estado de la calidad de vida incluyendo salud física, mental y espiritual

Impacts Spanish guide:

EJERCICIO 4 - Efectos del desarrollo en tu comunidad y su entorno		
Desarrollo		Perdida o daños a infraestructuras como daños de tuberías de agua, daños en el hogar debido a tormentas, etc.
		Colapso o retrasos de proyectos vitales para la comunidad como construcción de escuelas, tuberías, etc.
		Disminución de la visita de turistas en la región
Medio Ambiente		Disminución de la cantidad de corales debido a su extracción para rellenos
		Dificultad de encontrar especies marinas como langostas y tortugas
		Incremento de basuras plásticas en la comunidad
Seg		Dificultad en la movilidad y acceso al campo ubicados en tierra firme para trabajar en la agricultura

		Perdida de producción de alimentos nativos como ñame y maíz
		Cambio de dieta y perdida de comidas tradicionales (tulemasi) en favor de comidas externas (comida chatarra)
Estandar de vida		Incremento de entradas económicas en el hogar
Estandar de vida		Mejoras de calidad de vida a través de acceso de centros de salud, acceso a tuberías de agua, escuelas, etc.
Estandar de vida		Mejora de las capacidades personales a través de educación formal, talleres y entrenamientos
		Perdida de la lengua Guna en las nuevas generaciones dentro de las comunidades
Tradiciones		Falta de interés de los jóvenes Gunas en participar en actividades para fortalecer la comunidad
Tradiciones		Pérdida de conocimientos y tradiciones como tratados, producción de chicha, asistencia a la casa del congreso
Accesos		Acceso a nuevos tipos de alimentos como tuna en lata, bebidas (coca cola), agua embotellada, etc.
Accesos		Accesos a noticias e información en general a través de televisión, radio, internet
Accesos		Perdida al acceso de agua potable por daños a la tubería
Bienestar Social		Incremento de conflictos y violencia en la comunidad
Bienestar Social		Incremento de enfermedades debido a una deficiente nutrición, falta de acceso de agua potable, centro de salud
Bienestar Social		Falta de espacio para que nuevas familias tengan una casa propia dentro de la comunidad
		Disminución de entradas económicas dentro de la comunidad
Impactos		Pérdida de calidad de vida debido al incremento de basura, aumento de violencia o perdida de agua potable
Impactos		Perdida de habilidades tradicionales como trabajo al campo, pesca, cocinar platos tradicionales, etc.

Responses Spanish guide:

EJERCICIO 5 - Acciones más importantes a implementar en tu comunidad para el futuro desarrollo en Guna Yala

Colaboracion		Implementar proyectos y planes de desarrollo informando la comunidad y respetando sus deseos
		Buscar un punto intermedio, combinando las ideas Gunas y Latinas para el desarrollo de la región
		Trabajo en conjunto entre las autoridades locales y regionales, la comunidad y miembros externos
Nuevas Estrategias		Desarrollar nuevas formas de administrar los recursos de la región (monitoreo, grupos de trabajo, etc.)
		Desarrollar nuevas fuentes de ingresos (ecoturismo, turismo cultural, empleos locales, etc.)
		Traslado a tierra firme para reducir los efectos de tormenta, mejorar accesos de agua potable, sanidad, etc.
Programas		Desarrollo de programas de entrenamiento para desarrollar habilidades personales e incrementar ingresos
		Implementar talleres para educar a las comunidades sobre alimentación, salud, producción, liderazgo, etc.
		Desarrollo de programas en busca de rescatar los conocimientos y costumbres tradicionales de Guna Yala
Administracion		Implementar autorregulaciones (veda, etc.) dentro de cada comunidad para resolver problemas de la comunidad
		Implementar programas de reciclaje para resolver los problemas de contaminación en las playas y costas
		Implementar sanciones y multas para administrar los recursos de la comunidad
Instituciones		Incrementar la intervención de los Congresos en la administración de los recursos de las comunidades
		Incrementar la intervención de los líderes locales (sahilas) en la administración de los recursos de la comunidad
		Fortalecer los líderes locales para que tengan mayor intervención en la administración de la comunidad

Appendix 4: SQL coding to identify SDG interlinkages

Definitions for table Links

Field	Type	Description
ID	Number	Unique identifier for each of the 1,550 links
Case	Number	Unique identifier of each of the 97 DPSIR sub-system
Fromm	Short Text	Label containing the DPSIR element of origin
To	Short Text	Label containing the DPSIR element of destination
From DPSIR	Short Text	Label containing the DPSIR component of origin
To DPSIR	Short Text	Label containing the DPSIR component of destination

(source: List of links from all 97 DSPSIR sub-system. See **Table 8**)

Definitions for table SDG

Field	Type	Description
ID2	Number	Unique identifier for each of the 657 SDG targets
Case	Number	Unique identifier of each of the 97 DPSIR sub-system
SDGGoal	Short Text	Label of the related SDG
Target	Short Text	Label of the related target
Element	Short Text	Label of the related DPSIR element
DPSIR	Short Text	Label of the related DPSIR component
Sentiment	Short Text	Label of the overall sentiment of the DPSIR element

(source: List of targets related to key impacts across Gunayala SES. See **Table 13**)

Sequence of SQL queries to obtain the list of direct interlinks

```
//Query 1: DirectT
SELECT Links.case, Links.Fromm, Links.to, Links.[From DPSIR], Links.[To DPSIR]
FROM Links
WHERE (((Links.[From DPSIR])="Impact") AND ((Links.[To DPSIR])="Impact"));

//Query 2: Direct
SELECT A.Case AS [Case], A.Fromm As [From], A.to As [To], A.Case & A.Fromm & A.to as Vlook
From DirectT A
UNION SELECT B.Case AS [Case], B.to As [From], B.Fromm As [To], B.Case & B.to & B.Fromm as
Vlook
From DirectT B;

//Query 3: TempDirect
SELECT A.Case, A.Element, A.Target, B.To, A.Sentiment AS [From Sentiment], A.SDGGoal
FROM SDG AS A, Direct AS B
WHERE (((A.Case)=B.Case) And ((A.Element)=B.From) And ((A.DPSIR)='Impact'))
ORDER BY A.Case;

//Query 4: FinalDirect
```

```
SELECT A.Case AS [Case], A.Element AS [From Element], A.Target AS [From Target], B.Element AS
[To Element], B.Target AS [To Target], 'Direct' AS Type, A.SDGGoal AS [From Goal], B.SDGGoal AS [To
Goal], A.[From Sentiment], B.Sentiment AS [To Sentiment]
FROM TempDirect AS A, SDG AS B
WHERE A.Case = B.Case AND A.To=B.Element
ORDER BY A.Case;
```

SQL query to obtain the list of within interlinks

```
//Query 1: FinalWithin
SELECT A.Case, A.Element AS [From Element], A.Target AS [From Target], B.Element AS [To Element],
B.Target AS [To Target], 'Within' AS Type, A.SDGGoal AS [From Goal], B.SDGGoal AS [To Goal],
A.Sentiment AS [From Sentiment], B.Sentiment AS [To Sentiment]
FROM SDG AS A, SDG AS B
WHERE A.Case = B.Case AND A.Element = B.Element AND A.Target<>B.Target AND A.DPSIR =
'Impact' AND B.DPSIR = 'Impact';
```

Sequence of SQL queries to obtain the list of indirect interlinks

```
//Query 1: Indirect
SELECT A.Case, A.To AS [To], B.To AS [From], A.[From DPSIR], A.[To DPSIR], B.[From DPSIR], B.[To
DPSIR], A.Fromm, B.Fromm, (a.Case & A.To & B.To) AS Vlook
FROM Links AS A, Links AS B
WHERE A.Fromm = B.Fromm AND A.[From DPSIR]='State' AND  A.To<>B.To AND A.[To
DPSIR]='Impact' AND B.[To DPSIR]='Impact' AND A.Case=B.Case;

//Query 2: Indirect2
SELECT Indirect.*
FROM Indirect
WHERE Indirect.Vlook Not IN (Select Vlook from Direct);

//Query 3: TempIndirect
SELECT A.Case, A.Element, A.Target, B.To, A.SDGGoal, A.Sentiment
FROM SDG AS A, Indirect2 AS B
WHERE (((A.Case)=B.Case) And ((A.Element)=B.From) And ((A.DPSIR)='Impact'))
ORDER BY A.Case;

//Query 4: FinalIndirect
SELECT A.Case AS [Case], A.Element AS [From Element], A.Target AS [From Target], B.Element AS
[To Element], B.Target AS [To Target], 'Indirect' AS Type, A.SDGGoal AS [From Goal], B.SDGGoal AS
[To Goal], A.Sentiment AS [From Sentiment], B.Sentiment AS [To Sentiment]
FROM TempIndirect AS A, SDG AS B
WHERE A.Case = B.Case AND A.To=B.Element
ORDER BY A.Case;
```

Appendix 5: Characteristics of Indigenous People in Marine and Coastal Ecosystem Studies

Summary of the characteristics and foci of reviewed studies

	Contextual Research		Causal Research		Total		X^2
Time Scale							***
Cross-Sectional (qty)	24	40%	31	63%	55	50%	
Longitudinal (qty)	3	5%	13	27%	16	15%	
Mixed (qty)	33	55%	5	10%	38	35%	
Total	***60***	***100%***	***49***	***100%***	***109***	***100%***	
Spatial Scale							
Local (qty)	44	73%	43	88%	87	80%	
Regional (qty)	16	27%	6	12%	22	20%	
Total (qty)	***60***	**1%**	***49***	**1%**	***109***	**1%**	
System							
Coastal (qty)	38	63%	32	65%	70	64%	
Island (qty)	9	15%	5	10%	14	13%	
Marine (qty)	13	22%	12	24%	25	23%	
Total	***60***	***100%***	***49***	***100%***	***109***	***100%***	
Location							
Artic States (qty)	1	2%	0	0%	1	1%	
Australia (qty)	17	28%	13	27%	30	28%	
Brazil (qty)	1	2%	2	4%	3	3%	
Canada (qty)	13	22%	11	22%	24	22%	
Chile (qty)	1	2%	2	4%	3	3%	
Fiji (qty)	2	3%	1	2%	3	3%	
India (qty)	2	3%	1	2%	3	3%	
Indonesia (qty)	3	5%	2	4%	5	5%	
Madagascar (qty)	0	0%	1	2%	1	1%	
Mexico (qty)	2	3%	1	2%	3	3%	
New Zealand (qty)	3	5%	1	2%	4	4%	
Pakistan (qty)	0	0%	1	2%	1	1%	
Panama (qty)	0	0%	1	2%	1	1%	
Russia (qty)	0	0%	1	2%	1	1%	
Saudi Arabia (qty)	1	2%	0	0%	1	1%	
Solomon Islands (qty)	1	2%	3	6%	4	4%	
South Africa (qty)	1	2%	0	0%	1	1%	
Taiwan (qty)	2	3%	0	0%	2	2%	
Tanzania (qty)	0	0%	1	2%	1	1%	
Thailand (qty)	1	2%	0	0%	1	1%	
USA (qty)	8	13%	7	14%	15	14%	
Yemen (qty)	1	2%	0	0%	1	1%	
Total	***60***	**100%**	***49***	**100%**	***109***	**100%**	
Research Design							**
Action Research (qty)	2	3%	2	4%	4	4%	
Case Study (qty)	19	32%	16	33%	35	32%	
Experimental (qty)	0	0%	4	8%	4	4%	
Historical (qty)	7	12%	1	2%	8	7%	
Meta-Analysis (qty)	0	0%	1	2%	1	1%	
Observational (qty)	20	33%	25	51%	45	41%	
Philosophical (qty)	12	20%	0	0%	12	11%	
Total	***60***	**100%**	***49***	**100%**	***109***	**100%**	
Research *Question*							***

Descriptive (qty)	51	85%	3	6%	54	50%	
Exploratory (qty)	9	15%	46	94%	55	50%	
Total	**60**	**1%**	**49**	**1%**	**109**	**1%**	
Research Objective							***
Assessment (qty)	5	8%	42	86%	47	43%	
Raise Awareness (qty)	42	70%	0	0%	42	39%	
Resource Management (qty)	13	22%	7	14%	20	18%	
TK Integration Co-Designing (qty)	2	3%	5	10%	7	6%	
Discussion (qty)	12	20%	12	24%	24	22%	
Consultation (qty)	24	40%	18	37%	42	39%	
Information (qty)	17	28%	7	14%	24	22%	
Not Considered (qty)	5	8%	7	14%	12	11%	
Total	**60**	***100%***	**49**	***100%***	**109**	***100%***	
Modern Science Technique Integration							
Integrated (qty)	36	60%	29	59%	65	60%	
Considered (qty)	18	30%	11	22%	29	27%	
Not Integrated (qty)	2	3%	1	2%	3	3%	
Not Considered (qty)	4	7%	8	16%	12	11%	
Total	**60**	***100%***	**49**	***100%***	**109**	***100%***	
Indigenous People Integration							
Co-Designing (qty)	3	5%	5	10%	8	7%	
Discussion (qty)	15	25%	13	27%	28	26%	
Consultation (qty)	23	38%	19	39%	42	39%	
Information (qty)	19	32%	10	20%	29	27%	
Not Considered (qty)	0	0%	2	4%	2	2%	
Total	**60**	***100%***	**49**	***100%***	**109**	***100%***	
Research type							***
Qualitative (qty)	60	100%	12	24%	72	66%	
Quantitative (qty)	0	0%	16	33%	16	15%	
Mixed (qty)	0	0%	21	43%	21	19%	
Total	**60**	***100%***	**49**	***100%***	**109**	***100%***	
Multi Stakeholders							
No (qty)	41	68%	26	53%	67	61%	
Yes (qty)	19	32%	23	47%	42	39%	
Total	**60**	**100%**	**49**	**100%**	**109**	**100%**	
Transboundary							*
No (qty)	37	62%	19	39%	56	51%	
Yes (qty)	23	38%	30	61%	53	49%	
Total	**60**	**100%**	**49**	**100%**	**109**	**100%**	
Multi Value							*
No (qty)	9	15%	16	33%	25	23%	
Yes (qty)	51	85%	33	67%	84	77%	
Total	**60**	**100%**	**49**	**100%**	**109**	**100%**	
Multi Tools							**
No (qty)	34	57%	13	27%	47	43%	
Yes (qty)	26	43%	36	73%	62	57%	
Total	**60**	**100%**	**49**	**100%**	**109**	**100%**	

Note: * significance level at p<0.05; ** significance level at p<0.01; *** significance level at p<0.001

Appendix 6: Indigenous People Demographics

Percentage of indigenous people relative to the entire population by country/region (sorted from highest to lowest)

Country / Region	Indigenous %	Land %	Country / Region	Indigenous %	Land %
Venezuela	98.8%	3%	Canada	3.8%	44%
Greenland	88.4%	0%	Suriname	3.6%	0%
French Polynesia	77.0%	-	Colombia	3.0%	34%
Bolivia	58.9%	36%	Mali	3.0%	0%
Guatemala	34.8%	17%	Botswana	2.7%	71%
Nepal	32.2%	13%	Australia	2.7%	30%
Morocco	27.3%	36%	Cambodia	2.5%	3%
Algeria	26.2%	14%	Uganda	2.4%	69%
Kenya	23.8%	60%	Taiwan	2.4%	7%
Indonesia	22.5%	1%	Argentina	2.1%	3%
Philippines	14.2%	21%	Costa Rica	2.0%	6%
New Zealand	14.2%	6%	Paraguay	1.7%	-
Vietnam	13.9%	-	Thailand	1.3%	1%
Ethiopia	13.3%	15%	United States	1.3%	5%
Mexico	12.9%	56%	Norway	1.2%	14%
Peru	12.3%	30%	Israel	1.1%	-
Panama	10.0%	32%	Bangladesh	1.0%	-
Eritrea	8.9%	0%	Tanzania	0.9%	70%
Chile	8.7%	3%	South Africa	0.9%	13%
Tunisia	8.6%	20%	Burundi	0.7%	0%
China	7.9%	49%	Brazil	0.4%	23%
Namibia	7.7%	36%	Sweden	0.2%	2%
India	7.7%	0%	Russia	0.2%	4%
Ecuador	6.5%	15%	Finland	0.1%	1%
Niger	5.6%	10%	Zimbabwe	0.0%	42%
Cameroon	4.2%	9%			

Note: "Indigenous %" refers to the percentage of indigenous people compared to the total population of the country/region; "Land %" refers to the percentage of land officially recognized by the government as indigenous land relative to the country/region total land mass

Appendix 7: Evolution of disciplines studying indigenous people in marine systems

Number of studies conducted for each academic field for different time intervals

Academic Discipline/Field	1998 to 2002	2003 to 2007	2008 to 2012	2013 to 2018	Total
Agricultural and Biological Sciences	**2**		**8**	**29**	**39**
Agricultural and Biological Sciences			1	4	5
Agronomy and Crop Science				1	1
Aquatic Science	1		2	12	15
Ecology, Evolution, Behavior and Systematics	1		5	8	14
Food Science				1	1
Plant Science				3	3
Arts and Humanities		**1**	**2**	**5**	**8**
Archeology (arts and humanities)		1		1	2
Arts and Humanities			2	3	5
History				1	1
Biochemistry, Genetics and Molecular Biology			**1**	**1**	**2**
Biochemistry, Genetics and Molecular Biology			1	1	2
Business, Management and Accounting				**4**	**4**
Business, Management and Accounting				2	2
Tourism, Leisure and Hospitality Management				2	2
Chemical Engineering				**1**	**1**
Fluid Flow and Transfer Processes				1	1
Computer Science				**2**	**2**
Computer Science Applications				1	1
Software				1	1
Earth and Planetary Sciences	**1**	**1**	**9**	**14**	**25**
Atmospheric Science			1	3	4
Earth and Planetary Sciences		1	1	3	5
Earth-Surface Processes			5	1	6
Environmental Science			1		1
Geology				1	1
Geotechnical Engineering and Engineering Geology				1	1
Oceanography	1		1	5	7
Economics, Econometrics and Finance		**1**		**7**	**8**
Economics and Econometrics		1		6	7
Economics, Econometrics and Finance				1	1
Environmental Science	**2**	**7**	**26**	**80**	**115**
Ecological Modeling				1	1
Ecology			8	18	26
Environmental Chemistry		2		1	3
Environmental Engineering				2	2
Environmental Science	1	2	3	11	17
Global and Planetary Change			1	7	8
Health, Toxicology and Mutagenesis			1	4	5
Management, Monitoring, Policy and Law	1	2	6	17	26
Nature and Landscape Conservation		1	3	12	16
Pollution			1	1	2
Waste Management and Disposal				2	2
Water Science and Technology			3	4	7
Health Professions			**1**	**1**	**2**
Complementary and Manual Therapy			1	1	2
Medicine			**5**	**12**	**17**

Complementary and Alternative Medicine		1	3	4
Medicine		3	5	8
Public Health, Environmental and Occupational Health		1	4	5
Pharmacology, Toxicology and Pharmaceutics			**4**	**4**
Drug Discovery			2	2
Pharmacology			2	2
Social Sciences	**8**	**18**	**34**	**60**
Anthropology		2	3	5
Archeology	1		1	2
Cultural Studies			1	1
Development		2	3	5
Education			1	1
Geography, Planning and Development	1	6	10	17
Health (social science)		1	5	6
Law	1		5	6
Political Science and International Relations	1			1
Public Administration		1		1
Safety Research			1	1
Social Sciences	3	1		4
Sociology and Political Science		5	4	9
Urban Studies	1			1

Appendix 8: DPSIR elements from similar studies

List of DPSIR elements from Indigenous People in Marine and Coastal System Research

Drivers

		Total			Contextual Research			Causal Research		
		Trend	Consensus	Uncertain	Trend	Consensus	Uncertain	Trend	Consensus	Uncertain
Climate Change	(n=31/18/13)	1.9	0.9	26%	1.8	0.9	28%	1.9	0.9	23%
Demographic Shift	(n=16/5/11)	2.3	0.8	19%	2.8	0.6	0%	2.0	1.0	27%
Economic Development	(n=47/23/24)	2.2	0.8	40%	2.1	0.8	26%	2.4	0.7	54%
Energy Development	(n=2/2/0)			100%			100%			0%
Market Demand	(n=14/7/7)	2.3	0.7	29%	2.7	0.6	14%	1.8	0.9	43%
Natural Disasters	(n=8/4/4)	1.5	0.8	25%	1.3	0.9	0%	2.0	1.0	50%
New Technologies	(n=14/5/9)	2.2	0.5	29%	1.3	0.8	40%	2.6	0.5	22%
Policy Instruments	(n=37/24/13)	2.4	0.7	24%	2.4	0.7	13%	2.6	0.7	46%
Religion	(n=1/1/0)			100%			100%			0%
Tourism	(n=21/11/10)	2.4	0.6	29%	2.4	0.6	27%	2.4	0.6	30%
Urban Development	(n=6/5/1)	2.3	0.8	0%	2.4	0.7	0%	2.0	1.0	0%

= significant degradation	< 0.2	< 20%
= moderate degradation	0.2 - 0.4	20% - 40%
= remain the same	0.4 - 0.6	40% - 60%
= moderate improvement	0.6 - 0.8	60% - 80%
= significant improvement	≥ 0.8	≥ 80%

Pressures

		Total			Contextual Research			Causal Research		
		Trend	Consensus	Uncertain	Trend	Consensus	Uncertain	Trend	Consensus	Uncertain
Changing/Extreme Weather	(n=7/2/5)	1.8	0.9	29%	2.0	1.0	0%	1.7	0.8	29%
Commercial Fisheries	(n=25/13/12)	1.6	0.8	32%	1.7	0.8	16%	1.6	0.8	16%
Costal Erosion	(n=7/4/3)	1.5	0.8	43%	1.7	0.8	14%	1.0		29%
Ecosystem Conservation	(n=5/1/4)	2.5	0.7	20%	2.0	1.0	0%	2.7	0.6	20%
Education	(n=2/1/1)	2.0	1.0	0%	2.0	1.0	0%	2.0	1.0	0%
Habitat Destruction	(n=38/20/18)	1.7	0.8	8%	1.6	0.8	3%	1.9	0.8	5%
Inflation	(n=1/1/0)	2.0	1.0	0%	2.0	1.0	0%			0%
Infrastructure Development	(n=10/5/5)	2.3	0.8	30%	2.7	0.6	20%	2.0	1.0	10%
Invasive Species	(n=7/2/5)	1.9	0.9	0%	2.0	1.0	0%	1.8	0.9	0%
Lack Financial Support	(n=4/2/2)	2.7	0.6	25%	3.0	0.6	0%	2.0	1.0	25%
Lack Of Health Care System	(n=1/0/1)			100%			0%			100%
Land Use Change	(n=14/6/8)	1.9	0.9	14%	1.8	0.9	7%	2.0	1.0	7%
Overexploitation	(n=35/16/19)	1.8	0.9	9%	1.7	0.8	3%	1.8	0.9	6%
Poaching	(n=2/1/1)	1.5	0.8	0%	1.0		0%	2.0	1.0	0%
Political Instability	(n=2/0/2)	2.0	1.0	50%			0%	2.0	1.0	50%
Pollution	(n=17/10/7)	1.8	0.8	6%	1.7	0.8	6%	1.9	0.7	0%
Poor Management	(n=36/26/10)	2.1	0.8	6%	2.1	0.7	3%	2.0	0.8	3%
Population Migration	(n=5/2/3)	1.5	0.8	20%	2.0	1.0	20%	1.3	0.8	0%
Poverty	(n=2/0/2)	2.0	1.0	0%			0%	2.0	1.0	0%
Predatory Species	(n=5/1/4)	4.0	1.0	80%			20%	4.0	1.0	60%
Salt Water Intrusion	(n=1/0/1)			100%			0%			100%
Sustainable Management	(n=19/12/7)	4.2	0.7	53%	4.3		26%	4.0	1.0	26%
Technologie Usage	(n=13/6/7)	3.1	0.6	38%	3.0	0.8	15%	3.3	0.4	23%
Tk Education	(n=4/3/1)	2.0	1.0	0%	2.0	1.0	0%	2.0	1.0	0%
Under-Use	(n=1/0/1)	2.0	1.0	0%			0%	2.0	1.0	0%
Value Change	(n=20/13/7)	2.1	0.9	25%	2.1	0.8	15%	2.0	1.0	10%

= significant degradation	< 0.2	< 20%
= moderate degradation	0.2 - 0.4	20% - 40%
= remain the same	0.4 - 0.6	40% - 60%
= moderate improvement	0.6 - 0.8	60% - 80%
= significant improvement	≥ 0.8	≥ 80%

State

		Total			Contextual Research			Causal Research		
		Trend	Consensus	Uncertain	Trend	Consensus	Uncertain	Trend	Consensus	Uncertain
Access Rights	(n=18/12/6)	2.3	0.7	11%	2.4	0.7	11%	2.0	0.7	0%
Biodiversity	(n=55/25/30)	2.1	0.8	15%	1.9	0.8	5%	2.2	0.8	9%
Carbon Sequestration	(n=3/0/3)	2.7	0.6	0%			0%	2.7	0.6	0%
Community Involvment	(n=18/11/7)	2.2	0.8	11%	2.4	0.7	6%	1.8	0.9	6%
Ecosystem	(n=19/7/12)	2.1	0.9	11%	2.0	0.9	5%	2.1	0.8	5%
Food Security	(n=28/17/11)	1.8	0.9	25%	1.8	0.9	11%	1.9	0.9	14%
Landscape	(n=5/4/1)	1.3	0.8	40%	1.3	0.8	20%			20%
Livelihood	(n=33/17/16)	2.6	0.6	24%	2.4	0.7	9%	2.8	0.5	15%
Local Economy	(n=10/5/5)	3.2	0.5	40%	3.5	0.7	10%	2.5	0.3	30%
Local Institutions	(n=3/3/0)	2.0	1.0	0%	2.0	1.0	0%			0%
Resilience	(n=11/7/4)	2.4	0.6	0%	2.4	0.6	0%	2.3	0.6	0%
Seascape	(n=2/1/1)	2.0	1.0	50%	2.0	1.0	0%			50%
Water Security	(n=7/5/2)	2.0	1.0	14%	2.0	1.0	0%	2.0	1.0	14%
Wellbeing And Health	(n=53/32/21)	2.2	0.8	15%	2.2	0.8	8%	2.1	0.8	8%

= significant degradation	< 0.2	< 20%
= moderate degradation	0.2 - 0.4	20% - 40%
= remain the same	0.4 - 0.6	40% - 60%
= moderate improvement	0.6 - 0.8	60% - 80%
= significant improvement	≥ 0.8	≥ 80%

Impact

		Total			Contextual Research			Causal Research		
		Trend	Consensus	Uncertain	Trend	Consensus	Uncertain	Trend	Consensus	Uncertain
Coping Strategies	(n=4/2/2)	3.0	0.6	0%	3.0	0.6	0%	3.0	0.6	0%
Cultural Value Gain	(n=14/8/6)	3.3	0.7	50%	3.4	0.7	21%	3.0	0.6	29%
Cultural Value Loss	(n=50/30/20)	1.9	0.9	6%	1.8	0.9	4%	2.0	1.0	2%
Education Access	(n=5/5/0)	2.8	0.4	20%	2.8	0.4	20%			0%
Employment	(n=15/8/7)	2.7	0.5	27%	2.4	0.6	0%	3.7	0.5	27%
Food Access	(n=12/6/6)	2.1	0.8	17%	2.0	1.0	8%	2.2	0.7	8%
Food Availability	(n=21/14/7)	1.8	0.9	14%	1.7	0.8	5%	2.0	1.0	10%
Income	(n=31/13/18)	2.6	0.6	55%	2.6	0.5	19%	2.6	0.7	35%
Infrastructure Loss	(n=3/3/0)	1.7	0.8	0%	1.7	0.8	0%			0%
Leisure Activity Gain	(n=2/0/2)	4.0	1.0	50%			0%	4.0	1.0	50%
Leisure Activity Loss	(n=6/2/4)	1.5	0.8	0%	1.5	0.8	0%	1.5	0.8	0%
Medicinal Plants Access	(n=8/7/1)	2.3	0.8	13%	2.3	0.8	13%	2.0	1.0	0%
Mortality Rate	(n=5/3/2)	1.5	0.8	20%	1.5	0.8	20%	1.5	0.8	0%
Noncomunicable Deseases	(n=4/3/1)	2.7	0.6	25%	2.0	1.0	25%	4.0	1.0	0%
Quality Of Life	(n=3/3/0)	2.7	0.6	0%	2.7	0.6	0%			0%
Resources Access	(n=12/9/3)	2.2	0.8	25%	2.3	0.8	25%	2.0	1.0	0%
Social Capital	(n=2/1/1)	3.0	0.6	0%	4.0	1.0	0%	2.0	1.0	0%
Species Population	(n=53/23/30)	2.1	0.8	15%	1.8	0.8	6%	2.3	0.7	9%
Traditional Knowledge	(n=32/20/12)	2.2	0.7	9%	2.3	0.7	6%	2.1	0.8	3%
Vector-Borne Diseases	(n=1/1/0)	2.0	1.0	0%	2.0	1.0	0%			0%
Water Access	(n=3/2/1)	2.0	1.0	0%	2.0	1.0	0%	2.0	1.0	0%
Water Availability	(n=1/0/1)			100%			0%			100%
Water Quality	(n=1/1/0)	2.0	1.0	0%	2.0	1.0	0%			0%
Water Temperature	(n=2/1/1)	2.0	1.0	0%	2.0	1.0	0%	2.0	1.0	0%

= significant degradation	< 0.2	< 20%
= moderate degradation	0.2 - 0.4	20% - 40%
= remain the same	0.4 - 0.6	40% - 60%
= moderate improvement	0.6 - 0.8	60% - 80%
= significant improvement	≥ 0.8	≥ 80%

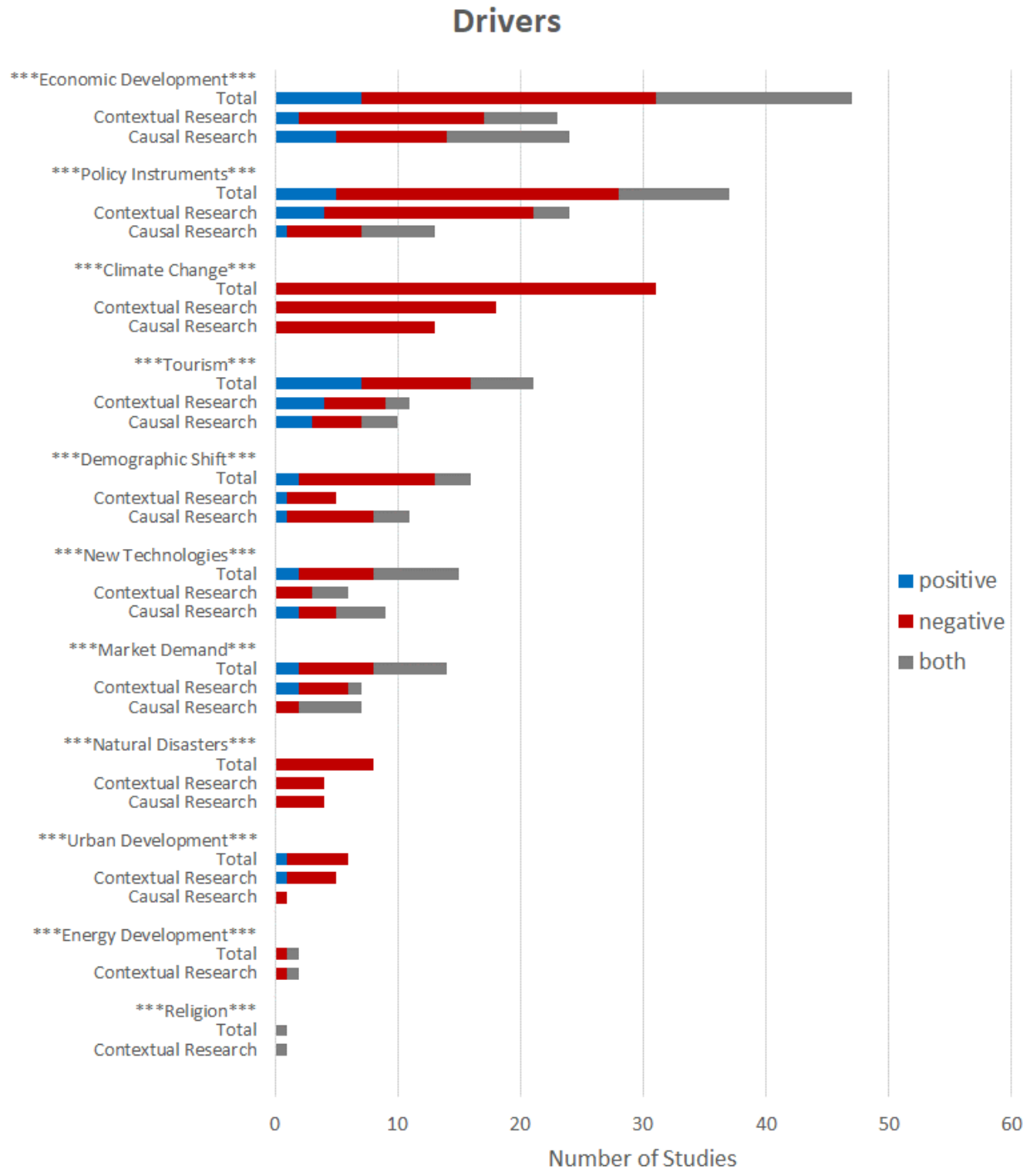
Response		Total			Contextual Research			Causal Research		
		Trend	Consensus	Uncertain	Trend	Consensus	Uncertain	Trend	Consensus	Uncertain
Adaptation Strategies	(n=12/6/6)	→ 3.3	◑ 0.4	67%	↗ 3.5	◔ 0.3	33%	→ 3.0	◑ 0.6	33%
Alternative Management	(n=24/15/9)	↗ 3.9	◑ 0.5	71%	↗ 3.6	◑ 0.4	42%	↑ 4.5	● 0.8	29%
Ban/Restrictions	(n=12/7/5)	↗ 4.0	● 1.0	75%	↗ 4.0	● 1.0	42%	↗ 4.0	● 1.0	33%
Capacity Building	(n=17/11/6)	→ 2.5	◔ 0.4	65%	↘ 2.0	◔ 0.4	47%	→ 3.0	◔ 0.4	18%
Co-Management	(n=23/17/6)	↘ 2.2	◑ 0.4	78%	↘ 1.5	● 0.8	65%	→ 2.7	◔ 0.2	13%
Community Projects	(n=3/2/1)	↗ 3.7	◑ 0.5	0%	↑ 4.5	● 0.8	0%	↘ 2.0	● 1.0	0%
Develop New Technologies	(n=1/1/0)			100%			100%			0%
Dissaster Mitigation Measures	(n=1/1/0)			100%			100%			0%
Education Programs	(n=20/10/10)	→ 2.7	◑ 0.4	70%	↘ 2.3	◑ 0.5	35%	→ 3.0	◔ 0.4	35%
Governance Improvement	(n=7/4/3)	→ 2.5	◕ 0.7	43%	→ 2.5	◕ 0.7	0%			43%
Holistic Approach	(n=39/22/17)	→ 2.9	◑ 0.5	67%	↘ 2.3	◑ 0.6	38%	↗ 3.7	◕ 0.8	28%
Livelihood Diversification	(n=2/1/1)	↗ 4.0	● 1.0	50%	↗ 4.0	● 1.0	0%			50%
Monitoring	(n=14/10/4)	↗ 4.0	● 1.0	71%	↗ 4.0	● 1.0	57%	↗ 4.0	● 1.0	14%
Payment For Ecosystem Services	(n=4/3/1)	↘ 2.0	● 1.0	75%	↘ 2.0	● 1.0	50%			25%
Priority Setting	(n=2/2/0)	↗ 4.0	● 1.0	50%	↗ 4.0	● 1.0	50%			0%
Rescue TEK	(n=3/2/1)	↗ 4.0	● 1.0	67%			67%	↗ 4.0	● 1.0	0%
Resettlement	(n=1/1/0)			100%			100%			0%
Set Protected Areas	(n=6/1/5)	↗ 4.0	● 1.0	67%			17%	↗ 4.0	● 1.0	50%
Strenghteng Local Institutions	(n=6/3/3)			100%			50%			50%
Sustainable Harvesting	(n=4/4/0)	↘ 2.3	● 0.8	25%	↘ 2.3	● 0.8	25%			0%

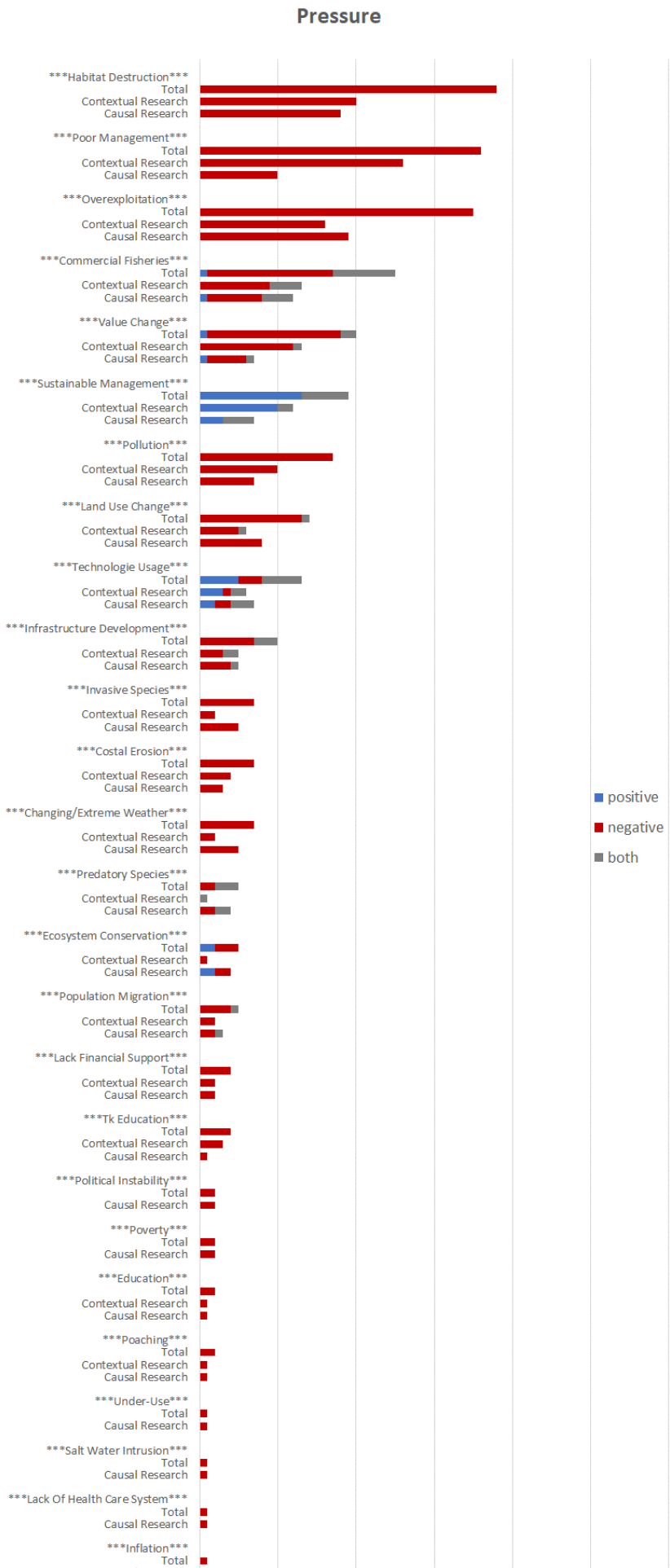
↓ = significant degradation	○ < 0.2	< 20%
↘ = moderate degradation	◔ 0.2 - 0.4	20% - 40%
→ = remain the same	◑ 0.4 - 0.6	40% - 60%
↗ = moderate improvement	◕ 0.6 - 0.8	60% - 80%
↑ = significant improvement	● ≥ 0.8	≥ 80%

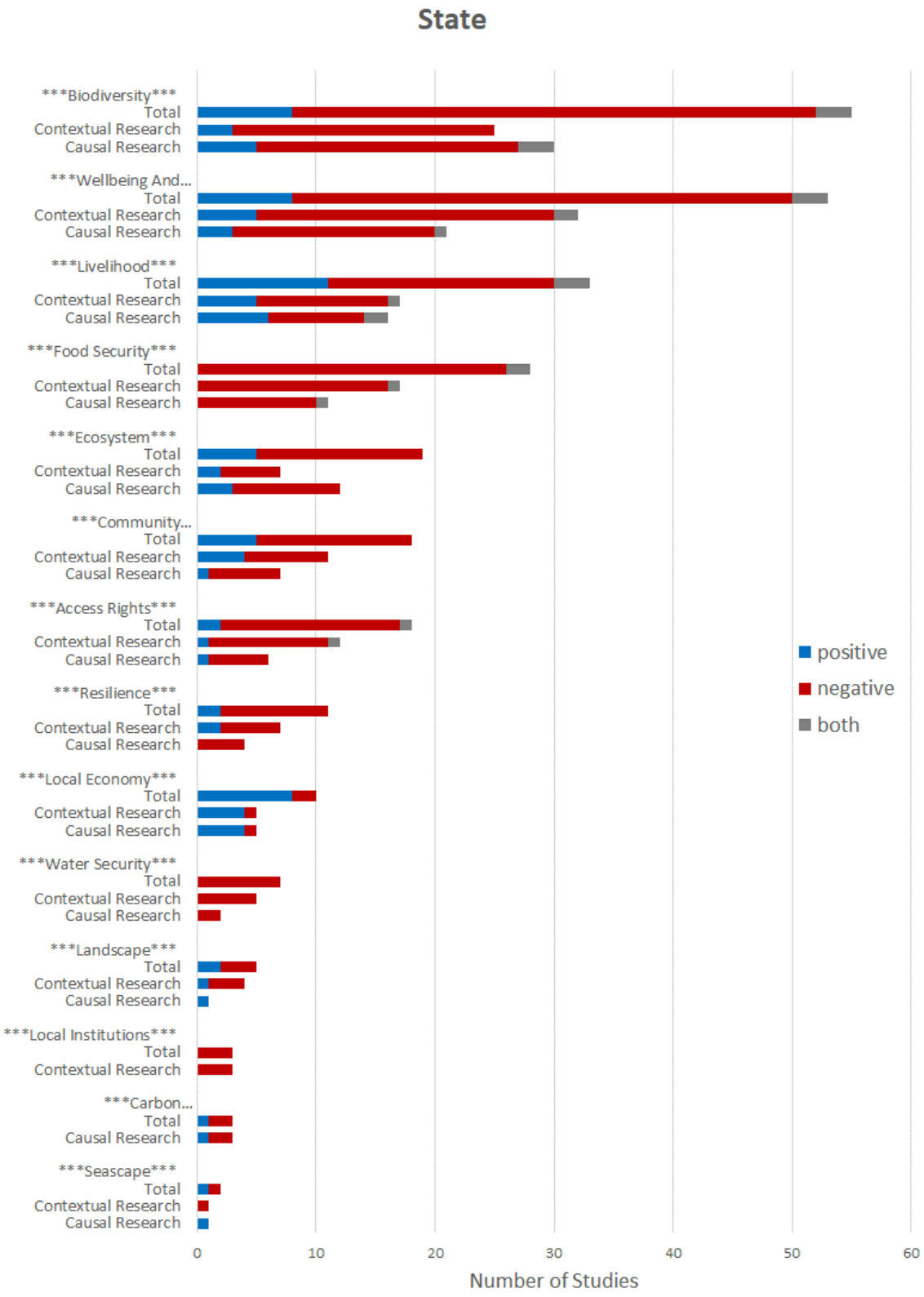
Note: Parentheses represent the number of papers that studied each variable (total/contextual/causal); Trends are based on an average of the results elicited from each individual study; Consensus (of the trend) is based on the level of agreement between studies. Uncertainty is based on the percentage of studies that identifies the variable without clear trend.

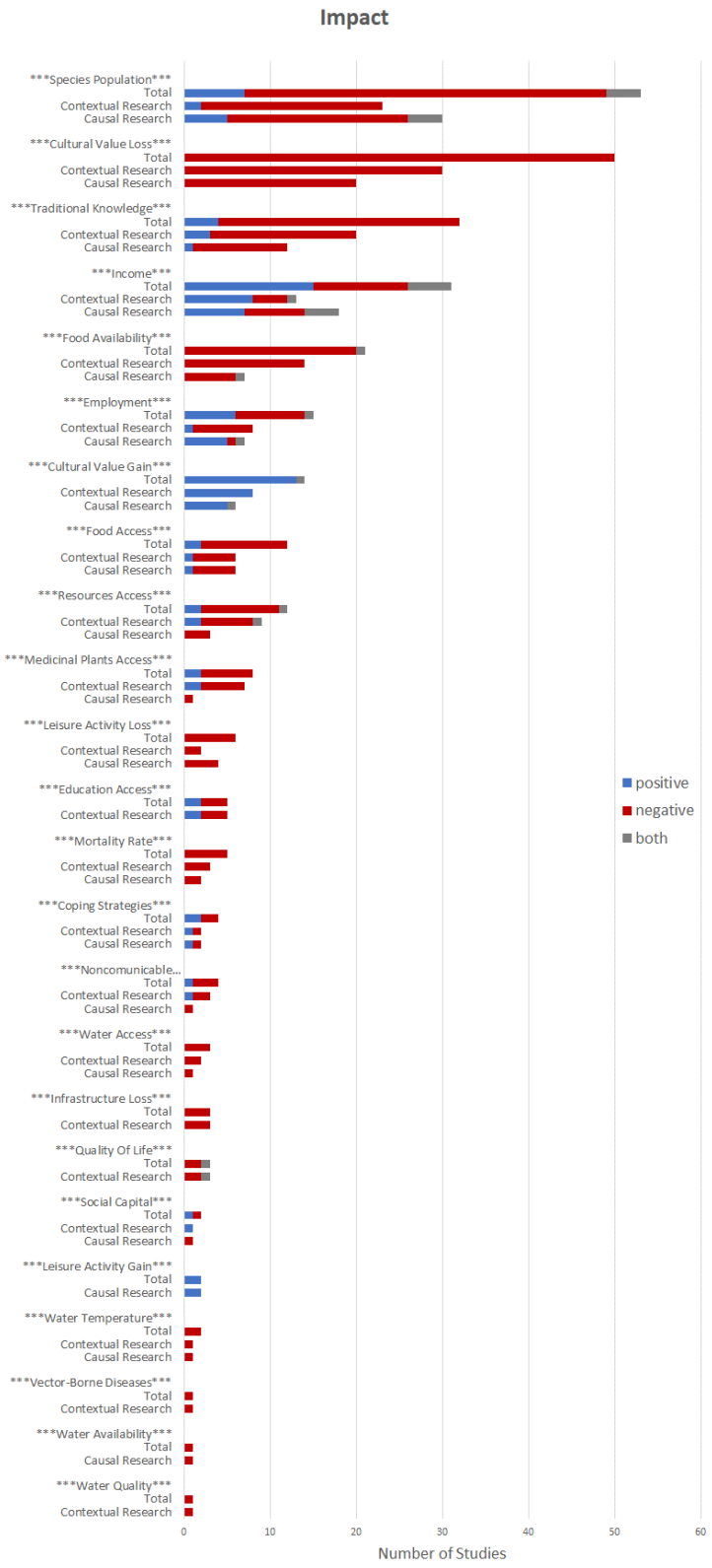
Appendix 9: Sentiment of DPSIR elements from similar studies

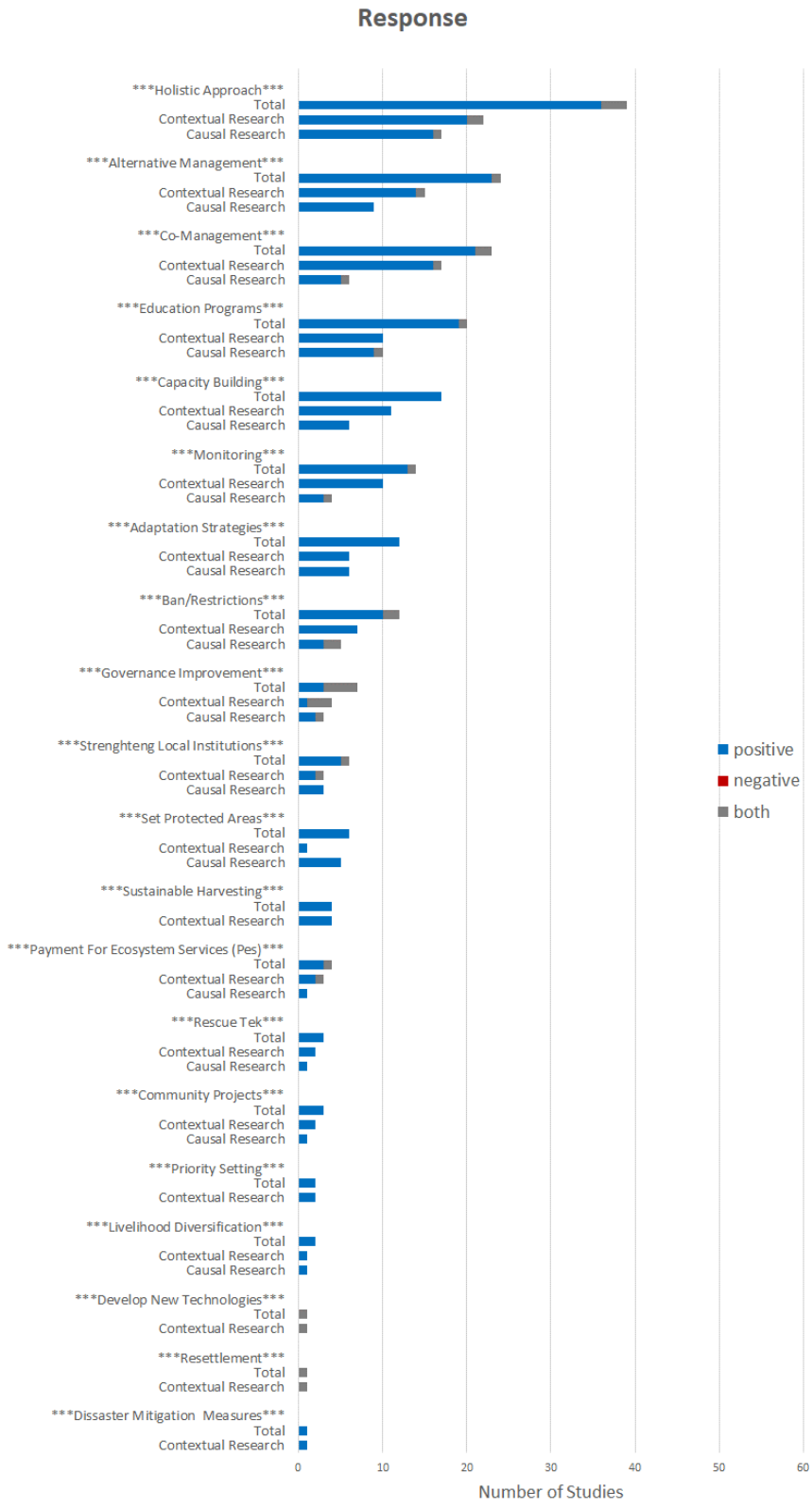
Sentiment of DPSIR elements from Indigenous People in Marine and Coastal System Research




Pressure
Habitat Destruction
Total
Contextual Research
Causal Research
Poor Management
Total
Contextual Research
Causal Research
Overexploitation
Total
Contextual Research
Causal Research
Commercial Fisheries
Total
Contextual Research
Causal Research
Value Change
Total
Contextual Research
Causal Research
Sustainable Management
Total
Contextual Research
Causal Research
Pollution
Total
Contextual Research
Causal Research
Land Use Change
Total
Contextual Research
Causal Research
Technologie Usage
Total
Contextual Research
Causal Research
Infrastructure Development
Total
Contextual Research
Causal Research
Invasive Species
Total
Contextual Research
Causal Research
Costal Erosion
Total
Contextual Research
Causal Research
Changing/Extreme Weather
Total
Contextual Research
Causal Research
Predatory Species
Total
Contextual Research
Causal Research
Ecosystem Conservation
Total
Contextual Research
Causal Research
Population Migration
Total
Contextual Research
Causal Research
Lack Financial Support
Total
Contextual Research
Causal Research
Tk Education
Total
Contextual Research
Causal Research
Political Instability
Total
Causal Research
Poverty
Total
Causal Research
Education
Total
Contextual Research
Causal Research
Poaching
Total
Contextual Research
Causal Research
Under-Use
Total
Causal Research
Salt Water Intrusion
Total
Causal Research
Lack Of Health Care System
Total
Causal Research
Inflation
Total
positive
negative
both


State
Biodiversity
Total
Contextual Research
Causal Research
***Wellbeing And...
Total
Contextual Research
Causal Research
Livelihood
Total
Contextual Research
Causal Research
Food Security
Total
Contextual Research
Causal Research
Ecosystem
Total
Contextual Research
Causal Research
***Community...
Total
Contextual Research
Causal Research
Access Rights
Total
Contextual Research
Causal Research
Resilience
Total
Contextual Research
Causal Research
Local Economy
Total
Contextual Research
Causal Research
Water Security
Total
Contextual Research
Causal Research
Landscape
Total
Contextual Research
Causal Research
Local Institutions
Total
Contextual Research
***Carbon...
Total
Causal Research
Seascape
Total
Contextual Research
Causal Research
positive
negative
both
0
10
20
30
40
50
60
Number of Studies


Impact
Species Population
Total
Contextual Research
Causal Research
Cultural Value Loss
Total
Contextual Research
Causal Research
Traditional Knowledge
Total
Contextual Research
Causal Research
Income
Total
Contextual Research
Causal Research
Food Availability
Total
Contextual Research
Causal Research
Employment
Total
Contextual Research
Causal Research
Cultural Value Gain
Total
Contextual Research
Causal Research
Food Access
Total
Contextual Research
Causal Research
Resources Access
Total
Contextual Research
Causal Research
Medicinal Plants Access
Total
Contextual Research
Causal Research
Leisure Activity Loss
Total
Contextual Research
Causal Research
Education Access
Total
Contextual Research
Mortality Rate
Total
Contextual Research
Causal Research
Coping Strategies
Total
Contextual Research
Causal Research
***Noncomunicable...
Total
Contextual Research
Causal Research
Water Access
Total
Contextual Research
Causal Research
Infrastructure Loss
Total
Contextual Research
Quality Of Life
Total
Contextual Research
Social Capital
Total
Contextual Research
Causal Research
Leisure Activity Gain
Total
Causal Research
Water Temperature
Total
Contextual Research
Causal Research
Vector-Borne Diseases
Total
Contextual Research
Water Availability
Total
Causal Research
Water Quality
Total
Contextual Research
0
10
20
30
40
50
60
Number of Studies
positive
negative
both


Response
Holistic Approach
Total
Contextual Research
Causal Research
Alternative Management
Total
Contextual Research
Causal Research
Co-Management
Total
Contextual Research
Causal Research
Education Programs
Total
Contextual Research
Causal Research
Capacity Building
Total
Contextual Research
Causal Research
Monitoring
Total
Contextual Research
Causal Research
Adaptation Strategies
Total
Contextual Research
Causal Research
Ban/Restrictions
Total
Contextual Research
Causal Research
Governance Improvement
Total
Contextual Research
Causal Research
Strenghteng Local Institutions
Total
Contextual Research
Causal Research
Set Protected Areas
Total
Contextual Research
Causal Research
Sustainable Harvesting
Total
Contextual Research
Payment For Ecosystem Services (Pes)
Total
Contextual Research
Causal Research
Rescue Tek
Total
Contextual Research
Causal Research
Community Projects
Total
Contextual Research
Causal Research
Priority Setting
Total
Contextual Research
Livelihood Diversification
Total
Contextual Research
Causal Research
Develop New Technologies
Total
Contextual Research
Resettlement
Total
Contextual Research
Dissaster Mitigation Measures
Total
Contextual Research
0
10
20
30
40
50
60
Number of Studies
positive
negative
both

Appendix 10: Perceived values of key SES components

Perceived values associated with components of Gunayala's social-ecological system.

	By Age Group			By Age Group and Sex					Total
	Adults	Young	Sig.	AW	AM	YW	YM	Sig.	Total
Agricultural Land	8.1	8.5		7.8	8.4	8.3	8.6		8.3
No Value	3 (3%)	1 (1%)		3 (5%)	0 (0%)	1 (2%)	0 (0%)		4 (2%)
Instrumental	76 (66%)	76 (66%)		38 (63%)	38 (68%)	36 (64%)	40 (67%)		152 (66%)
Option	14 (12%)	19 (16%)		8 (13%)	6 (11%)	10 (18%)	9 (15%)		33 (14%)
Bequest	33 (28%)	36 (31%)		19 (32%)	14 (25%)	16 (29%)	20 (33%)		69 (30%)
Intrinsic	14 (12%)	22 (19%)		8 (13%)	6 (11%)	10 (18%)	12 (20%)		36 (16%)
Relational	12 (10%)	28 (24%)	**	7 (12%)	5 (9%)	16 (29%)	12 (20%)	*	40 (17%)
Beach	6.7	7.4		7.1	6.3	6.8	8.0	*	7.1
No Value	18 (16%)	8 (7%)	*	3 (5%)	15 (27%)	8 (14%)	0 (0%)	***	26 (11%)
Instrumental	16 (14%)	24 (21%)		11 (18%)	5 (9%)	8 (14%)	16 (27%)		40 (17%)
Option	25 (22%)	29 (25%)		16 (27%)	9 (16%)	14 (25%)	15 (25%)		54 (23%)
Bequest	38 (33%)	47 (41%)		21 (35%)	17 (30%)	21 (38%)	26 (43%)		85 (37%)
Intrinsic	35 (30%)	47 (41%)		19 (32%)	16 (29%)	19 (34%)	28 (47%)		82 (35%)
Relational	4 (3%)	15 (13%)	**	3 (5%)	1 (2%)	6 (11%)	9 (15%)	*	19 (8%)
Coconut	7.6	7.6		7.6	7.5	7.3	8.0		7.6
No Value	12 (10%)	12 (10%)		6 (10%)	6 (11%)	9 (16%)	3 (5%)		24 (10%)
Instrumental	57 (49%)	58 (50%)		30 (50%)	27 (48%)	26 (46%)	32 (53%)		115 (50%)
Option	14 (12%)	21 (18%)		9 (15%)	5 (9%)	13 (23%)	8 (13%)		35 (15%)
Bequest	32 (28%)	28 (24%)		21 (35%)	11 (20%)	9 (16%)	19 (32%)		60 (26%)
Intrinsic	24 (21%)	30 (26%)		13 (22%)	11 (20%)	12 (21%)	18 (30%)		54 (23%)
Relational	12 (10%)	23 (20%)	*	5 (8%)	7 (13%)	12 (21%)	11 (18%)		35 (15%)
Coral Reef	6.9	7.0		6.9	6.8	6.4	7.6		6.9
No Value	15 (13%)	11 (9%)		8 (13%)	7 (13%)	9 (16%)	2 (3%)		26 (11%)
Instrumental	18 (16%)	19 (16%)		9 (15%)	9 (16%)	8 (14%)	11 (18%)		37 (16%)
Option	19 (16%)	20 (17%)		12 (20%)	7 (13%)	8 (14%)	12 (20%)		39 (17%)
Bequest	23 (20%)	19 (16%)		11 (18%)	12 (21%)	4 (7%)	15 (25%)		42 (18%)
Intrinsic	54 (47%)	61 (53%)		29 (48%)	25 (45%)	26 (46%)	35 (58%)		115 (50%)

Relational	8 (7%)	14 (12%)		2 (3%)	6 (11%)	7 (13%)	7 (12%)	22 (9%)
Fish	8.3	8.5		8.4	8.2	8.4	8.6	8.4
No Value	8 (7%)	4 (3%)		4 (7%)	4 (7%)	3 (5%)	1 (2%)	12 (5%)
Instrumental	73 (63%)	78 (67%)		41 (68%)	32 (57%)	37 (66%)	41 (68%)	151 (65%)
Option	4 (3%)	8 (7%)		1 (2%)	3 (5%)	3 (5%)	5 (8%)	12 (5%)
Bequest	12 (10%)	16 (14%)		5 (8%)	7 (13%)	6 (11%)	10 (17%)	28 (12%)
Intrinsic	26 (22%)	41 (35%)	*	15 (25%)	11 (20%)	23 (41%)	18 (30%)	67 (29%)
Relational	13 (11%)	13 (11%)		5 (8%)	8 (14%)	6 (11%)	7 (12%)	26 (11%)
Forest	7.5	7.5		7.6	7.3	7.2	7.9	7.5
No Value	10 (9%)	8 (7%)		5 (8%)	5 (9%)	7 (13%)	1 (2%)	18 (8%)
Instrumental	41 (35%)	49 (42%)		22 (37%)	19 (34%)	18 (32%)	31 (52%)	90 (39%)
Option	8 (7%)	14 (12%)		5 (8%)	3 (5%)	6 (11%)	8 (13%)	22 (9%)
Bequest	18 (16%)	19 (16%)		8 (13%)	10 (18%)	7 (13%)	12 (20%)	37 (16%)
Intrinsic	52 (45%)	48 (41%)		26 (43%)	26 (46%)	22 (39%)	26 (43%)	100 (43%)
Relational	29 (25%)	30 (26%)		16 (27%)	13 (23%)	15 (27%)	15 (25%)	59 (25%)
Galu	7.8	7.5		8.1	7.6	7.2	7.8	7.7
No Value	3 (3%)	14 (12%)	**	2 (3%)	1 (2%)	9 (16%)	5 (8%)	* 17 (7%)
Instrumental	19 (16%)	18 (16%)		11 (18%)	8 (14%)	7 (13%)	11 (18%)	37 (16%)
Option	19 (16%)	17 (15%)		11 (18%)	8 (14%)	5 (9%)	12 (20%)	36 (16%)
Bequest	28 (24%)	26 (22%)		16 (27%)	12 (21%)	11 (20%)	15 (25%)	54 (23%)
Intrinsic	13 (11%)	14 (12%)		6 (10%)	7 (13%)	4 (7%)	10 (17%)	27 (12%)
Relational	57 (49%)	64 (55%)		28 (47%)	29 (52%)	32 (57%)	32 (53%)	121 (52%)
Gold	5.1	5.7		5.2	5.0	5.2	6.2	5.4
No Value	32 (28%)	26 (22%)		18 (30%)	14 (25%)	16 (29%)	10 (17%)	58 (25%)
Instrumental	4 (3%)	6 (5%)		4 (7%)	0 (0%)	2 (4%)	4 (7%)	10 (4%)
Option	36 (31%)	37 (32%)		18 (30%)	18 (32%)	16 (29%)	21 (35%)	73 (31%)
Bequest	30 (26%)	33 (28%)		18 (30%)	12 (21%)	10 (18%)	23 (38%)	63 (27%)
Intrinsic	9 (8%)	11 (9%)		2 (3%)	7 (13%)	4 (7%)	7 (12%)	20 (9%)
Relational	13 (11%)	16 (14%)		7 (12%)	6 (11%)	6 (11%)	10 (17%)	29 (13%)
Homeland	8.6	8.6		8.6	8.5	8.5	8.7	8.6
No Value	1 (1%)	1 (1%)		1 (2%)	0 (0%)	1 (2%)	0 (0%)	2 (1%)
Instrumental	25 (22%)	27 (23%)		13 (22%)	12 (21%)	13 (23%)	14 (23%)	52 (22%)
Option	9 (8%)	15 (13%)		3 (5%)	6 (11%)	4 (7%)	11 (18%)	24 (10%)

Bequest	50 (43%)	47 (41%)	29 (48%)	21 (38%)	22 (39%)	25 (42%)		97 (42%)
Intrinsic	22 (19%)	29 (25%)	9 (15%)	13 (23%)	15 (27%)	14 (23%)		51 (22%)
Relational	50 (43%)	61 (53%)	25 (42%)	25 (45%)	26 (46%)	35 (58%)		111 (48%)
Lobster	7.6	7.8	7.8	7.3	7.5	8.0		7.7
No Value	10 (9%)	5 (4%)	2 (3%)	8 (14%)	4 (7%)	1 (2%)	*	15 (6%)
Instrumental	59 (51%)	55 (47%)	34 (57%)	25 (45%)	25 (45%)	30 (50%)		114 (49%)
Option	12 (10%)	11 (9%)	4 (7%)	8 (14%)	4 (7%)	7 (12%)		23 (10%)
Bequest	15 (13%)	21 (18%)	11 (18%)	4 (7%)	4 (7%)	17 (28%)	**	36 (16%)
Intrinsic	42 (36%)	50 (43%)	24 (40%)	18 (32%)	24 (43%)	26 (43%)		92 (40%)
Relational	5 (4%)	11 (9%)	1 (2%)	4 (7%)	6 (11%)	5 (8%)		16 (7%)
Mangroves	6.9	7.0	7.0	6.8	6.4	7.5		6.9
No Value	12 (10%)	11 (9%)	4 (7%)	8 (14%)	10 (18%)	1 (2%)	*	23 (10%)
Instrumental	13 (11%)	13 (11%)	8 (13%)	5 (9%)	5 (9%)	8 (13%)		26 (11%)
Option	15 (13%)	12 (10%)	9 (15%)	6 (11%)	4 (7%)	8 (13%)		27 (12%)
Bequest	17 (15%)	22 (19%)	6 (10%)	11 (20%)	6 (11%)	16 (27%)	*	39 (17%)
Intrinsic	64 (55%)	62 (53%)	37 (62%)	27 (48%)	24 (43%)	38 (63%)		126 (54%)
Relational	13 (11%)	17 (15%)	4 (7%)	9 (16%)	7 (13%)	10 (17%)		30 (13%)
Sea	7.4	7.8	7.5	7.4	7.4	8.2		7.6
No Value	11 (9%)	7 (6%)	2 (3%)	9 (16%)	5 (9%)	2 (3%)	*	18 (8%)
Instrumental	32 (28%)	34 (29%)	20 (33%)	12 (21%)	14 (25%)	20 (33%)		66 (28%)
Option	6 (5%)	9 (8%)	3 (5%)	3 (5%)	2 (4%)	7 (12%)		15 (6%)
Bequest	26 (22%)	24 (21%)	15 (25%)	11 (20%)	11 (20%)	13 (22%)		50 (22%)
Intrinsic	60 (52%)	58 (50%)	30 (50%)	30 (54%)	24 (43%)	34 (57%)		118 (51%)
Relational	15 (13%)	19 (16%)	9 (15%)	6 (11%)	8 (14%)	11 (18%)		34 (15%)
Nature/Landscape	8.4	8.2	8.5	8.3	7.8	8.6		8.3
No Value	2 (2%)	3 (3%)	0 (0%)	2 (4%)	3 (5%)	0 (0%)		5 (2%)
Instrumental	57 (49%)	61 (53%)	30 (50%)	27 (48%)	28 (50%)	33 (55%)		118 (51%)
Option	12 (10%)	9 (8%)	7 (12%)	5 (9%)	2 (4%)	7 (12%)		21 (9%)
Bequest	22 (19%)	20 (17%)	10 (17%)	12 (21%)	9 (16%)	11 (18%)		42 (18%)
Intrinsic	46 (40%)	52 (45%)	25 (42%)	21 (38%)	23 (41%)	29 (48%)		98 (42%)
Relational	27 (23%)	35 (30%)	14 (23%)	13 (23%)	17 (30%)	18 (30%)		62 (27%)
Sea Turtle	6.8	7.0	7.1	6.5	6.6	7.4		6.9
No Value	25 (22%)	20 (17%)	9 (15%)	16 (29%)	14 (25%)	6 (10%)	*	45 (19%)

Instrumental	21 (18%)	21 (18%)		12 (20%)	9 (16%)	12 (21%)	9 (15%)	42 (18%)
Option	9 (8%)	11 (9%)		6 (10%)	3 (5%)	2 (4%)	9 (15%)	20 (9%)
Bequest	14 (12%)	17 (15%)		10 (17%)	4 (7%)	4 (7%)	13 (22%) *	31 (13%)
Intrinsic	52 (45%)	60 (52%)		29 (48%)	23 (41%)	26 (46%)	34 (57%)	112 (48%)
Relational	8 (7%)	16 (14%)		4 (7%)	4 (7%)	4 (7%)	12 (20%) *	24 (10%)
River	7.9	8.0		8.1	7.8	7.6	8.4	8.0
No Value	13 (11%)	5 (4%)	*	4 (7%)	9 (16%)	5 (9%)	0 (0%) *	18 (8%)
Instrumental	54 (47%)	57 (49%)		26 (43%)	28 (50%)	26 (46%)	31 (52%)	111 (48%)
Option	3 (3%)	7 (6%)		2 (3%)	1 (2%)	2 (4%)	5 (8%)	10 (4%)
Bequest	19 (16%)	25 (22%)		12 (20%)	7 (13%)	12 (21%)	13 (22%)	44 (19%)
Intrinsic	48 (41%)	43 (37%)		27 (45%)	21 (38%)	19 (34%)	24 (40%)	91 (39%)
Relational	13 (11%)	14 (12%)		9 (15%)	4 (7%)	7 (13%)	7 (12%)	27 (12%)
Dolphin	5.9	6.3		5.9	5.8	6.1	6.5	6.1
No Value	32 (28%)	24 (21%)		14 (23%)	18 (32%)	13 (23%)	11 (18%)	56 (24%)
Instrumental	2 (2%)	9 (8%)	*	1 (2%)	1 (2%)	2 (4%)	7 (12%) *	11 (5%)
Option	7 (6%)	14 (12%)		6 (10%)	1 (2%)	9 (16%)	5 (8%)	21 (9%)
Bequest	14 (12%)	13 (11%)		11 (18%)	3 (5%)	3 (5%)	10 (17%) *	27 (12%)
Intrinsic	51 (44%)	50 (43%)		27 (45%)	24 (43%)	19 (34%)	31 (52%)	101 (44%)
Relational	11 (9%)	22 (19%)	*	4 (7%)	7 (13%)	9 (16%)	13 (22%)	33 (14%)

Appendix 11: SDG Interlinkages Summary

SDG interlink matrix heatmap showing the unique combinations of related SDG targets for Gunayala's SES.

	SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG 10	SDG 11	SDG 12	SDG 13	SDG 14	SDG 15	SDG 16	SDG 17	*Total*
SDG 1																		***0***
SDG 2		16																***16***
SDG 3	1	30	16															***47***
SDG 4		8	10	8														***26***
SDG 5		4	9	2														***15***
SDG 6	4		10			6												***20***
SDG 7		2	6			4	1											***13***
SDG 8	1		1			2												***4***
SDG 9				4			2											***6***
SDG 10								1										***1***
SDG 11	3	7	12	8	3	9	4	2	2		5							***55***
SDG 12	2		7	1	1	8	4	2	1		10	1						***37***
SDG 13	1		1			3		1			2	2						***10***
SDG 14	2	11	8	5	1	7	4	2	2		9	9	1	10				***71***
SDG 15			1	1	1				1		2	1		1				***8***
SDG 16		16	12	6	4			1		1	4	3		3	3	7		***60***
SDG 17											1	1		1	1		1	***5***
Total	***14***	***94***	***93***	***35***	***10***	***39***	***15***	***9***	***6***	***1***	***33***	***17***	***1***	***15***	***4***	***7***	***1***	***394***