RESEARCH PAPER

DRIVERS OF DEFORESTATION AND FOREST DEGRADATION IN PALAWAN, PHILIPPINES: AN ANALYSIS USING SOCIAL-ECOLOGICAL SYSTEMS (SES) AND INSTITUTIONAL ANALYSIS AND DEVELOPMENT (IAD) APPROACHES

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Received: May 26th, 2022 / Accepted: November 11th, 2022 / Published: December 31st, 2022
https://DOI-10.24057/2071-9388-2022-081

ABSTRACT. Palawan Island is home to one of Southeast Asia's largest, oldest, and most diversified rainforests hence it was called the «Last Frontier.» However, the island province's forest is contending with increased conversion of forest lands to plantation and household-level agriculture, intensive mineral mining, illegal logging, and other pressures on its ecosystems. Understanding these factors in relation to the prevalence of deforestation and forest degradation in Palawan is imperative. This paper analyzed these drivers of deforestation and forest degradation in Palawan using the social-ecological systems (SES) and institutional analysis development (IAD) frameworks. A literature review was conducted using a variety of web-based databases and sources and additional data were collected from official websites and reports. The identified major drivers of deforestation and forest degradation in the province include increasing population, migration from lowland to upland areas, illegal logging, mining, wide-scale *kaingin* and oil palm plantation, wildlife poaching, and weak policy implementation and enforcement. These identified drivers can be the target of the government of Palawan for their forest management plans. Additional findings and recommendations of this paper will also aid in the forest management planning in Palawan and other areas where similar settings exist.

KEYWORDS: deforestation, Palawan, social-ecological systems, institutional analysis and development, resource conflict

CITATION: Nolos R. C., Zamroni A., Evina K.F.P. (2022). Drivers Of Deforestation And Forest Degradation In Palawan, Philippines: An Analysis Using Social-Ecological Systems (SES) And Institutional Analysis And Development (IAD) Approaches. Geography, Environment, Sustainability, 4(15), 44-56
https://DOI-10.24057/2071-9388-2022-081

ACKNOWLEDGEMENTS: The authors thank Dr. Jessica Villanueva-Peyraube and Prof. Eduardo Roquiño who gave insights into this paper. They also want to extend their gratitude to Haris Nur Eka Prasetya who created some maps in the paper. They also thank Deutscher Akademischer Austauschdienst (DAAD) and Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) for giving scholarship funding for one of the authors (Akhmad Zamroni).

Conflict of interests: The authors reported no potential conflict of interest.

INTRODUCTION

Forests provide some of the world's most important ecosystem services. These include carbon sequestration (Richards and Stokes 2004), hydrologic cycle and nutrient cycling (Waring and Schlesinger 1985), watershed protection (Kramer et al. 1997), habitat for animals and biodiversity (Reeves and Daniels 2020), and livelihood for humans (Chechina et al. 2018) among others. However, just like any other ecosystems, forests are faced with a myriad of threats such as natural and anthropogenic forest fires (Johnson and Miyanishi 2001; Dugarjav et al. 2010; López and Saavedra 2021), climate change (Nikitin et al. 2019; Seidl et al. 2017), pollution (Smith 2012), and deforestation and forest degradation which are considered to be the biggest threats to the forests worldwide (Gichuki 2019). The act or process of converting forest land to non-forest land is known as deforestation, while forest degradation is

a decrease in forest production capacity as measured by forest quality, carbon stock, and vegetation type (Van Khuc et al. 2018). Both threats have far-reaching and long-term detrimental environmental repercussions. Degradation of habitat and loss of biodiversity, impairment of water quality, air pollution, increased emission of greenhouse gases, and diminution of ecosystem goods and services are just a few of these repercussions (Austin et al. 2019; Birhan et al. 2021; Engdaw, 2020; Ghazoul 2015).

The world's total forest area is 4.06 billion hectares (ha), or 31% of the total land area. Since 1990, deforestation has caused the loss of an estimated 420 million hectares of forest around the world (FAO 2020). Between 2015 and 2020, deforestation is expected to increase by 10 million hectares each year, with agricultural development remaining the primary cause of deforestation and forest degradation (Jayathilake et al. 2021). In 2010, 593 million people lived in Southeast Asia, comprising 11 nations (Brunei, Cambodia, East Timor, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam). Primary land use and land cover changes, as well as significant deforestation, have taken place in the area due to the increasing need for food, fiber, water, and shelter. Following the Amazon and the Congo Basin as the largest tropical rainforest regions in the world, Southeast Asia saw more dramatic annual deforestation than any other continent in the 1990s. From 2000 to 2010, this area was also a focal point for changes in the forest cover. For instance, Indonesia and Myanmar were listed among the top ten countries with the most significant annual net loss of forests (Dong et al. 2014). Southeast Asian nations had a crucial causal relationship between environmental-demographic factors and a lack of forest cover. The residual forest area was adversely associated with population density. According to numerous studies, the low remaining forest area results from high population pressure. Several factors also contribute to forest degradation, including irresponsible selective logging (both legal and illegal), shifting cultivation, small-holder forest encroachment, fuel wood collection, wood extraction for charcoal production, overgrazing, fires, and even modifications to natural water regimes (Koike et al. 2013). Southeast Asia's leading cause of forest loss has been the expansion of agriculture in the lowlands. In Southeast Asia, conflicts over the ownership and control of natural resources and ecological advantages have a long history. These conflicts range from land occupations and resistance to forest eviction to opposition to mega-dams and mining operations. Land politics has been heavily influenced by land control, alienation, and dispossession since colonial domination (Pichler and Brad 2016).

The Philippines, like many other tropical countries, had a long history of forest loss, with the peak of deforestation occurring between 1977 and 1988, owing to 25-year logging concessions (Araza et al. 2021). The surviving rainforest in the country has been drastically decreased, from almost 70% in the 1900s to less than 10% now (Perez et al. 2020). Palawan Island is home to one of Southeast Asia's largest, oldest, and most diversified rainforests (Supsup et al. 2020). In addition to providing a home for wildlife and a source of income for its citizens, its forests prevent soil erosion, preserve watersheds, and mitigate the impacts of climate change. Despite possessing substantial protected areas and a large share of the country's surviving forests, Palawan is contending with increased conversion of forest lands to plantation and household-level agriculture, intensive mineral mining, illegal logging, and other pressures on its ecosystems. Palawan's natural forest cover decreased from 55 to 48% between 1992 and 2010, with an annual forest loss of 5,500 hectares (Supsup et al. 2020). Other socioeconomic difficulties in Palawan include a lack of renewable energy sources, poor solid waste management in city centers, low conservation activity, and a high poverty rate (Fuentes n.d.). Hence, understanding these factors in relation to the prevalence of forest degradation and deforestation in Palawan is imperative. Analyzing connections between biological and socioeconomic components of forest ecosystems, as well as their ramifications for ecosystem integrity, need a multidisciplinary framework that may give a shared lexicon for understanding emergent interaction patterns (Houballah 2019) as well as the possible causes of its degradation. This can be done by using various frameworks such as the social-ecological systems (SES) and institutional analysis and development (IAD). Such frameworks were used in various settings such as in small-scale fisheries (Basurto et al. 2013), mining (Nilsson et al. 2021), water resource management (Gain et al. 2021), resource governance (Clement 2010) and urban ecosystems (Mincey 2013). However, there were very few studies which analyzed the drivers of deforestation and forest degradation in Palawan with the mentioned frameworks, hence, this study was conducted. Institutional gaps were further identified and policy recommendations were provided.

MATERIALS AND METHODS

Study Area

Palawan is a 1 768-island province in the Philippines located at 9.8349° N and 118.7384° E (Figure 1). The main island is a narrow strip of land that stretches for 625 kilometers and is 40 kilometers broad at its widest point. It is located to the southwest of Luzon. The Sulu Sea is to the southeast and the South China Sea is to the northwest. It is separated from Borneo by the Balabac Strait, with Mindoro Island looming beyond the northeastern Mindoro Strait (NSO 2000). It is a long, narrow island that is the country's largest province and is known to have primary forests with high endemicity of flora and fauna (Araza et al. 2021). On mainland Palawan, there are two major climatic regions: the south-eastern side, which has little rainy season (maximum annual precipitation ≤ 2 000 mm), and the north-western side, which has a more noticeable rainy season (maximum annual precipitation 3 000 mm); both have mean annual temperatures of 27.3–28.0 °C (Supsup et al. 2020).

Literature Review and Data Collection

A literature review was conducted using a variety of web-based databases and sources. Some of the most major web-based databases used in this study include Google Scholar, Science Direct, and Scopus. The search focused on deforestation and forest degradation in the Philippines' Palawan province. A thorough grasp of this case study necessitates a review of some past research (Zamroni et al. 2020). Reading abstracts to comprehend the main idea of the previous study was conducted to deepen understanding of the article (Suprapto et al. 2017).

Annual statistics on forest cover and forest cover decline in Palawan were provided by Global Forest Watch (GFW), an open-source web program that uses real-time data to monitor global forests, Philippines from 2001 to 2020. Other secondary data were collected from the websites of

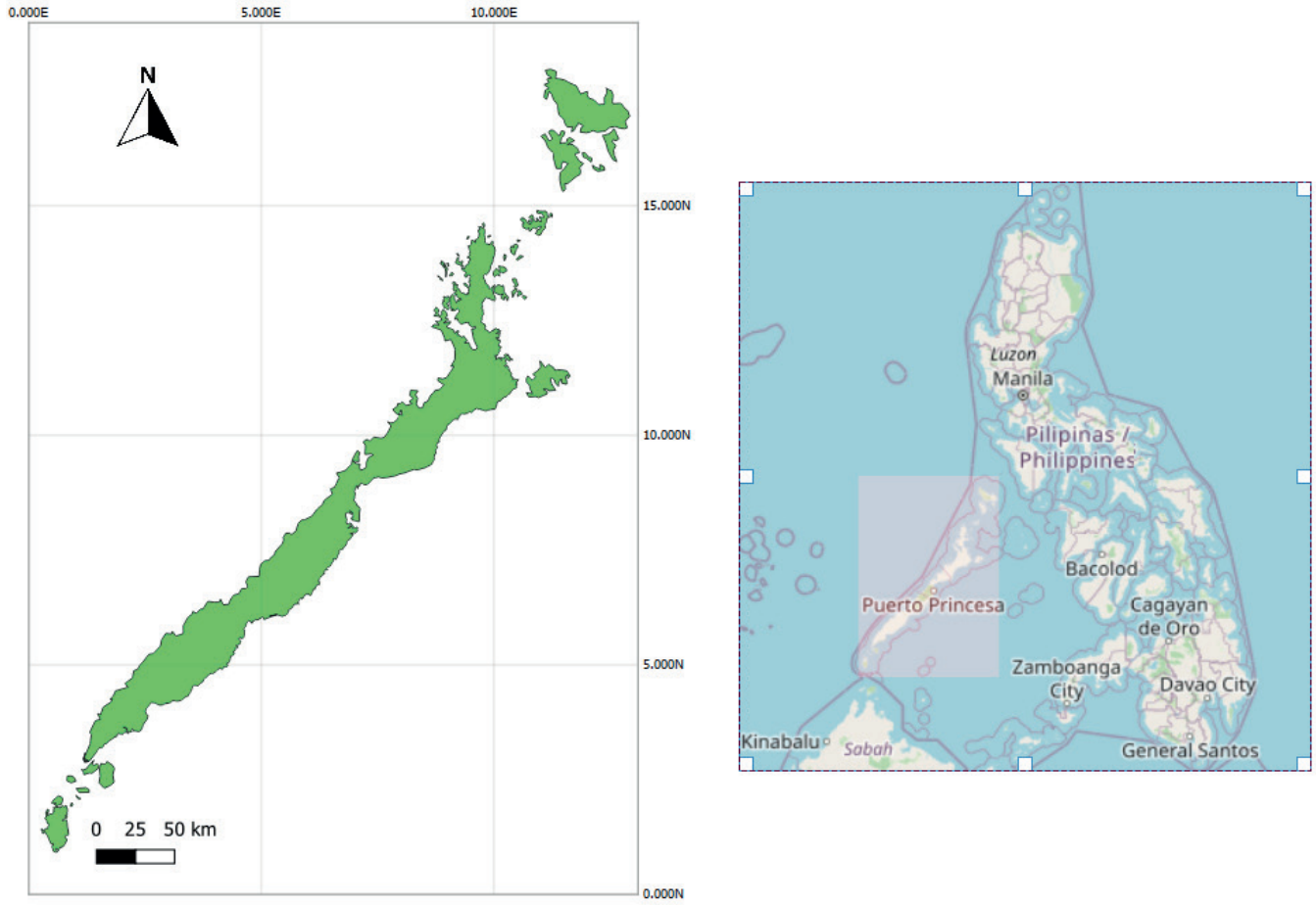

Fig. 1. Map of the study area

DENR-Forest Management Bureau and Philippine Statistics Authority. National and local reports were also utilized in this study.

Social-Ecological Systems (SES) Framework

The SES framework was used to analyze and understand the plethora of variables, its interaction, and outcomes to the forest ecosystem of Palawan, especially the drivers of forest degradation and deforestation (Partelow 2018). It is an important diagnostic tool which can be used to organize variables of interest and level of tier into connected groups. It identifies the characteristics and interactions of resource units, resource system, actors, and governance system, in a specific economic, social, and political setting. Because it is multi-tiered, the SES framework is hierarchical. Each of the variables in the first tier unpacks to expose a number of variables in the second tier, which can then unpack into a third tier, and so on (Basurto et al. 2013; Ostrom 2009). It is utilized a lot in the field of sustainability research.

Institutional Analysis and Development (IAD) Framework

The IAD framework is a multi-tiered conceptual map. Identification of an action arena, subsequent patterns of interactions and repercussions, and evaluation of these outcomes are all part of the framework (Ostrom 2010). Through a nested collection of operational, collective-choice rules, and constitutional, the IAD framework connects the decisions of actors at several governance levels (Clement 2010). It is a powerful analytical tool, particularly when looking at how local institutional structures affect natural-resource governance. This framework could be useful for a variety of tasks in decentralized forest governance research, including 1) establishing favorable conditions for good natural-resource governance, and 2) organizing efforts to track and learn about the impact of previous and current policy initiatives on sustainability (Andersson 2006).

RESULTS AND DISCUSSION

In the Lens of Socio-Ecological Systems Framework

The SES framework used in the Palawan forest case study is shown in Figure 2. The solid boxes represent first-tier categories, such as resource units, resource systems, actors, and governance systems, which are the highest-level variables. At the lower tiers, they have several variables. All of the actions in an action situation take place as interactions and then transform into outcomes. Dashed arrows show feedback from action circumstances to each of the top-tier categories. Any component of the SES can be affected by exogenous effects from linked natural systems or social-economic-political situations.

Social, economic, and political settings

Under this first-tier category, three (3) second-tiers were considered which include the demographic trends (S1), economic development (S2), and political stability (S3). For the demographic trends, there was an increase in the population of both the Palawan province and its capital, the Puerto Princesa City (PSA 2021). In 2000, the population in Palawan province (including Puerto Princesa City) was 755 412. In 2010, the population was 994 340 and in 2015, it was 1 104 585 (Figure 3). In the study of Carandang et al. (2013), it was found that the rapid growing population has a direct impact on the loss of forest cover in the Philippines. They selected sites in various provinces of the country which included Palawan.

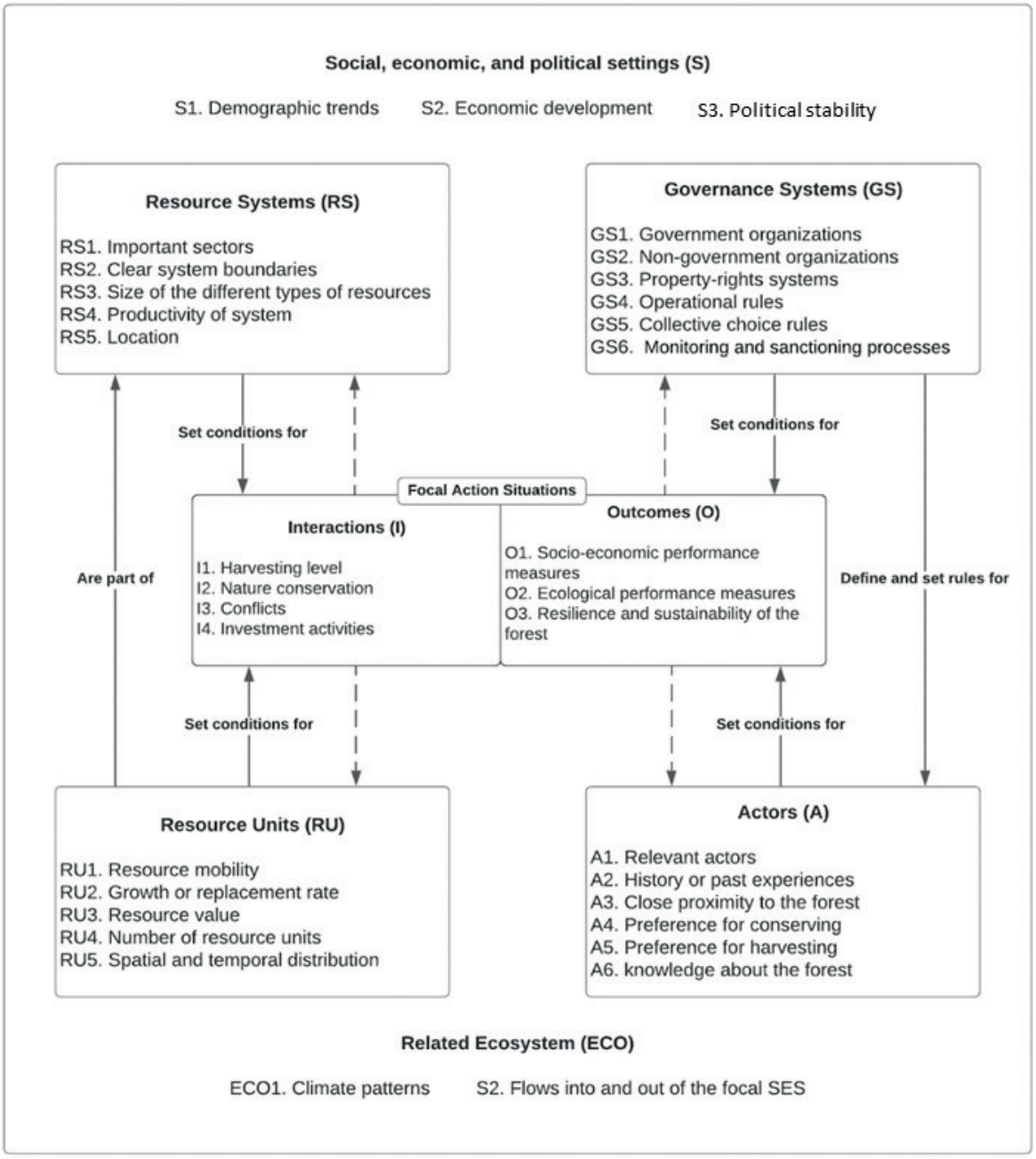

Fig. 2. The modified SES framework for the Palawan case study (Ostrom 2009)

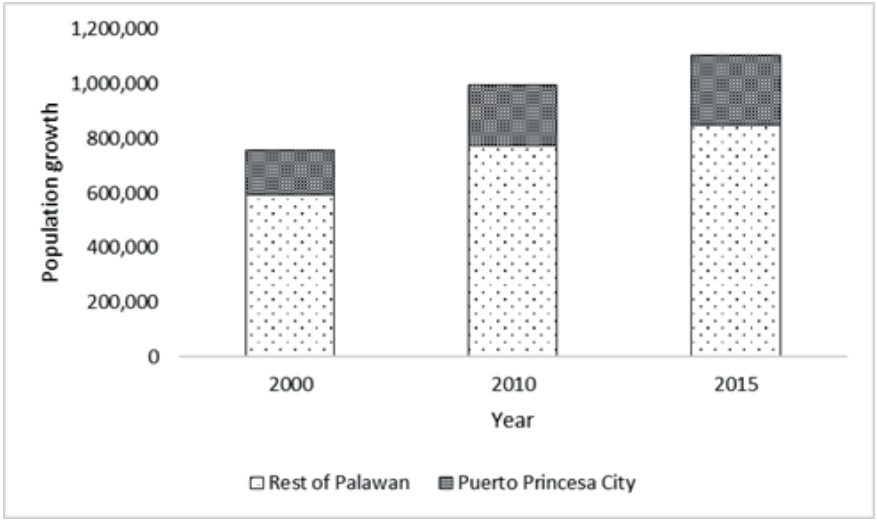

Fig. 3. Population growth in the Palawan province and Puerto Princesa City (2000-2015)

The immediate causes of the disappearance of the forests at a shocking rate are also brought by the settlement of lowlanders and commercial logging. The impacts of immigration and development are also found to increase the impacts not only on the forest but to other resources as well such as fishery, corals, and mangroves among others (Eder 1990).

For economic development, the Palawan province's employment sector is dominated by industry sectors. Figure 4 shows the labor productivity per sector in Palawan from 2009-2017. For agriculture, forestry, and fishing, there was an increasing trend from 68 365 (2009) to 119 321 (2017). The same goes for services where an increasing trend was shown from 116 839 (2009) to 191 751 (2017). However, a decreasing trend was observed for the industry sector where the labor productivity of 488 268 (2009) decreased to 374 266 (2017) (PSA, 2021).

There was also an increasing annual per capita income in the province of Palawan from 1994-2000 (PSA, 2018). The annual income per capita in the province was Php10 582 in 1994, Php18 673 in 1997, and Php26 279 in 2000. Additionally, the National Economic and Development Authority (NEDA) reported that the average annual family income in the province of Palawan in 2009 was Php132 640 (NEDA 2022). Although this figure was in average annual family income, it is still larger than the annual per capita income reported in the years 1994, 1997, and 2000.

For political stability, there were conflicts identified not only in the study area but in the entire country, as well. Many politicians and well-connected persons saw the forests as an asset from which they could derive benefits, which explains why many politicians were also loggers at the same time. During the 1950s-1970s, these perspectives supplied the push to rationalize and campaign for enormous mechanization of logging, which severely degraded natural forests (Guiang et al. 2001). Land-use conflicts between conservation and mining activities were also possible due to the lack of a clear delineation of protected area boundaries and uncertainty about the idea of intact forests (Carandang et al. 2013). As a result, disagreements are common when it comes to forest management, particularly when it comes to ownership and allocating resource rights.

Resource system

The environmental circumstances in which the resources are situated or produced are described in this first-tier category. Five (5) second-tier variables were considered which include important sectors (RS1), clear system boundaries (RS2), size of the different types of resources (RS3), productivity of the system (RS4), and location (RS5). The forest is considered to be the important sector here. The forest in Palawan is divided into five (5) major classifications as shown in Figure 5. National parks account for 51% of the total forest area in Palawan. This was followed by certified alienable and disposable land (30%), established timberland (12%), established forest reserves (5%), and civil reservation (2%) (DENR-FMB 2020).

Boundaries of regions such as forest can emerge over time or be imposed abruptly; they can be enforced by an external authority or a local faction in control, or they can be approved by vote or agreement. Custom, ritual, consensus, and/or compulsion can all be used to keep boundaries in place. By design or by accident, they may be more or less permeable (McDermott 2000). Also, unclear forest boundaries still exist in Palawan.

Moreover, based on the 19-year forest cover data of GFW in Palawan from 2001-2020, there was an increasing trend of forest cover loss in the province (Figure 6). A major forest cover loss was reported in 2016 which was more than 20 000 ha. This can be attributed to anthropogenic activities, especially illegal logging. Some of the illegal logging hotspots in Palawan are the municipalities of Brooke's Point and Taytay. On the other hand, the forest cover is slowly regained due to the reforestation projects of the government like the National Greening Program (NGP).

Resource units

The natural resource units created by the resource system are described by this variable. Five (5) second-tier variables were considered which include resource mobility (RU1), growth or replacement rate (RU2), resource value (RU3), number of resource units (RU4), and spatial and temporal distribution (RU5). The extent of Palawan's forests in 2010 (692 288 hectares) can be conservatively evaluated at Php 161 billion, based on multiple research, and includes regulating services (Php 111 billion), supporting services

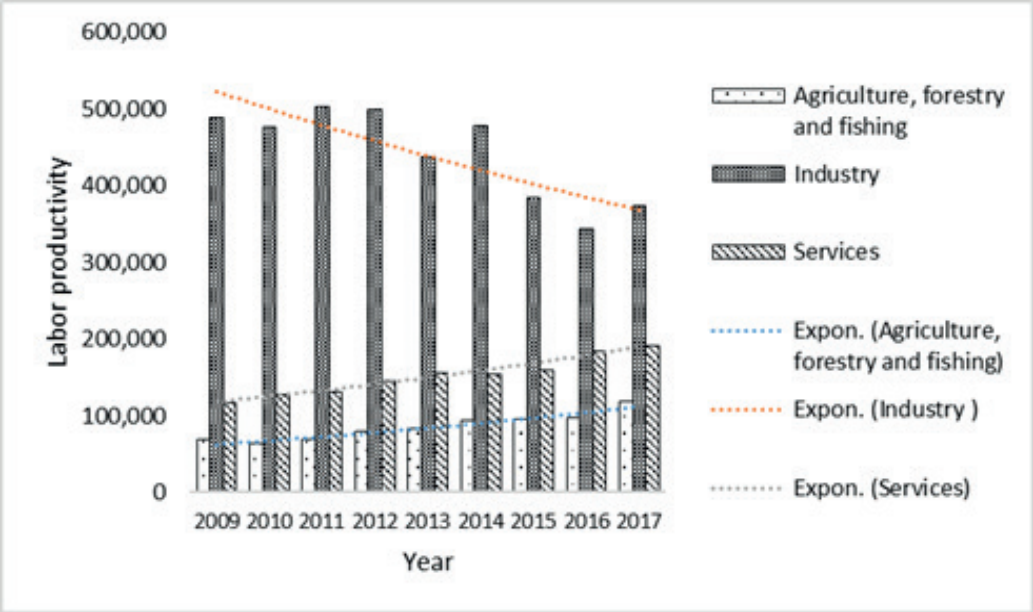

Fig. 4. Labor productivity per sector in Palawan from 2009-2017

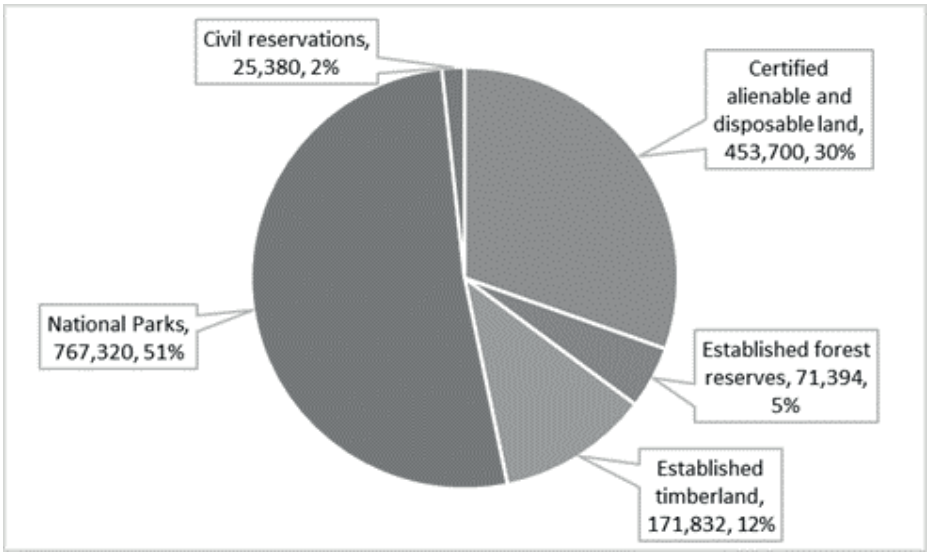

Fig. 5. Structure of forest lands in Palawan (ha)

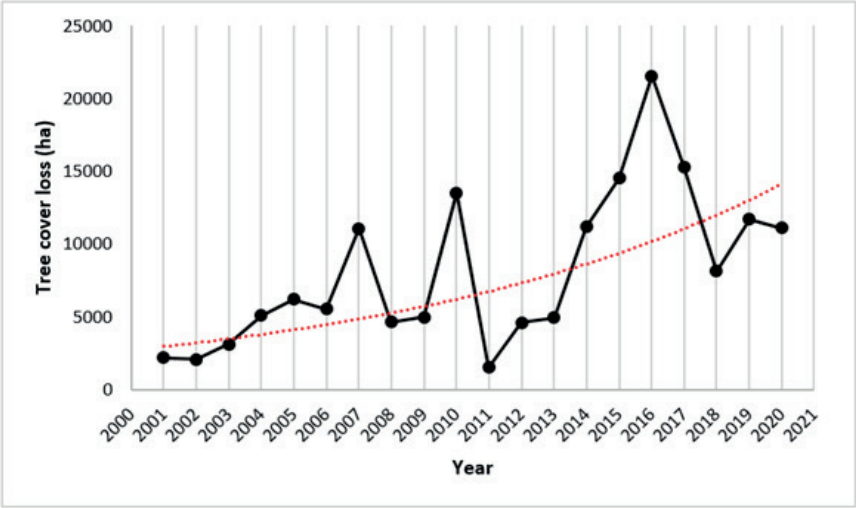

Fig. 6. Forest cover loss (ha) in Palawan, Philippines from 2001-2020

(Php 29 billion), and provisioning services (Php 21 billion) provided by forest ecosystems (Palawan LGU n.d.). One of the forest resources includes logs. The log production in Palawan in 2018, 2019, and 2020 was 9 601, 9 821, and 6 372.25 m^3, respectively.

Despite the fact that 48% of urban households and 71% of rural households in mainland Palawan got their fuelwood from their own farms, 25% of urban and 28% of rural residents still got it from public forest areas (Carandang et al. 2013). Moreover, extraction of non-timber forest products (NTFPs) continues to degrade forests in various parts of the Philippines, including Palawan. Many rural households in the Philippines benefit from NTFP gathering and harvesting since it provides them with additional monetary income. These can be utilized for either survival or commercial purposes. Some of the NTFPs derived from the forests of Palawan include wild honey, almaciga resin (*Agathis philippinensis*), stick broom from batbat leaf midribs (*Caryota sp.*), local bamboo poles, rattan, and buri (*Corypha elata*) among others (Matias et al. 2018).

Actors

Actors are simply the people affecting or affected by the resource. Six (6) second-tier variables were considered which include relevant actors (A1), history or past experiences (A2), close proximity to the forest (A3), preference for conserving (A4), preference for harvesting (A5), and knowledge about the forest (A6). Relevant actors include the community or people, private organizations, government organizations, and non-government organizations (NGOs). Despite its abundant natural resources, the province of Palawan has a high poverty rate. According to the 2014 Community-Based Monitoring System (CBMS) census, 61% of total households in Palawan's 20 (out of 23) municipalities earn less than the poverty line (Palawan LGU n.d.). The impacts of immigration and development are also found to increase the impacts on forest ecosystems. Special groups must also be considered under this sector which includes persons with disabilities, elderlies, and minority groups such as Tagbanua, Palaw'an, Tau't bato and the Bataks. Community and traditions values related to natural resource use include agricultural practices (i.e. monoculture and slash-and-burn activities) which are all contributing to Palawan's forest loss (Supsup et al. 2020).

Governance systems

Government, either local or national, is indispensable in the management and conservation of natural resources. Six (6) second-tier variables were considered which include government organizations (GS1), non-government organizations (GS2), property-rights systems (GS3), operational rules (GS4), collective choice rules (GS5), monitoring and sanctioning processes (GS6). Some of the line agencies when it comes to the management of natural resources like forest in Palawan are the Department of

Environment and Natural Resources (DENR), Department of Agriculture (DA), National Economic Development Authority (NEDA), Department of Interior and Local Government (DILG), and Department of Agrarian Reform (DAR). The roles of local government units (LGUs) in the management of forest resources cannot be neglected. They are on the ground, hence, they are knowledgeable of the things which are happening in their respective territories. However, it was also found out that some government officials are accomplices of illegal loggers and/or they are the ones owning illegal logging companies. NGOs, on the other hand, have spearheaded political projects aimed at mediating local–state relations in order to minimize, correct, and/or improve the effects of development and conservation. NGOs and their partners can use political action to help alter bad policies (Austin and Eder 2007).

Interactions

In Palawan, it is crucial to understand the relationships between the resource system and units, the governing system, and the actors. Four (4) second-tier variables under the subsystem interactions were considered. These are harvesting level (I1), nature conservation (I2), conflicts (I3), and investment activities (I4). Logs, fuelwood, and non-timber forest products are commonly harvested in the province either for subsistence or commercial uses. One of the well-known conservation efforts in the province is the World Network of Biosphere Reserves under the Man and Biosphere (MAB) Program of UNESCO (R. Fuentes n.d.) which encourages solutions that balance biodiversity protection with long-term use. However, resource conflicts exist in the province such as resource extraction, onshore mineral extraction using open pit technologies, land use change and conversion, expansion of exotic species plantations, and illegal wildlife trade (R. Fuentes n.d.) among others.

Outcomes

This subsystem represents the outcomes of the variables' interactions. Three (3) second-tier variables were considered namely socio-economic performance (O1), ecological performance measures (O2), and resiliency and sustainability of the forest (O3). It's noteworthy that the actors and the governance system are the major variables which greatly affect the conditions of the resource system and resource units. Good interactions among these variables will lead to the resource's efficiency and sustainability. On the other hand, the management measures that the actors do to the forest resources will be reciprocated by good environmental quality, resiliency, and abundant resources. This will, in turn, entail win-win conditions for all the variables involved. However, these ideal interactions are still persisted with negative ones which hamper the good outcomes that can arise from these.

Using the Institutional Analysis Development (IAD) framework

The IAD framework used in the Palawan forest case study is shown in Figure 7. These include the exogenous variables, action arena, interactions, outcomes, and the management plans. The exogenous variables include the biophysical/material conditions, attributes of the community, and the rules/governance. Action arena, on the other hand, consists of the interacting action situations and the participants. The exogenous variables affect the action arena resulting in particular interactions. These will result in outcomes which will require management plans and will have feedback loops to the exogenous variables and the action arena.

Exogenous variables
Biophysical/Material conditions

Palawan is a long, narrow island that is the country's largest province. Primary forests with high endemism of flora and fauna are known to exist in Palawan, although they are being threatened by a rise in active mining operations, slash-and-burn farming, oil palm expansion, and timber poaching (Araza et al. 2021). Due to its great biodiversity, it is recognized as the Philippines' «Last Frontier» (Matias et al. 2018). It has the country's largest terrestrial forest cover, accounting for 46% of the land area of Palawan Province. Palawan is also noted for having a

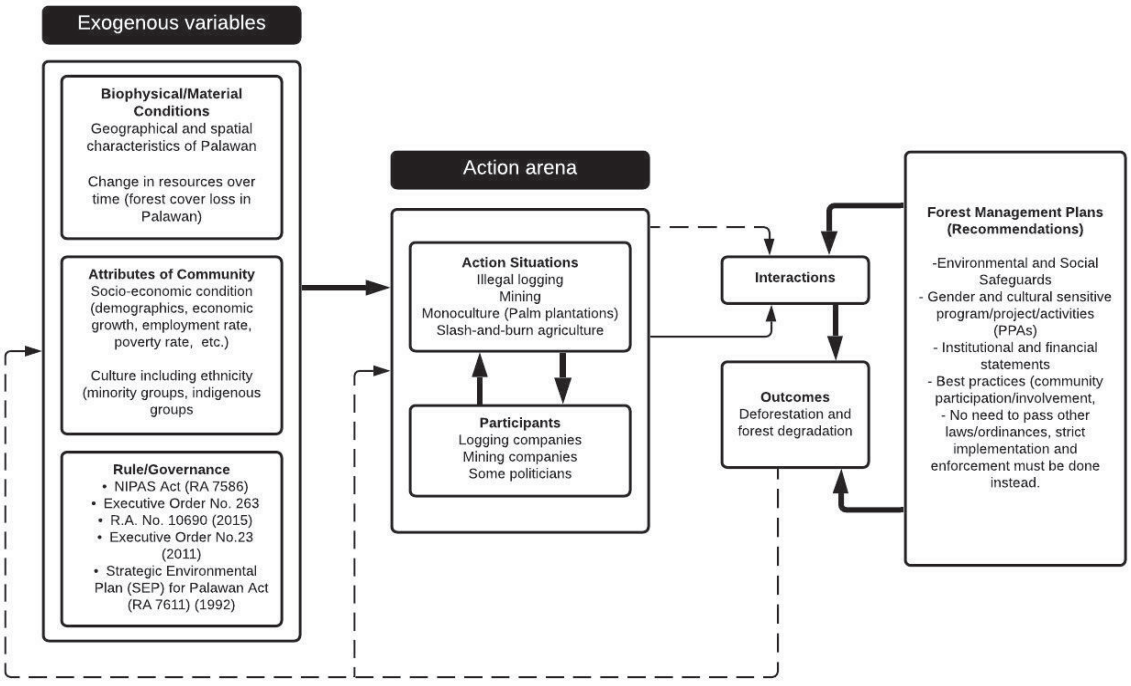

Fig. 7. The IAD framework for Palawan forest resources

large number of endemic plants and animals (Fuentes et al. 2015). However, an increasing trend of forest cover loss in Palawan was reported by the GFW from 2001-2020 as shown in Figure 6. Deforestation hotspots in Palawan are primarily located in the southern portion of the province which includes the Mt. Matalingahan and Malamplaya Protected Landscape (Araza et al. 2021). During the Marcos administration, deforestation became even worse. Timber Licensing Agreements (TLAs) and other timber license holders controlled over 10 million ha of land in the country, indicating that the logging sector was on the rise (Pamintuan 2011). Based on Landsat imagery from 1979, the government's Strategic Environmental Plan for Mainland Palawan estimated that 68% of the island was still forested. However, the forest is rapidly disappearing, at a rate of 19,000 hectares each year.

Attributes of the community

It describes the primary actors' historical background, values, culture, beliefs, religion, skills, knowledge, poverty level, health problems, and other socioeconomic aspects. This component was elaborated in the SES framework which shows the socio-demographic and economic conditions of the province (Figure 2). Increased demand for food, as a result of demographic variables such as population growth, may need the clearance of more land for agricultural expansion or subsistence farming (Carandang et al. 2013). Likewise, to make ends meet, many people who couldn't find jobs in the area turned to illegal logging, wood poaching, and *kaingin* production. On the other hand, local communities that rely on forest services become stewards of these resources, protecting them against illegal actions such as indigenous people. Environmental stewardship is becoming increasingly important to rural community leaders, who see it as a key component of their towns' long-term existence (Johnson 1993).

Indigenous people like Tagbanwa and Palawano are occupying the forest lands in Palawan. However, they are affected by the deforestation and forest degradation that are happening in the province. They mainly rely on the services provided by the forests, hence, these greatly affect their way of life. They have their cultural practices such as slash-and-burn methods of agriculture but for subsistence purposes only and these have very minimal impact on the forest ecosystem. What contribute largely to the land cover change and deforestation in Palawan are the logging activities for timber production, mining, and oil palm production. Malaysian and Filipino investors are reportedly cooperating to establish oil palm plantations in Palawan by renting smallholder farmers' and indigenous peoples' lands. Many smallholder agricultural farms, including indigenous fallow areas within forestlands, have already been turned to oil palm plantations, which require enormous tracts of land. The majority of oil palm farms are in the municipality of Espanola, but they are spreading to other towns in Palawan, including Brooke's Point, Quezon, and Bataraza (Carandang et al. 2013). In addition to local dynamics, macro-scale factors such as poverty, international prices of agricultural commodities and forest products, high rural population growth, and government land tenure policy all have a role in reducing forest cover.

Rules and Governance

The forests in the Philippines just like in Palawan are protected and conserved under various laws and provisions. These include the Executive Order (EO) 192 (1987), Local Government Code of 1991, National Integrated Protected Areas System (NIPAS) Act (RA 7586) of 1992, EO 263 (1995), and Indigenous People's Rights Act (RA 8371) of 1997 (Guiang et al. 2001).

Despite these many rules and laws on forest management, deforestation and forest degradation, not only in Palawan, but in the entire country still persist. According to Domingo and Manejar (2019), forest protection, as a policy, lacked adequate provisions for enforcement and institutionalization. Conflicting policy also opened forestlands to various extractive industries such as mining, exportation, timber and lumber businesses, contracting, and land conversions. In addition, Pulhin (2002) revealed that there (3) are three major concerns in forest policy formulation. These include the difficulty of achieving consensus among many policy actors, the urgent need for legislation that incorporates community-based forest management (CBFM's) methodology and aims, and the necessity to place a greater emphasis on monitoring and evaluating existing policies. Gradel et al. (2019) also argue that effective forest administration with local participation is significant to better support sustainable forestry.

Action arena

The action arena is made up of action situations and participants. The action situation is a social space in which actors interact, solve common problems, and trade services and goods; participants are those who participate in the situation (Nigussie et al. 2018).

Action situations

The action situations that were found to be imperative on the prevalence of forest degradation and deforestation in Palawan were the illegal logging, mining, monoculture, slash-and-burn type of agriculture, and immigration patterns. Land grabbing and illegal logging have increased in the frontier province, owing to the expansion of plantations and mining (Dressler 2021). The main issue is the difficulty of government forest guards to stop illegal logging activities in woods that are generally located in remote locations which they can barely protect due to lack of equipment and personnel support (Carandang et al. 2013). Just like a Palawan municipal official who attempted to curb illegal logging but was assassinated allegedly by the bodyguards of one of the province's most powerful politicians (Broad and Cavanagh 2020).

Mining is also prevalent in the province. In Southern Palawan province, specifically in Narra, Bataraza, and Quezon, about four (4) mining enterprises operate. While mining benefits mining towns and the country economically, it also has many social and environmental consequences (Agarin et al. 2021; Asih et al. 2022; Carandang et al. 2013; Nolos et al. 2022; Senoro et al. 2022; Zamroni et al. 2022). For example, the Rio Tuba Mine represents one of the Philippines' largest nickel ore reserves. In that area, chromium in the nickel laterite has polluted the surrounding surface water (Delina et al. 2020). To increase low-grade ore and laterite operations around the Mount Bulangao range in southern Palawan, the Rio Tuba Nickel Mining Corporation, a Filipino-Japanese partnership founded in 1973, has pushed to enclose ancestral territories and clear more forests. Up to 2176 hectares of ancestral lands of the Palawan have been claimed by Citi-Nickel Mining Corporation in Sofronio Española, located further north. Due to widespread evictions, toxic tailing

pond overflows into highland rivers, and lowland paddy irrigation schemes, NGOs and allies in Palawan have tried to prevent these practices (Dressler 2021). Figure 8 shows Google Earth images of the conditions before Rio Tuba Mine was developed in 1985 and after Rio Tuba Mine was developed in 2021. It can be seen also in the figure that the forest changes to mining land.

Participants

The IAD framework divides contextual elements into three (3) categories, which can be used to describe each actor's conduct in certain action situations: 1) physical factors, 2) community characteristics, and 3) institutional structures in the local area (Andersson 2006). The participants considered under the IAD framework were the logging and mining companies, government agencies, NGOs, and the community. Pagdanan Timber Products is the main logging enterprise in Palawan, and its politically powerful owner has Timber License Agreements covering a staggering 168 000 hectares. On the other hand, some of the major mining companies in the province are the Rio Tuba Nickel Mining Corporation in Puerto Princesa, Citinickel Mines and Development Corporation in Sofronio Española, and the Berong Nickel Corporation in Quezon, Palawan. The DENR-Mines and Geosciences Bureau has reported that the province of Palawan has the second largest nickel mine output in the Philippines in 2014 (PCSDC 2015). Figure 9 shows the nickel ore production in metric tons (MT) of the three (3) nickel mines in the province of Palawan in 2014. It is shown in the figure that the Rio Tuba Nickel Mining Corporation has the highest nickel mine output averaging to 4 800 000 MT. The Citinickel Mines and Development Corporation has a nickel mine output of approximately 2 200 000 MT while the Berong Nickel Corporation has 813 300 MT. Despite these mineral outputs which are important in the economy, mining causes deforestation and soil erosion of the area (Zambales 2021).

The role of government is also crucial in the management of forest resources. On the other hand, there were cases where many politicians and «well-connected» persons saw the forests as an asset from which they could derive benefits, which explains why many politicians were also loggers at the same time.

Interactions and Outcomes

By identifying the exogenous variables and the action arena, as well as their interactions, it's much clearer now why forest degradation and deforestation are prevalent in the province of Palawan. There were a myriad of drivers why these resource conflicts happen. The province has an increasing population which demands additional resources, land for housing or agriculture, and rapid migration to upland areas. These were then aggravated by major threats which include illegal logging, mining, oil palm plantation, wildlife poaching, and a wide-scale *kaingin* system. The slow rejuvenation of the forest makes it difficult to compensate for these lost resources, hence, degradation happens. Figure A1 shows a comparison of some parts of Palawan in year 2000 and 2020. It was evident from the images that parts of the province experienced deforestation and land cover changes, in general.

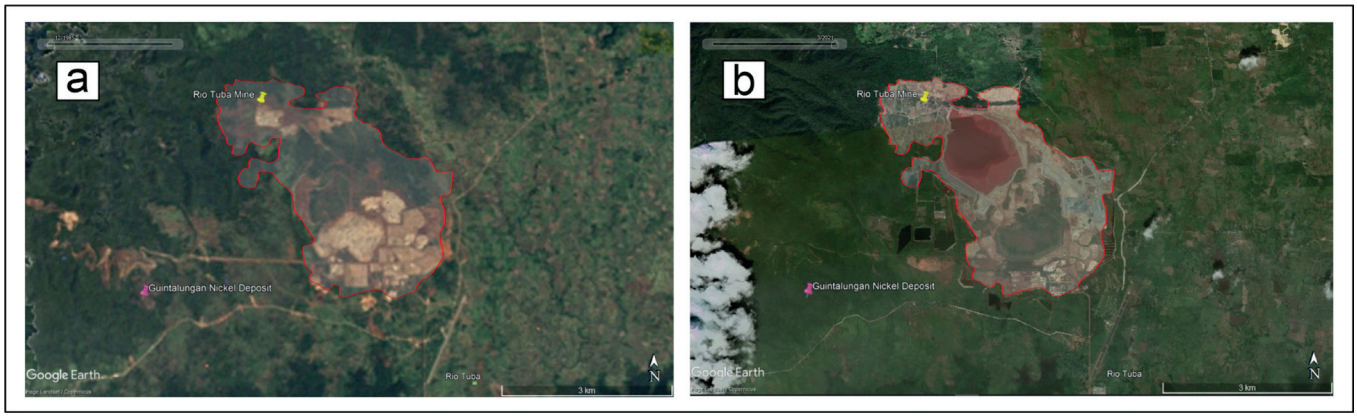

Fig. 8. Google Earth images, a) Before Rio Tuba Mine developed (1985), b) After Rio Tuba Mine developed (2021)

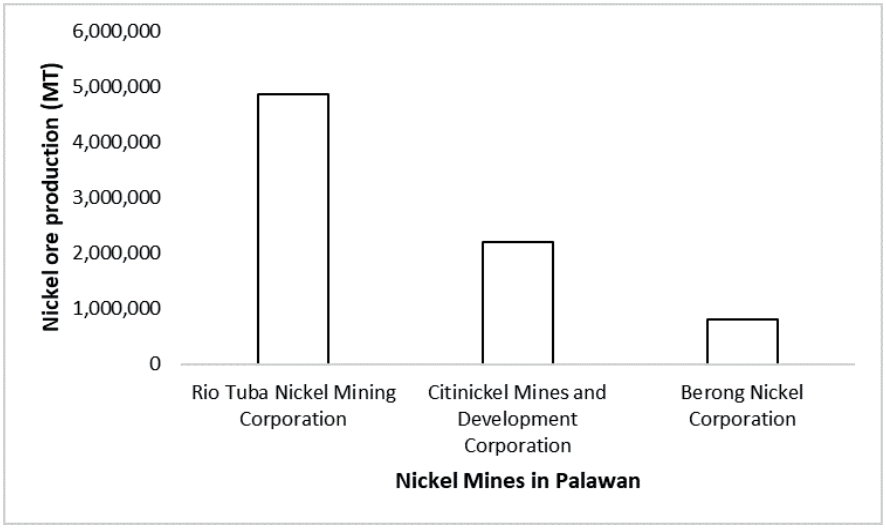

Fig. 9. Nickel ore production (MT) in the province of Palawan in 2014

Forest Management Plans

Inclusive and holistic approaches to the management and conservation of the forests in Palawan are to be considered. The institutional analysis revealed important aspects in the forest resources management in the province. Some of the recommended forest management plans are environmental and social safeguards, strict adherence to land use plan, culturally-sensitive programs, clear institutional and financial statements, community-involvement such as CBFM, reforestation such as the NGP, and the need for proper enforcement and implementation of existing forest laws instead of passing additional ones.

CONCLUSIONS

This paper analyzed and assessed the drivers of deforestation and forest degradation in the province of Palawan using the social-ecological systems (SES) and institutional analysis development (IAD) frameworks. Palawan Island is home to one of Southeast Asia's largest, oldest, and most diversified rainforests hence it was called the «Last Frontier». However, the island province's forest is contending with increased conversion of forest lands to plantation and household-level agriculture, intensive mineral mining, illegal logging, and other pressures on its ecosystems. Palawan's natural forest cover decreased from 55 to 48% between 1992 and 2010, with an annual forest loss of 5 500 ha. Further, the province still experienced forest cover loss in recent times as it was reported that approximately 23 400 ha of forest was lost from 2002 to 2021. The SES evaluated the variables like resource systems and units, governance systems, and actors considering the economic, social, and political settings of the study area. It revealed that aside from timber and logs, non-timber forest products (NTFPs) were also harvested in Palawan. These were initially harvested by indigenous peoples (IPs) for subsistence use but lowland communities partook on this which contributed to forest degradation. The increasing population and rapid migration from lowland areas to upland areas also contributed to this issue. On the other hand, the IAD identified major drivers of forest degradation and deforestation in the province which include illegal logging, mining, wide-scale *kaingin* and oil palm plantation, and wildlife poaching. Most of the illegal logging activities are in remote locations which the government forest guards can barely protect due to lack of equipment and personnel support. There were also cases where many politicians, who should be the frontline in forest management, saw the forests as an asset from which they could derive benefits, which explains why many of them were also loggers at the same time. There were already many laws on the Palawan forest resources conservation and management but the issue of deforestation still remains. The IAD also identified policy recommendations for forest management in Palawan which include strict adherence to land use plan, culturally-sensitive programs, clear institutional and financial statements, community-involvement such as CBFM, reforestation such as the NGP, and the need for proper implementation and enforcement of existing forest laws instead of passing additional ones. The findings and recommendations of this paper will aid in the policy-making of forest management plans in Palawan and other areas where similar settings exist.

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APPENDIX

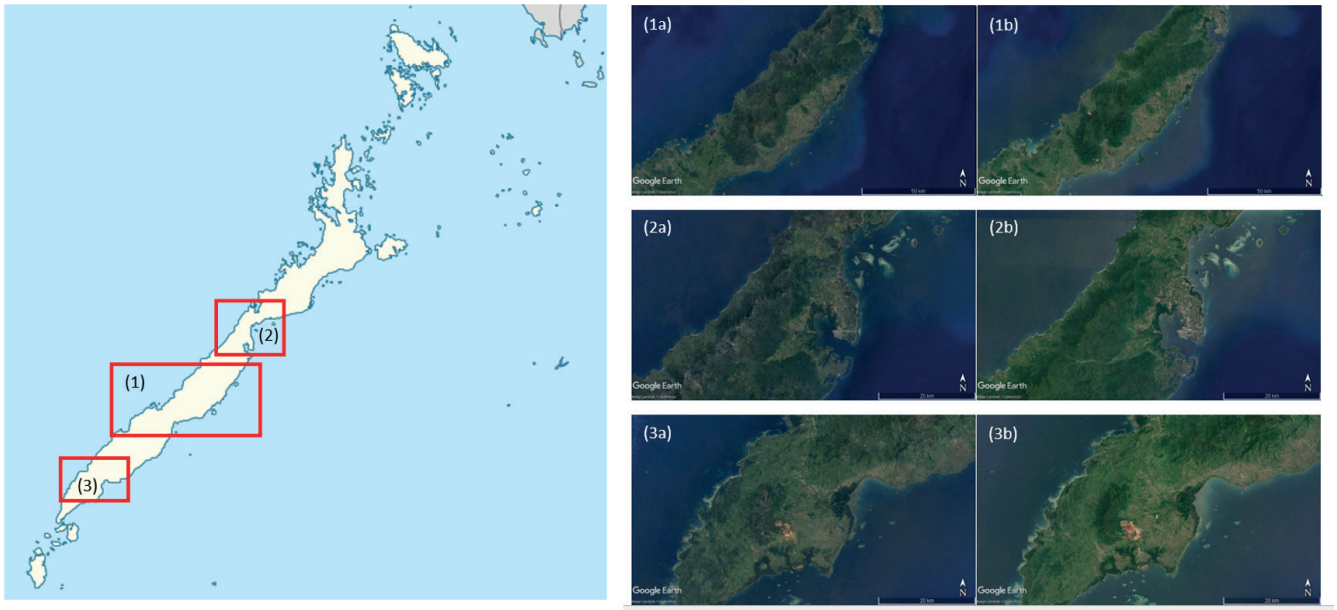

Fig. A1. Land cover change in some parts of the Palawan province in years 2000 (1a, 2a, and 3a) and 2020 (1b, 2b, and 3b)