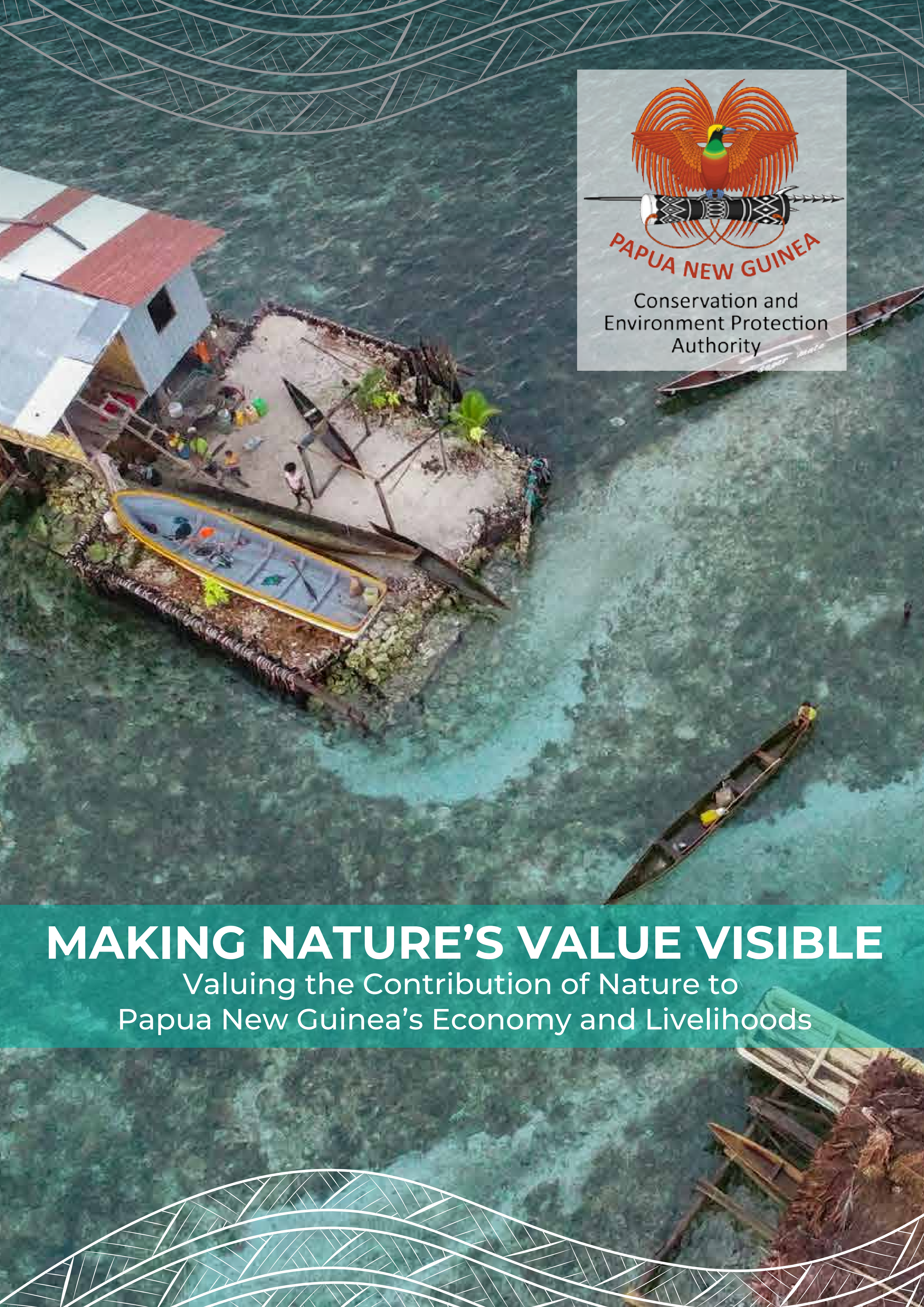

PAPUA NEW GUINEA

Conservation and Environment Protection Authority

MAKING NATURE'S VALUE VISIBLE

Valuing the Contribution of Nature to Papua New Guinea's Economy and Livelihoods

Sustainable Financing of Papua New Guinea's Protected Area Network
Valuing the Contribution of Nature to Papua New Guinea's Economy and Livelihoods

Analysis Report: Making Nature's Value Visible

2022

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ACRONYMS

ABV	Altruistic and Bequest Value
ADB	Asian Development Bank
APEC	Asia-Pacific Economic Cooperation
BT	Benefit Transfer
CBD	Convention of Biodiversity
CEPA	Conservation and Environment Protection Authority
CO2	Carbon dioxide
CVM	Contingent Valuation Method
CPI	Consumer Price Index
DUV	Direct Use Value
ESVD	Ecosystem Services Valuation Database
FAO	Food and Agriculture Organization of the United Nations
EWTP	Economic Willingness to Pay
GPNG	Government of Papua New Guinea
GDP	Gross Domestic Product
IRL	Indigenous Language Revitalisation
IUCN	International Union for Conservation of Nature
IUV	Indirect Use Value
LMMA	Locally Managed Marine Area
MEA	Millennium Ecosystem Assessment
MPA	Marine Protected Area
MPC	Marginal Propensity to Consume
MPS	Marginal Propensity to Save
NBSAP	National Biodiversity Strategy and Action Plan
NAQIA	National Agriculture Quarantine and Inspection Authority
NARI	National Agricultural Research Institute
NFA	National Fisheries Authority
NPV	Net Present Value
NUV	Non-use Value
OV	Option value
PA	Protected Area
PGK	Papua New Guinea Kina
PNG	Papua New Guinea
PNG NRI	PNG National Research Institute
PNG TPA	PNG Tourism Promotion Authority
SDGs	Sustainable Development Goals
SIDS	Small Islands Developing States
StaRs	Strategy for Responsible Sustainable Development
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
US$	United States Dollars
UN	United Nations
UV	Use Value
UNDP	United Nations Development Programme
WWF	World Wild Fund for Nature
WTA	Willingness to Accept
WTP	Willingness to Pay
XV	Existence Value

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Executive Summary

Papua New Guinea's (PNG) natural environment is the foundation upon which the country's economy stands. **The terrestrial environment underpins the country's productive sectors and supports the livelihoods of 80 percent of PNG's population who live in rural areas**. The coastal and marine environment provides food security, important sources of protein, protection from coastal erosion, and livelihoods in tourism and fisheries. Most people in PNG (approximately 80 percent of the active workforce) work outside the formal sector and depend upon their land, gardens, and coastal waters for subsistence or cash sales or other informal economic activities for their livelihoods. The natural environment provides services that benefit the productive sector – regulating water quantity and flow of clean water, preventing soil erosion by stabilising landscapes, soil enrichment to help crop productivity, and mangroves and reefs to provide nurseries for fish populations, to name a few.

Ensuring that the natural environment is maintained so that these ecosystem services continue to flow supports the country's future economic prosperity. Conversely, exploitative activities that deplete the natural environment are, by definition, unsustainable and will reduce the economic prosperity of the country and its people.

The role that the natural environment plays, and the importance of its ecosystem services are often undervalued because either they are unseen (take place under ground or under water) or there is no tradable market value placed on them. The result is an environment sector that receives an inadequate budgetary allocation that relatively relates to its contribution to the economy and livelihoods. In PNG, this is certainly the case. Currently, only **PGK 112 million per annum (US$ 32 million) is allocated to environment protection. This equates to 0.5 percent of total government expenditure.**

This represents a significant underinvestment, as the value of nature is not appropriately captured in traditional accounting, such as Gross Domestic Product (GDP).

Therefore, focusing on 'beyond GDP' measures allow for a more comprehensive approach to fully consider the wide range of values held for ecosystem. The Total Economic Value framework identifies that the economic value of ecosystem goods and services extends beyond that which is generally represented in markets. The Total Economic Value Framework conceptualizes economic values as either 'use values' or 'non-use values'. These include provisioning services (e.g., food), regulating services (e.g., water, soil erosion prevention, flood control), supporting services (e.g., habitats for biodiversity) and cultural services (e.g., recreational tourism).

Globally, the value of ecosystem services equates to approximately 4.5 times the value of Gross World Product (GWP) in the year 2000 (Costanza et al., 2014). In particular, countries with tropical forests were estimated to have Total Economic Values of US$ 5,264/ha/yr. The Total Economy Value estimates in specific locations vary depending on the level of biodiversity. PNG has some of the highest values of ecosystem services globally.

The assessment outlined in this report implemented a Total Economic Value framework for PNG, the first of its kind in the country. The report outlines the approach, data acquisition, calculations and gaps. **The Total Economic Value of the natural environment in PNG is estimated to be worth PGK 1 trillion (US$ 310 billion) per annum, 13 times the value of the country's GDP** in 2020 (see Figure 3). The table below outlines the contributions of individual ecosystem services and their intermediate and final contributions to economic output. Therefore, **each hectare in PNG contains a Total Economic Value equivalent to PGK 23,700 per year (US$ 6,704)** in 2020 prices, corresponding with the global average Total Economic Value for tropical forests of US$ 5,264/ha/yr (Costanza et al., 2014), as well as a conservative estimate compared to the findings of Costanza et al. (1997), indicating the value of ecosystem services tends to be the greatest (and up to US$ 10,000/ha/yr in some places) in highly diverse warm, low-latitude regions (locations found between the Equator), such as PNG.

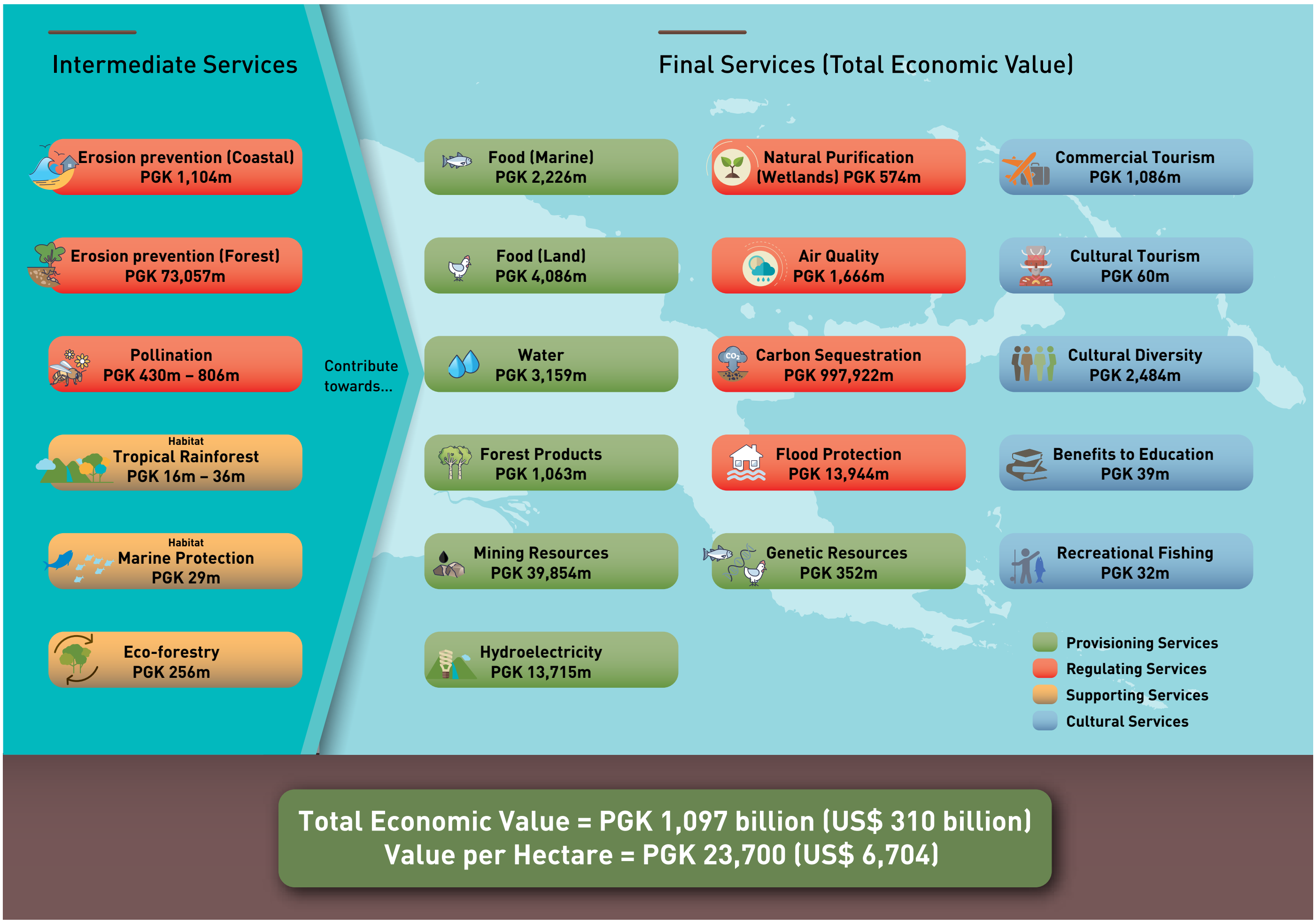

Figure 1 - The illustration above presents a summary of economic values of ecosystem services in PNG.

In summary, the study highlights that **for every PGK 1 invested in environment protection, this report demonstrates that nature provides PGK 9,800 in ecosystem services.** This represents a significant return on investment for the government of PNG's current 0.5 percent allocation of government budget.

Furthermore, if the government budget expenditure for environment protection increased to 1.8 percent (PGK 382m) per year this would finance (i) the implementation of the Protected Area Policy in its entirety, as well as (ii) maintain and expand the country's Protected Area network to achieve PNG's international targets under the Convention for Biological Diversity.

This would maintain and enhance the country ecosystem services and subsequent GDP further. It would support the country to diversify its economic sectors to include more sustainable 'green' and 'blue' sectors. These burgeoning industries would support business models that are more inclusive of communities, create greater value addition (i.e., through product certification) as well as positively contribute to the underlying ecosystem services that they depend – providing a sustainable development pathway to lead to greater economic prosperity that leaves no one behind.

Recommendations

- **Increased financial support** for environmental protection from 0.5 percent to 1.8 percent of government budgetary expenditure.
- **Whole government approach** that incorporates environment authorities into joint implementation of actions that impact the highlighted intermediate and final ecosystem services.
- **Natural capital accounting** to capture the market and non-market value of the environment – making invisible, visible and informing economic decision-making.
- Incorporate **independent ecosystem service valuations** into the Environmental Impact Assessments to ensure the total cost of resource development projects on the environment.
- **Policy shifts towards a 'green' and 'blue' economy**, stimulating longer-term economic prosperity and greater economic inclusion of communities, that retains, enhances and sustains PNG's natural wealth.

Introduction

Ecosystem services are the contribution (either direct or indirect) made from the natural environment to human well-being. At the extreme level ecosystems support all life on earth so it can be argued that they have infinite value. Identifying the values associated with changes in ecosystem services from the protection of core habitats will allow the consideration of those values in decision support frameworks such as Cost-Benefit Analysis, Natural Capital Accounting and can be used to develop Green National Accounts. The flow of natural resources from the environment to humankind is most commonly known as 'ecosystem services, a term that reflects the benefits that humans acquire from the existence of these ecosystems (MEA 2005). According to the Common International Classification of Ecosystem Services (CICES) (Haines-Young & Potschin 2012; MEA 2005), ecosystem services are identified and classified using three broad categories: provisioning services, regulating and maintenance services, and cultural services. The qualification, quantification, and valuation (both monetary and non-monetary) of ecosystem services are essential for ensuring sustainable governance of the built and natural environments that support human life (Farber et al. 2002, De Groot et al. 2002, MEA, 2005, Costanza et al. 2011).

The most appropriate approach to valuing nature's contribution depends on the reasons for the valuation efforts. In this project, the main reason is to assess the overall contribution of terrestrial and marine ecosystems to the economic well-being of the Papua New Guinea (PNG) population and assess the relative impact of alternative actions to help decision-making. Accordingly, this report focuses on measuring the economic benefits of ecosystem services in PNG.

To date, most ecosystem service valuation studies have mainly used marginal changes in the value of a narrow suite of ecosystem services from a single, locally important habitats (Costanza et al., 1997; de Groot et al., 2012; Deloitte Access Economics, 2017; Kubiszewski et al., 2017; Sannigrahi et al., 2018). However, from the perspectives of policymakers or the provision of sustainable financing and environmental accounting, aggregated flows from nature (i.e., an estimate of the value of all ecosystem services) is needed (Gashaw et al., 2018; Mackey et al., 2017; Tolessa et al. 2018).

Total Economic Value (TEV) generally makes distinctions between use- and non-use value categories, each of which is subsequently disaggregated into other value components. These categories and measurement methods have been progressively advanced over the past couple of decades. TEV framework (as demonstrated in Figure 1) is widely recognised, and the UN recommends its application in the UN System of Environmental-Economic Accounting for Water -SEEA-Water- UN, 2012. It is also being used by the Economics of Ecosystems and Biodiversity (TEEB) group- Pascual et al. (2010), New Zealand's Treasury (van Zyl & Au, 2018) for the conceptualisation of natural capital, and the World Bank (by Pagiola et al. 2004) to measure the worth of ecosystems. Accordingly, influenced by the Millennium Assessment (MA) Framework and the TEEB (The Economics of Ecosystems and Biodiversity) classification, in this project, we adopt a TEV framework and categorisation of use and non-use values for ecosystem services assessment. The approach informs decisions that support the long-term sustainability of the PNG economy and the well-being of the population.

Nonetheless, it is important to note that the literature around the valuation of non-market environmental goods and services is still evolving and a work in progress.

Following Munasinghe (1992) and Pearce & Moran (1994), the TEV can be expressed by a simple formula: $TEV=UV+NUV=(DUV+IUV+OV)+(XV+ABV+OV)$

Where:

UV: Use value

NUV: Non-use value

DUV: Direct use value

IUV: Indirect use value

OV[2] : Option value

XV: Existence value

ABV: Altruistic and Bequest Value

Use values tend to be the easiest to evaluate; the direct consumptive use of resources can generally be valued through observation of market prices, while non-consumptive uses – such as recreation – have closely linked markets that can be used to infer value. Direct use values also include the direct use value of extractive industries such as water, mining and petroleum, as illustrated in figure 4.

Geographic Scope:

PNG is approximately 462,840km² in area[3]. It is the world's third-largest island country and one of the most linguistically diverse countries globally. In terms of the indigenous population, PNG is the most heterogonous country in the world, with over several thousand separate communities and an overall population of 8.947 million in 2020. The society spectrum ranges from traditional village-based life, dependent on subsistence and small cash-crop agriculture, to modern urban life in the main cities[4]. The population density is low overall. However, there are areas of overpopulation in certain locations. Population distribution in PNG is presented in Figure 5.

PNG landmass occupies the eastern half of the island of New Guinea, which borders the Indonesian province of West Papua (Irian Jaya) to the west. PNG has a monsoonal climate with a hot and humid wet season from December to March and a dry season from May to October. With four regions of Highlands, Island, Momase and Papua Region and 20 provinces, the country has a wealth of biodiversity, including but not limited to tropical forests,

[2] Option values have a contested status due to the ongoing debate (Hanley & Barbier 2009). However, they are considered as they can refer either to UV or to NUV.

[3] https://web.archive.org/web/20171207094959/http://www.worldatlas.com/articles/which-are-the-island-countries-of-the-world.html

[4] https://www.dfat.gov.au/geo/papua-new-guinea/papua-new-guinea-country-brief

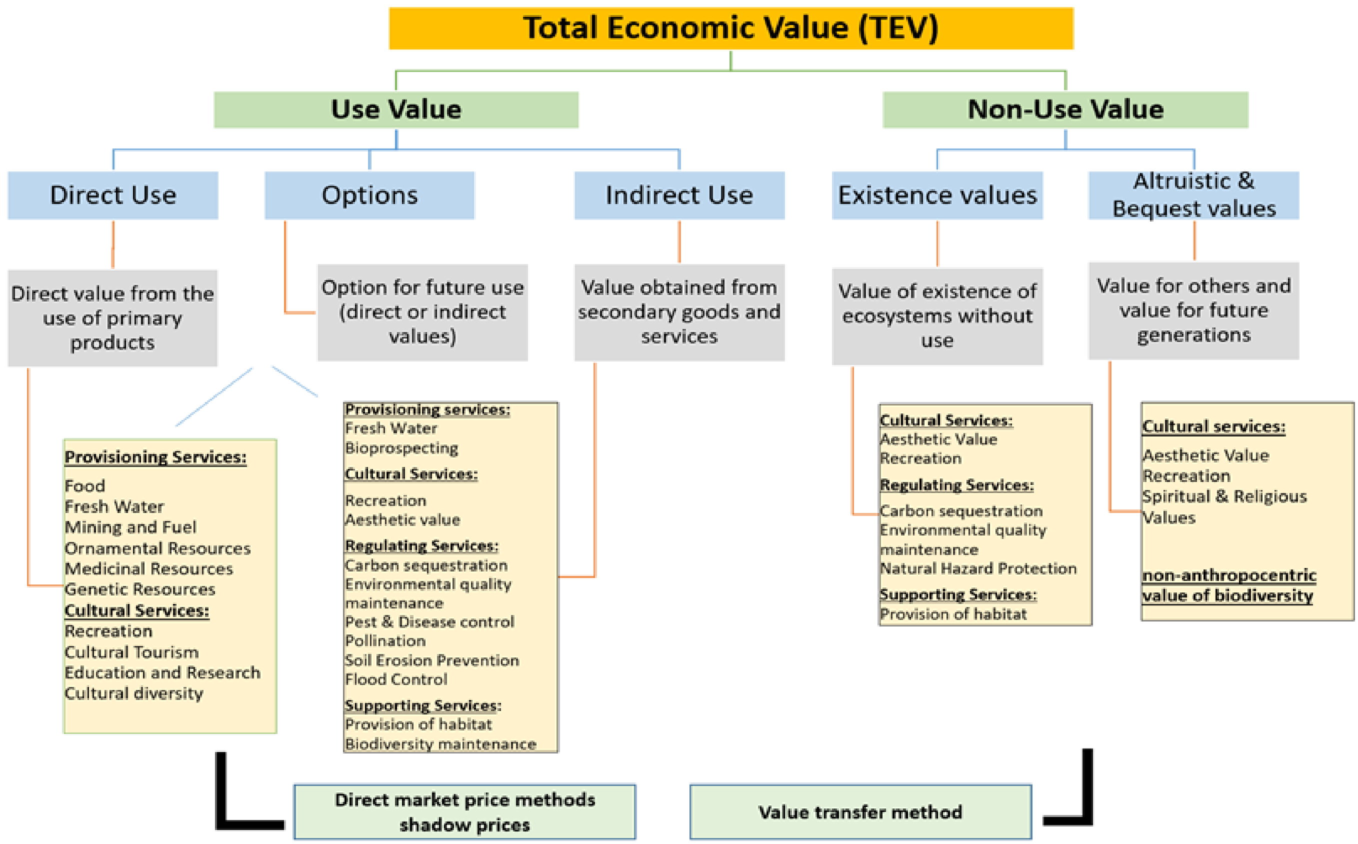

Figure 4 - The conceptual framework and applicable evaluation methods in the context of PNG
Source- elaboration from MA Framework and TEV approach

savannah grass plains, big rivers and deltas, swamps and lagoons, barrier reef systems, shallow banks and deep offshore, with numerous islands and atolls to the east and northeast of the country (Adams et al. 2017). Figure 6 represents the scientific classification of ecosystems in PNG.

The Process

The analysis of national ecosystem values was undertaken through a consultative process involving various stakeholders from diversified sectors and institutions within Papua New Guinea (PNG). The main tasks of the assessment included (1) Review of Literature; (2) Developing a methodological framework; (3) Stakeholder Consultation; and (4) Analysing the Data. These tasks were complemented with status updates and workshops, and presentations to communicate results. The project culminated in this **Final Report on Valuing Nature in PNG**. A full-day training workshop with presentation materials was delivered to UNDP, CEPA, and other government departments. Through a mixture of instructive and participatory exercises, the interactive training session equipped participants with knowledge and understanding to think through how to design, manage, and apply processes to assess the economic value of ecosystem services and effectively use the results in decision-making.

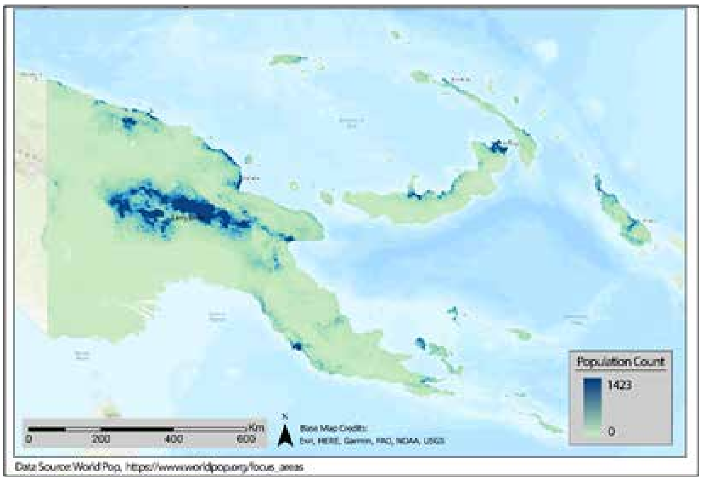

Figure 5- Population count per 1 kilometre squared, 2020 modelled estimates (Source: authors)

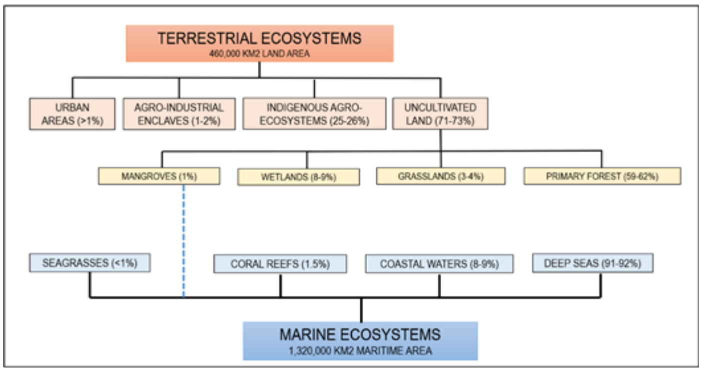

Figure 6- Scientific classification of ecosystems in Papua New Guinea[5]

[5] As per previous milestone report "Review of Literature relating to Ecosystems and Ecosystem Services in Papua New Guinea"

Review of Literature

A comprehensive literature search of studies containing data on various ecosystem services in monetary (and non-monetary) terms in PNG was conducted (refer to 'Review of literature relating to ecosystems and ecosystem services in Papua New Guinea', July 2021). Within the literature review, we sought relevant values for benefits transfer where possible (refer to 'Data Acquisition Report', April 2022).

Developing a Framework for the Assessment of Ecosystem Services

The second stage involved the identification of a framework for valuing ecosystem services from the various key ecosystems of PNG. This involved comparing available methodologies for valuing nature to (a) identify an appropriate methodology, and) b) develop a conceptual framework, including parameters, to identify and value the direct use and non-use values.

Influenced by the Millennium Assessment (MA) Framework and the TEEB (The Economics of Ecosystems and Biodiversity) classification, in this project, we adopted a TEV framework and the categorisation of use and non-use values for an ecosystem services assessment. These two frameworks are complementary. TEV is a strong tool that helps explore the types of ecosystem service values that need to be elicited while also ensuring that essential components of ecosystems in PNG and the relationship among those components are addressed.

Stakeholder Consultation

In addition to maintaining a working relationship with CEPA and UNDP and providing periodic briefings, the team conducted several multi-stakeholder workshops, in particular:

i. The first stakeholder workshop was held in July 2021, attended by researchers and representatives from government departments and institutions in PNG, including developmental partners and NGOs. The workshop was part of a peer review process to validate the conceptual framework.

ii. A second stakeholder workshop was held in March 2022. This workshop provided an overview of the methodology, data, and final estimates of the project model with stakeholders. Feedback was sought to explore ways to improve estimation if and when needed.

iii. A third stakeholder workshop was held in April 2022. During this workshop, key economic valuation concepts were covered. Particular attention was paid to the concept of TEV (a methodology that is used in this project), which includes the demonstration of methods such as the direct market price approach and benefit transfer. The workshop included a mixture of interactive lecture topics, open discussions, group work, and real-world examples. The training session provided stakeholders with knowledge and understanding to think through how to design, manage and apply processes to assess the economic value of ecosystem services and to use the results effectively in decision-making.

Analysing the Data

The TEV Framework adopted captures the value of ecosystem services from an anthropocentric viewpoint – i.e., the benefits that ecosystem services in PNG provide to support human wellbeing. As such and considering the particular need to assess and communicate the economic value of ecosystem services benefits, in this project, the valuation provides economic insights and evidence to complement the non-anthropocentric value of biodiversity value. The project also recognises that non-

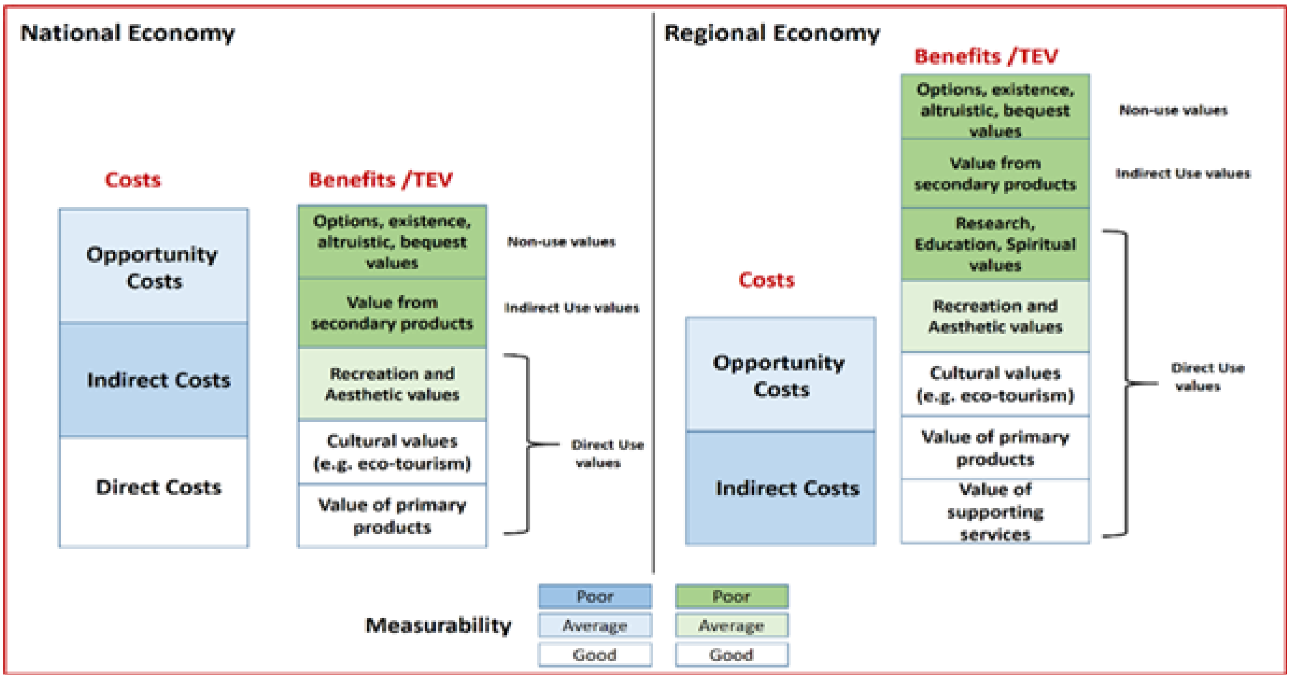

Figure 7: Costs and benefits of ecosystems on the national and regional levels. Source: Methodology Report, July 2021

monetary assessments of the importance of ecosystems are also necessary; however, the evaluation results from this exercise should be seen as complementary to non-market evaluations instead of competing with them.

Figure 7 differentiates benefit (and cost) categories of protected areas on the national and regional economic levels. The measurability of these categories is also shown in different colours (the darker the colour, the harder to measure costs or values in monetary terms. Following cost classification by Dixon & Sherman (1990, 1991), direct costs consist of expenditure on equipment, management and maintenance of protected areas; indirect costs include damages outside the protected areas such as damages caused by wildlife from the parks and opportunity costs that are defined as forgone income from alternative land use possibilities (such as mining or infrastructure-based tourism developments).

By providing a means for measuring and comparing the various ecosystem benefits through the application of the TEV framework, the outcome of this exercise is envisaged to aid and improve the appropriate use and management of natural resources. The findings can also be used to inform and elevate their significance in policy decisions. Valuing nature in monetary terms can effectively inform policy settings, and help industry, government, the scientific community and the wider public understand the contribution of the environment to the economy and society.

It is important to note that mainstream economic development theories cannot inform sustainability decisions and transformations as they largely ignore nature protection and the opportunity cost of ignoring nature in national accounting. Modernity and neoclassical economic theories of the twentieth century have also, unfortunately, continued to employ the same mechanistic view and basic concepts. Nonetheless, schools of thought, including heterodox economics (such as post-Keynesian economics) and environmental economics, play strong roles in contributing to the development and analysis of environmental policies and the concept of "green growth" opportunities that assumptions in mainstream theories have neglected.

Protected areas conserve ecosystems and their services that sustain human life. Protected areas build resilience by controlling habitat threats and protecting against climatic related events and human disturbances. Protected areas also sustain and support indigenous knowledge and its application in the conservation of landscapes and cultural practices of significance. Furthermore, most environmental goods and services, such as clean air, water, biodiversity, gene pool, cognitive development, and cultural diversity, are not traded in markets. Nonetheless, measuring their values is relevant to policy analysis because the non-market value is mainly associated with market failures when there are conflicting uses of the environment, which give rise to a trade-off between market outcomes (e.g., market value of logging) and non-market outcomes (the real cost of deforestation). Therefore, measuring the TEV of ecosystem services (including market and non-market values) is extremely important to inform decisions about synergies and trade-offs.

Estimation Methods and Techniques

The assessment of ecosystem services can be carried out at several levels and across a range of geographical extents. Of these, the national assessment of ecosystem services presents a range of challenges. A number of national ecosystem services have been carried out globally to date using various qualification, quantification, and valuation methods. There are a number of frameworks that aim to evaluate the benefits that ecosystem services provide to humans, including the Millennium Ecosystem Assessment (MEA 2005a), The Economics of Ecosystems and Biodiversity (TEEB) (TEEB 2010), and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (Díaz et al. 2015).

These frameworks layout guidelines for the assessment of benefits provided by ecosystem services (Hein et al. 2016), which is necessary to ensure the conservation of these services and the continued provision of benefits. It is particularly vital to quantify the flow of benefits in physical and monetary units, as well as to quantify the impacts of historical, current and future human use of ecosystems. Natural capital is defined as the renewable or non-renewable natural resources that provide a flow of benefits to people, which can be quantified in physical and monetary units (Hein et al., 2016). Natural Capital Accounting (NCA) frameworks seek to make this possible by capturing the impact of human use on ecosystems and ecological function over time.

The ecosystem services framework has been used to consider the contribution of the natural environment to human wellbeing since the work carried out in the Millennium Ecosystem Assessment (MEA 2005). There are significant advantages to the approach, but there are issues around the adequacy of the data available to assess the value of ecosystems (DEFRA, 2007). Within the ecosystem services framework, services are defined as Provisioning, Regulating, Cultural and Supporting. To date, the most comprehensive ecosystem service assessment at a national level that uses the ecosystem services framework is the UK National Ecosystem Assessment (UK NEA 2011) (which is adapted in this project to define the socio-ecological context of PNG).

The Total Economic Value (TEV) framework (Ledoux & Turner 2002) sits within the ecosystem service framework. It provides an important approach to fully considering the wide range of values held for ecosystems. Figure 14 presents the range of values considered in the TEV framework. The TEV framework identifies that the economic value of ecosystem goods and services extends beyond that which is generally represented in markets. TEV generally makes distinctions between use- and non-use value categories, each of which is subsequently disaggregated into other value components. These categories and measurement methods have been progressively advanced ever since. It is the most widely applied ecosystem identification and evaluation framework to date. TEV is also particularly helpful in identifying values associated with the markets (by assigning tangible values to ecosystem services), thus readily amenable to valuation. TEV framework is widely recognised by leading organisations: the UN recommends its application (in the UN System of Environmental-Economic Accounting for Water -SEEA-Water- UN, 2012).

Other leading organizations and governments also have widely used TEV in valuing the environment, for example, the TEEB group (The Economics of Ecosystems and Biodiversity, Pascual et al., 2010), New Zealand's Treasury (van Zyl & Au, 2018) for the conceptualisation of natural capital, and the World Bank (2004) to measure the worth of ecosystems. Nonetheless, the literature around the valuation of non-market environmental goods and services is still evolving and a work in progress.

Accordingly, in this report, the application of the TEV approach first involved identifying all ecosystem services that PNG's nature generates. Market-based valuation methods often exclude the consideration of values perceived by stakeholders. The stakeholders' perception of values is often non-monetary and sometimes not utilitarian. Nonetheless, these perceptions could assist decision-makers. Therefore, the engagement step was accomplished through a series of workshops with national stakeholders in 2021, which allowed a rapid assessment of data availability for choosing appropriate valuation techniques.

In terms of data collection, it is important to note that this report draws on available published and unpublished (although verified) information. Financial value data are mainly available for marketed goods and services. The involvement of the local population in the project was considered essential within the research process to ensure local values were factored in. However, the level of involvement was limited due to a lack of local research capacity during the life of this project. No primary data was collected as this report was assembled from available data. Nonetheless, in some cases, due to the scarcity of public information, economic theory is extensively used to set necessary assumptions as a malleable guide to estimate the value of a service (such as the direct use-value of water, indirect use-value of pollination services, and the value of cultural (language) diversity).

In the valuation of non-marketed services, the benefit-transfer (BT) technique is used to obtain values from a study site to transfer, adjust, and sign to the policy site (i.e., PNG). In all but two cases of benefit transfer, the Philippines is used as the study site, affording a degree of consistency in our estimated values the rationale is explained in section 3.6 of this report. In some other cases, data constraints prevented the researchers from arriving at estimates for particular categories of values. Examples include the value of medicinal resources, ornamental resources, or water regulation, and therefore, no economic value was assigned to such services. During the course of secondary data collection, it became clear that due to the significant absence of data and, on a few occasions, the presence of ambiguous data, the research team realised that the current best-practice guidelines for the application of TEV methods in PNG might not be appropriate. Consequently, this report has undertaken several modifications of standard approaches in order to provide a satisfactory valuation.

In addition to the above, there are inadequacies in the database assembled for this report. The inadequacies stem from:

1. Lack of research (and data) in placing monetary values on some of the non-market ecosystem services in PNG
2. Lack of research (and data) in placing monetary values on supporting services or regulating services despite global consensus around measurement techniques

The estimated value of ecosystem services provided in this report is not definitive and is based on collating available secondary data. Nonetheless, as the first assessment, this report provides both indicative and conservative estimates of the benefits of natural assets in PNG and an applied framework to populate new information as they become available.

Another practical challenge was the existence of an informal or subsistence economy. According to Bourke and Harwood (2009), about 80 percent of PNG's population earns a living from subsistence agriculture and selling crops in domestic and international markets. The consequence is that it would be challenging to place a monetary value on a complex environmental good or service. Hence there would be heavy reliance on national databases, some of which are not publicly available or easily attainable.

Multiplier effects

Multiplier effects are a specific type of financial value. They reflect the gross impact of any economic activity flowing onto the rest of the economy. In economics, three types of multipliers are usually calculated (Encyclopaedia of Social Measurement, Reference Work, 2005):

- Output multiplier: represents the total output produced by all industries in response to a US$ increase in final demand for an industry's output
- Income multiplier
- Employment multiplier

In calculating the economic value of ecosystem services, multiplier effects are only used for estimating all direct-use activities or values. The inclusion of the multiplier effect shows how further economic activities and employments are supported more broadly due to the direct use of ecosystem services (as demonstrated in Figure 8). Regardless, the estimates need to be interpreted with care as unpriced (non-market) environmental costs (values) are not considered.

Financial values extracted from market information reflect US$ generated within the economy through economic activities and transactions. Therefore, economic benefits of services with expected direct use-values (such as tourism, food, fisheries, etc.) will generate more than immediate benefits through markets. They also create a knock-on effect through the expenditure multiplier through the economy. Accordingly, the final estimates of these values include the multiplier effect.

The research team could not source any publications (recent or dated) that provide an estimation for the expenditure (GDP) multiplier (or the Keynesian multiplier) for PNG. The only result discovered was the work of Cain et al. (1990, page 82) which estimated a tourist income multiplier of 0.87 and the government revenue (tax) multiplier of 0.43. These figures are outdated and not suitable to be used in our calculation. So, the research team set out to calculate a conservative estimate for the GDP multiplier. To calculate the GDP multiplier, the research team needed data on either Marginal Propensity Save (MPS) or Marginal Propensity to Consume (MPC). None of these figures was readily available, nor were basic data around changes in consumption (or saving) and changes in income levels. Subsequently, the research team followed Schmidt et al. (2020) and used PNG's dependency ratio as a proxy for marginal propensity to save. The total dependency ratio for PNG (0-14 and 65+ per 15-64) of PNG is found to be 63.2 (0.63) in 2020[6], which has been gradually falling from 0.86 in 1971. Accordingly, the research team assumed MPS= 0.63.

The formula to calculate the GDP multiplier is

K= 1/MPS= 1/0.63= 1.58

This estimated multiplier indicates that every US$ 1 spent within the economy causes real GDP to increase by US$ 1.7 (i.e. the immediate and the knock-on effects).[7]

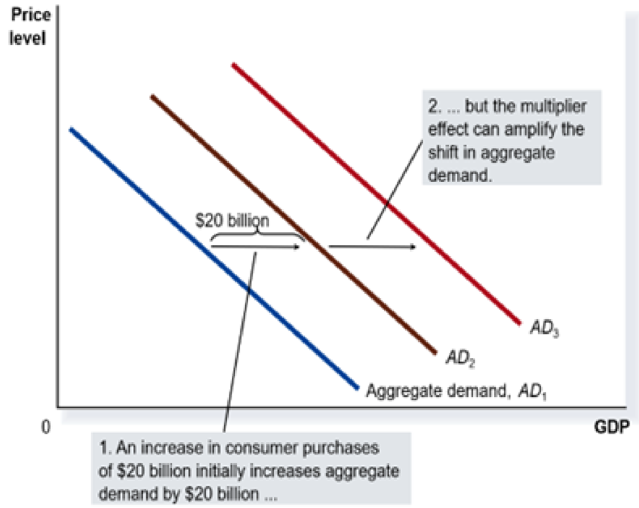

Figure 8- The multiplier effect

The Assessment Procedure

To evaluate PNG's ecosystem services, the following steps were undertaken:

1. Base-year selection and dealing with and price information
2. Identification of annual flows of outputs provided by terrestrial and marine ecosystem services.
3. Identification of intermediate and final ecosystem services to avoid double counting
4. Application of benefit transfer method (for categories with missing market values)
5. Calculation of overall potential contribution of terrestrial and marine ecosystems to the economic well-being of the PNG.

Base Year and price information

As this report focuses on estimating the annual flow of benefits from ecosystem services in PNG, a base year for the analysis had to be selected. The year was chosen to be 2020, and while some data were available, some were inevitably unavailable for this year. If the data was available for 2019 only, the price information for 2019 was used; for older data, prices were converted to 2020 prices (i.e., inflated to 2020 US$) to produce a single long-running series that is representative of changes in consumer prices. To achieve this, a consumer price index (CPI) deflator is used to capture period-to-period proportional change in the prices. For example, for all the products under the Provisioning Services Group: Food sub-service category, the "CPI deflator- Food" is used to convert price information to 2020 prices, which according to PNG Economic Database,[8] is reported to be 121.99 for 2020 (with the base year of 2010). Occasionally, data collected had to be complemented by data from one-off studies on particular issues, then they had to be adjusted to bring them in line with the chosen base year. Accordingly, current values (2020 values) are reported, but the possible future values are not predicted. Extrapolation of the data is not recommended. Although, it is expected that the value of ecosystem services continues to increase, and the supply of these services diminishes globally as the population increases.

Approximating the direct use-value is usually more straightforward than other TEV components. A wide range of ecosystem service outputs are broadly commercialised in the markets, and their quantities and average prices are often provided in databases. However, some other outputs do not make it to markets. Clearly, however, the absence of a market price does not mean that a good or service has no economic value. And therefore, the valuation of these outputs becomes complex and requires the application of more advanced techniques than the use of market price.

Direct price measure: In this report, values are derived, when possible, from data provided by market transactions relating directly to the ecosystem service. Valuation using this method requires evidence of Willingness to Pay (WTP) and the Willingness to Accept (WTA)[9]. The market price method uses "prevailing" prices (or marginal values) for traded goods and services (Figure 9). This method reflects buyers' WTP for costs and benefits of goods bought and sold in commercial markets and the sellers' WTA relinquishing an amenity or service. Therefore, people's values are likely to be well defined. This method is advantageous when calculating the direct use value of provisioning and cultural ecosystem services. In the absence of market price, the price information is derived through benefit transfer methods (explained later in this report).[10]

Annual flows of outputs

At any given time, ecosystem services provide a specific flow of services, depending on the type of ecosystem, its condition (the stock of the resource), its governance and socio-economic context. It is important to note that the values of ecosystem services are likely to vary depending on the characteristics of the ecosystem, beneficiaries and the

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6 https://knoema.com/atlas/Papua-New-Guinea/topics/Demographics/Dependency-Ratios/Total-dependency-ratio-0-14-and-65-per-15-64

7 All relevant estimations will be updated if the research team is provided with a more accurate multiplier.

8 https://devpolicy.org/pngeconomic/

9 In some cases, prices are likely to underestimate the value of ecosystem services or goods

10 Similar to any other valuation method, these methods come with limitations that have been discussed in details in the previous milestone report.

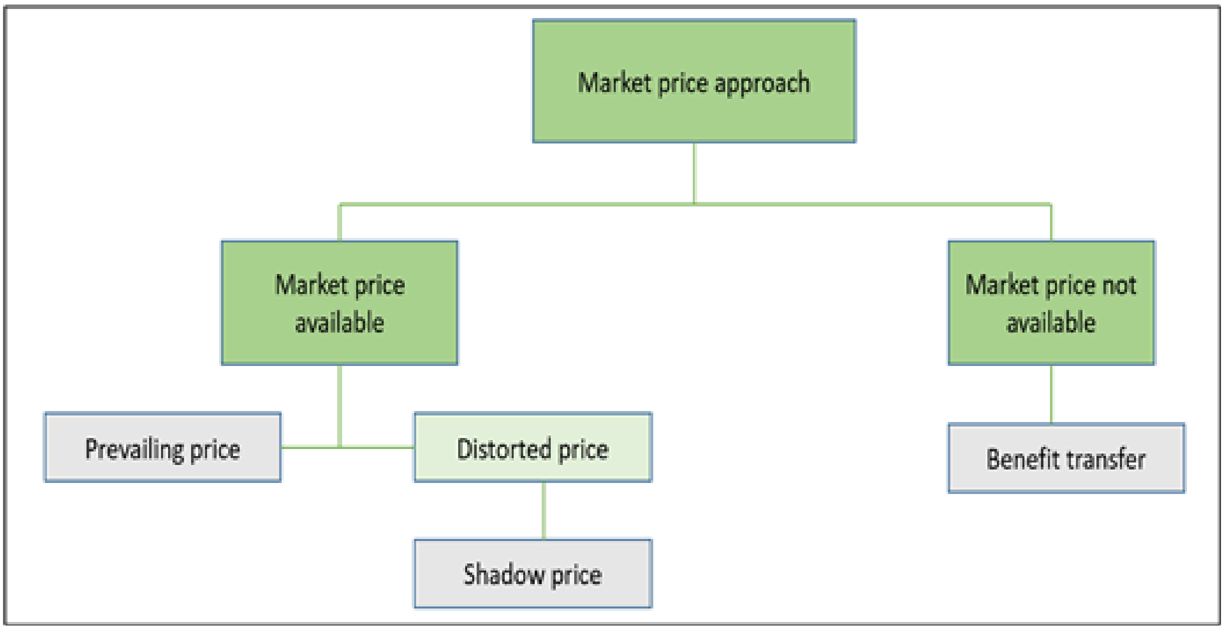

Figure9- Market-based evaluation

context. In terms of characteristics, the research team has considered types of ecosystems and relevant services and their area. In terms of beneficiaries, the researchers have considered factors such as the number of heterogeneous groups of beneficiaries, distance to site, culture and preferences (where available).

Thus, the report also focuses on estimating the annual flows of outputs provided by forests and marine resources as they stand now under current management practices. Many of the estimated outputs are benefits with positive values, and some have negative values such as negative externalities (e.g., social costs) and public 'bads' (e.g., poor governance) or natural conditions (e.g., climate change).

For provisioning and cultural ecosystem services, the economic value assigned to a decision to sell is simply the product of the commodity's market price and quantity. Accordingly, the research team identified which ecosystem goods and services are traded in commercial markets and examined if the efficient prices are available in the official statistics for those goods and services. The "Data and Data Acquisition" report provides details of price data availability.

Intermediate and Final Ecosystems

Upon identification of all ecosystem services in PNG, the next step would be making judgements as to what constitutes intermediate ecosystem services and final ecosystem services. Final ecosystem services include services directly "enjoyed, consumed, or used to yield human well-being" (Boyd & Banzhaf, 2007, page 619). It is important to note that ecosystem accounting resolves inputs and outputs in a manner so that the value of final services is the sum of value-added through intermediate components. Accordingly, this disentanglement exercise is essential as it avoids the problem of double counting.

Millennium Ecosystem Assessment (MEA) (2005) defines types of ecosystem services to include:

- Supporting services – ecosystem processes and intermediate ecosystem services
- Regulating services – intermediate or final services (e.g., pollination, climate and hazard regulation)
- Provisioning services – final ecosystem services (e.g., food, timber, water and biodiversity)
- Cultural services – final ecosystem services (e.g., recreational tourism and biodiversity).

Application of benefit transfer method

Furthermore, to overcome the lack of system-specific data, the benefits transfer technique is widely adopted in this study to estimate some ecosystem services' values. When it is too time-consuming or too expensive to directly estimate monetary measures, surrogate measures are collected through the application of Benefit Transfer approach using an existing valuation estimate from a similar ecosystem elsewhere (the study site) to PNG (the policy site) (as illustrated in Figure 10). Accordingly, as more PNG information becomes available, the total estimated value of nature in this report is expected to increase and the overall reliance on the Benefit Transfer method will decrease, which in turn will improve estimation confidence of the total economic value of nature in PNG.

Care is taken to match policy and study sites as closely as possible and reduce transfer and generalisation errors. It is not possible to entirely eliminate transfer errors. Still, the research team has made exemplary efforts to reduce the errors to an acceptable level depending on the context of the value estimate. For example, errors are found to be smaller when there is geographic proximity between the study and policy cites, and populations in both locations are similar (Boyle and Bergstrom (1992), Desvousges et al. (1992), Loomis (1992), Kask and Shogren (1994), Piper and Martin (2001)), which has been taken on board in this report.

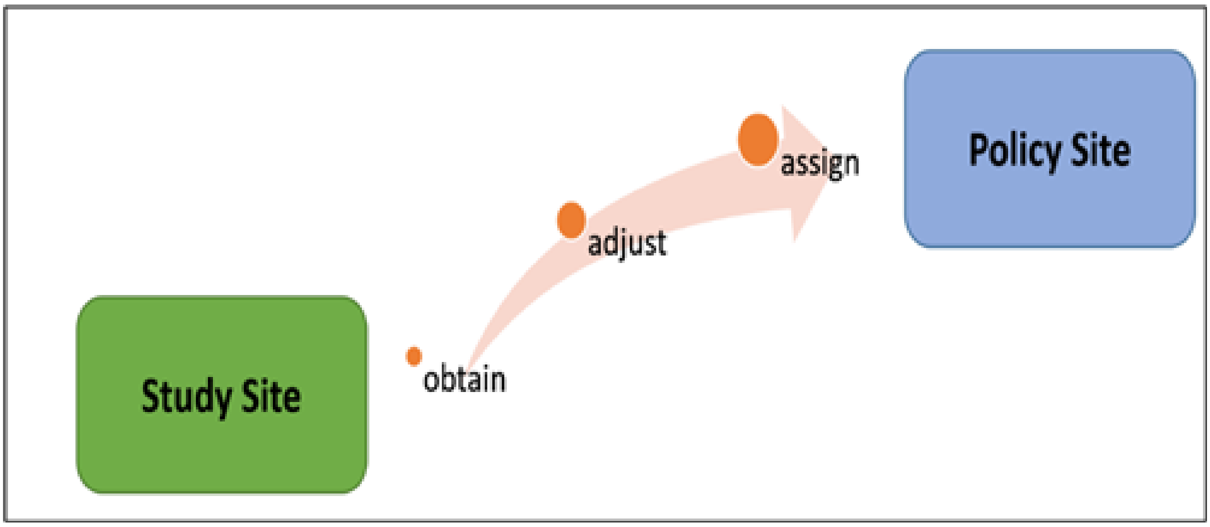

Figure 10- Value transfer estimation process as a value per unit (Source: authors)

Furthermore, the studies that have used stated preference with the application of contingent valuation have been preferred over those that used choice modelling. Finally, the studies with the application of revealed preference and demand estimation have been preferred to studies that used site choice models. Moreover, in a poor data environment, higher transfer errors are considered acceptable Several studies also argue that the reliability of the benefit transfer method depends on the level of error deemed acceptable in a given context (Ben-Akiva, 1981; Desvousges et al., 1998; Bergstrom and DeCivita, 1999; Kristofersson and Navrud, 2005; Columbo and Hanley, 2008). And for those reasons, the literature has been hesitant to set a minimum acceptable error threshold.

The values which were the object of the benefit transfer techniques were adjusted to 2020 price levels by using consumer price index deflators. Benefit transfer is the procedure of estimating missing values/price information of ecosystem service (i.e., the policy site) by transferring and assigning current price information from a similar ecosystem elsewhere (i.e., the study site).

This report also follows Boyle and Bergstrom (1992) and Desvousges et al. (1983) in the following criteria to determine which studies are appropriate for benefit transfer in that:

- Services that are being valued are the same in both the study site and policy sites
- Populations relevant to the services are similar
- Quality of studies- for quality assurance of the selected studies, the research team has selected studies that are included in the TEEB database. TEEB database is supported by the Foundation for Sustainable Development, and it is a global searchable database of 1,310 estimates of monetary values of ecosystem services

In terms of the context, the research team has looked at the potential availability of substitute and complimentary services. However, the specific information about these was scarce. Accordingly, the researchers made appropriate adjustments when transferring values between study sites and policy sites with different characteristics and contexts.

Calculation of overall potential contribution

For provisioning services in both terrestrial and marine ecosystems, values were estimated by computing the market value of products using efficient prices or shadow prices. Benefits transfer techniques were used for values such as indirect use value of erosion prevention services, indirect use value of natural purification, direct use value of medicinal resources, etc.

The first step to estimating PNG's natural assets' contribution to the local and national economies was to overview a range of ecosystem services and their annual flows of output under their current land use (as opposed to alternative land use). The ecosystem service flows currently delivered by nature in PNG and their associated benefits in monetary terms are summarised in Table 1. Furthermore, Table 1 describes the types of variables used as a proxy to quantify the financial and economic values of the services. Primary sources used to elicit volume and value information about the ecosystem services are also introduced in the table.

Finally, a traffic light system expresses confidence levels of flow quantities and monetary values. The green indicates a higher level of certainty related to the quality of the identified data. Market-based valuations provide the greatest confidence (e.g., provisioning and tourism), and Yellow (amber) refers to estimations that may require further work to yield more accurate results (i.e. indicate priorities for potential future data collection to improve). However, red refers to situations where data is not available. Although the ecosystem services exist in Papua New Guinea, the reliability of the current data is not sufficient enough to be used in the estimation. This means that the overall calculation should be considered an underestimation of the Total Economic Value. As more information becomes available, from strengthened data collection, the overall Total Economic Value will undoubtedly increase.

Ecosystem Services	Description	Units	Main Data Sources	Confidence
Provisioning Services				
Food	Food extracted from marine resources	Mg (t) (2020)	Bank of Papua New Guinea website and PNG Economic Database platform	
Food	Food extracted from terrestrial resources	Mg(t) (2020)	Bank of Papua New Guinea website and PNG Economic Database platform	
Water (surface & groundwater)	Value of water for water-dependent sectors	Value data	ILO (2019) , World Bank (2019), Moody's Analytics	
Raw Materials	Timber log- average export volume 2019-2020	Trade Data	PNG Economics Database	
Raw Materials	Mining and petroleum- 2017	Trade Data	PNG Economic Database	
Renewable Energy	Hydroelectricity from hydrological basins in tropical forests	Electricity data & Direct Market Price	PNG various data, Our World in Data and Hydrology.org	
Genetic resources	Conservation of genetic resources/	BT (the Philippines)	Arin and Kramer's (2002) Secretariat of the Convention on Biological Diversity (2001) and TEEB database	
Medicinal resources	Medical components, medical products, using Factor Income / Production Function		No reliable and transferable data are available	
Ornamental resources	Resources for producing handicrafts and fashion products	Market value	No reliable data are available	
Regulating Services				
Regulation of water flow	Ecosystem area- filtration, sequestration or absorption of waste (indirect use value)	Flow rates (m3); forest area (designated to protect water resources)	Data not available	
Erosion prevention (coastal)	Erosion prevention in coastal wetlands and mangrove area (Replacement Cost method)	US$/ha/yr.- BT (the Philippines)	FAO (2010), CEPA (2020), Samonte-Tan et al. (2007), Van der Ploeg, S. and R.S. de Groot (2010) /TEEB database	
Erosion prevention (forest)	Erosion prevention in tropical forests	US$/ha/yr.- BT (the Philippines)	'Hodgson G. and J. Dixon (1988) and Van der Ploeg, S. and R.S. de Groot (2010) & TEEB database	
Natural purification (coastal wetlands)	Mangroves	US$/ha/yr	Asian Development Bank project in PNG	
Air quality	Air regulated by tropical forests by capturing fine dust	US$/ha/yr- BT (Tropical North QLD, AU)	Curtis (2004) and TEEB database	
Pollination	Percentage of contribution to the overall market value of agricultural production	US$ (or K) per annum	Gibbs & Muirhead (1998), Khalifa et al. (2021), Borges et al. (2020), Gordon & Davis (2003), Winston & Scott (1984), Hein (2009), Tremlett et al. (2021), Rockettes et al. (2004)	
Carbon Sequestration	Total carbon in forests (with 66% stored in the soil and 34% in the biomass)	Tonnes	Hunt (2010), CEPA (2020), and Sam et al. (2021)	
Disturbance moderation	Human disturbance moderation- the annual cost of damage, environmental quality and flood control	Value for marine and terrestrial area	CEPA (2020)	
Supporting Services				
Coastal Protection	Area of protected shoreline			
Provision of Habitat - Tropical Rainforest	An increase in the area of tropical rain forest set aside for preservation by 5% (2001)	Mean WTP per household	Manoka, B. (2001)	
Provision of Habitat	Existence value of Marine protected areas	US$/ km²/yr- BT (the Philippines)	Charmaine et al. (2018) , Subade, (2007) and White et al. (2000)	
Eco-forestry	Suggested benefit by subsidised eco-forestry	Net Present Value (NPV) at 0.08 discount rate, US$/ha	Hunt, C. (2002)	
Recreation Services				
Water	In-land water (existence & aesthetic value)	WTP	Data not available	
Recreational fishing	Fishing as recreation activities, BT	WTP , US$ /ha/yr- BT (the Philippines)	Ahmed et al. (2007) and the TEEB database	
Tourism	Tourist expenditure		International Finance Corporation (2018), PNG TPA (2019)	
Cognitive development	Science and research, expenditures for fieldwork, primary data gathering, boat/vessel rental, supplies, and some diving equipment		UNESCO Institute for Statsitics	
Cultural Services				
Cultural tourism	Aggregate annual value of WTP	WTP	Ezebilo (2016)	
Cultural diversity	Cultural diversity (860 indigenous languages)	Languages- Threat status data	Various sources, but estimate is arbitrary	

Table 1- Summary of ecosystem flows and benefits of PNG ecosystem services assessed

**BT= Benefit Transfer method is used to transfer the value*

**Estimate confidence: Relative level of confidence in measurements: Higher Moderate Lower*

The red categories refer to ecosystem services for which no reliable and transferable data are available, hence not included in the report

[11] https://www.ilo.org/global/research/global-reports/weso/2019/lang--en/index.htm

[12] https://esg.moodys.io/insights-analysis

Economic Value of Provisioning Services

Direct use-value of agriculture – Food

The PNG Government has begun to develop policies to encourage greater agricultural production in order to attain and maintain national income security after the end of mining and liquefied natural gas (LNG) booms. Enhancing agricultural food production has been identified as a priority in the current Medium-Term Development Plan III (2018-2022), National Development Plan (2016-2030) and Vision 2050.

To achieve national support, policy initiatives need to be implemented with the full engagement and consent of PNG citizens and local communities in a way that respects their cultural and ecological rights; and should be explicitly designed to provide measurable benefits.

The agriculture sector dominates the national and rural economies in PNG. The sector accounts for approximately a third of GDP and provides direct benefits to over 80percent of the population (Bourke and Allen, 2009). In addition, the size of subsistence farming in PNG is also significant. It is estimated that 80percent of PNG's population relies on the subsistence and semi-subsistence economy (CEPA, 2020). Subsistence economy refers to situations where market transactions are absent or rudimentary. To estimate the direct use-value of food, this report resorts to the market value and volume of agricultural food products traded on markets. The direct market price method was used in calculations resulting in well-defined values. Market prices are "prevailing" prices or marginal values of traded goods that reflect buyers' WTP and sellers' WTA.

Most of the data (i.e., volume in tonnes and value in Kina) on food products extracted from marines or terrestrial resources are obtained from the Bank of Papua New Guinea website and the PNG Economic Database platform. Information on some of the food categories was dated, and where relevant, the "CPI deflator- Food" is used to convert price information to 2020 prices. The market value of food extracted from terrestrial resources was estimated to be around K 2,688,300,000, adjusted to 2020 prices, with palm oil, coffee, cocoa, copra, copra oil and tea being the most important contributors. Furthermore, PNG is home to at least 500 species of stony corals, 1,635 reef fish species, 43 mangrove species, and seven seagrass species (CEPA 2020). Marine recreational sector and fish discard (i.e. catch and release) in PNG accounts for 3percent of the total catch of 2.4 million tonnes from 1950-to 2010 or 72,000 tonnes (CEPA, 2020). This figure excludes unreported catches that amount to 1.8 million tonnes in the subsistence sector, equivalent to 66percent of the total catch of 2.4 million tonnes from 1950–to 2010. The market value of food extracted from marine resources was estimated to be around K 1,464,700,000, adjusted to 2020 prices. Adopting a multiplier of 1.58, the economic value (immediate plus knock-on effects) of food expenditure from terrestrial resources becomes K 4,086,216,000 (or US$ 1,154,800,191.7) and from marine resources equals K 2,226,344,000 (or US$ 629,184,183.6).

It is important to note that both these values are significantly underestimated. The reason behind this underestimation is the existence of subsistence farming that covers an area of 3.2 million ha in PNG (CEPA, 2020), with production being almost entirely consumed domestically with surpluses sold on the local market for cash. While subsistence agriculture supports and sustains the economic well-being of the population in rural areas, it is also recognised as one of the most significant threats to forest degradation and deforestation in PNG, accounting for around 45.6percent (CEPA, 2020; UNDP, 2018; Shearman and Bryan, 2010). The damages are more intense in highly populated areas, specifically the highlands.

Direct Use-value of Water

Two types of natural water resources are considered: groundwater and surface water. Surface water, produced internally, is bodies of water above the ground, including rivers, lakes, wetlands and the ocean. Groundwater, also produced internally, is any water that seeps deep into the ground. It is groundwater recharge by infiltration and percolation of detained floodwaters into aquifers for later discharge as "surface water". This water enters the calculation only if the recharged water benefits society (such as water use for irrigation or domestic use). Regardless of where the water originates from, it does not influence the value attributable to the generation of surface water.

Water resources play crucial roles in creating wealth, health and jobs across PNG. However, there is still a significant knowledge gap regarding the exact contribution of water to PNG's economy. Moreover, data required for an economic evaluation of water resources in PNG are scarce. Accordingly, measures are taken in response to this limitation. For instance, while the market value of water use can be defined as the gross value added per gigalitre ($/GL) of water used in the production of goods and services, it does not reflect the capital cost and price changes that may occur as a result of changes in the production volume in different sectors. Accordingly, this report evaluates water's tangible contribution to PNG's economy using macro-economic parameters.

In this report, we classify economic sectors based on their water dependencies to show the worth of the ecosystem services so they can be compared and prioritised for conservation.

PNG's water-dependent sectors such as agriculture, tourism and recreation, mining and fishing significantly contribute to the country's economy by creating income, jobs, and exports. The majority of economic sectors in PNG are dependent on a steady and reliable supply of water in sufficient quantity and quality. Figure 12 shows how sectors in PNG are ranked according to their degree of dependence on the water.

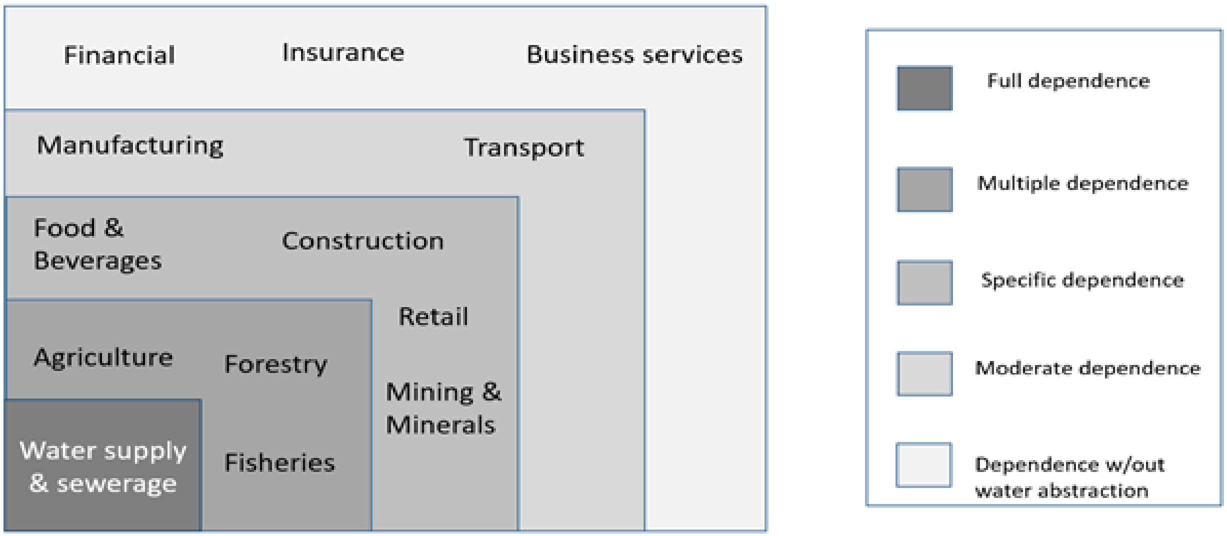

Figure 12- Degree of water dependency of PNG's economic sectors (Source: author's elaboration)

Table 2 shows employment in three sector categories of Agriculture, Industry and Services as a percent of total employment, modelled ILO estimate for PNG for the year 2019. Notably, multiple water-dependent sectors of Agriculture, Fisheries, and Forestry employ 745,210[13] and contribute the most to the PNG's economy by providing 56.15percent[14] of the total employment of 1,327,177 (in 2019).

Sectors	As % of total employment
Agriculture Sector= agriculture, forestry and fishing	56.15%
Mining & manufacturing Sector= mining, manufacturing, construction, and public utilities	13.22%
Service Sector= retail, food, transport, financing, insurance and business services and other services	30.63%

Table 2- Sector as percentage of total employment - 2019

Source- World Bank data

[13] https://www.economy.com/papua-new-guinea/agriculture-employment/

[14] https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=PG

To complete the assessment about the economic value of water in PNG, the total value-added should also be included in the mix. Total value-added or TVA captures the contribution of industry/sectors to overall gross domestic product (GDP), also referred to as GDP-by-industry. In 2020, the TVA for Papua New Guinea was US$ 23.7 billion (as shown in Table 3), showing a significant increase from US$ 5.6 billion in 1970, growing at an average annual rate of 3.2 percent[15]. A somewhat significant share of 18 percent or US$ 4.4 billion of water-dependent TVA relates to Agriculture, Forestry and Fishery sector[16], which showed a substantial increase from US$ 1.1 billion in 1971.

Interestingly, the TVA in the mining & manufacturing sector was reported at US$ 8.3 billion in 2020, and the TVA in the service sector was reported at US$ 10.8 billion, indicating that industries with specific water dependence and moderate water dependence could generate much higher economic values than water used in the agriculture sector.

Water-dependent Sectors	TVA in US$ (millions)
Agriculture Sector= agriculture, forestry and fishing	4,444
Mining & manufacturing Sector= mining, manufacturing, construction, and public utilities	8,326
Service Sector= Retail, Food, Transport, financing, insurance and business services and other services	10,887
Total TVA	**23,657**

Table 3- Total Value-Added by sector

Data on costs, including the cost of acquisition, abstraction, recirculation and treatment of water by the water-dependent sectors, are not available, but the cost of water in PNG is considered very small compared to the value-added by these sectors. One of the reasons for the low cost of water is that most agricultural water is supplied from farmer-built and owned infrastructure, where the farmers directly cover the capital and operational costs, avoiding water storage and delivery charges (over 50percent of farmers in Queensland, Australia follow such practices (OECD, 2010)). Therefore, the cost of water as input is assumed to be up to 2percent of TVA.

The one sector with full dependence on water is the water supply and sewerage sector. According to a World Bank report in 2016[17], over 60percent of the PNG's population do not have access to safe and improved water supply, and over 55 percent don't have access to sanitation. The same report estimated that an annual investment of US$31 million on water supply and US$70 million per year on sanitation would be required to achieve government water supply and sanitation targets for 2030. The World Bank report also projected that in addition to the above, another US$22 million per year would be required to finance the operation maintenance of current and future infrastructure.

This indicates that an average annual investment of US$ 132 million is required to cover the country's need for safe water and sanitation services. This required investment in an entirely dependent water sector is a small fraction of the total benefit (0.5percent of total TVA) that will pass on to the community and other economic sectors. Accordingly, in this project, the research team uses 2.5 percent of TVA as an indicator to reflect the immediate value of water, which is estimated to be at around K 2,078,858,885. Adopting a multiplier of 1.58, the economic value (immediate plus knock-on effects) of water is equal to K 3,159,865,505 (or US$ 893,005,482.5).

In addition to the direct use value of water, water-dependent ecosystems deliver a wide range of other ecosystem services that generate indirect economic value, with intrinsic values beyond any economic consideration. The non-use values associated with water resources results in intangible benefits to various social groups. These benefits are often motivated by ethical concerns and altruistic preferences. They include the existence value of water resources (satisfaction from knowing water resources exist), bequest value (satisfaction from knowing water resources will be available to future generations), and even option value (satisfaction from knowing water resources will be available in the future-under uncertainty). Due to lack of data, this report recommends the following methods to estimate these benefits in more detail:

- hedonic pricing that can be conducted based on changes in the availability of groundwater irrigation supplies; costs of establishing substitute water (wells), and
- the contingent valuation that will calculate individuals' willingness to pay for alternative supply of water such as piped water supplies

No data or information was obtainable around the non-use value of water in PNG. Consequently, our economic valuation of water is **a significant underestimation**.

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15 https://knoema.com/atlas/Papua-New-Guinea/topics/Economy/National-Accounts-Value-Added-by-Economic-Activity-at-constant-2015-prices-US-Dollars/Total-value-added#:~:text=In%202019%2C%20total%20value%20added,average%20annual%20rate%20of%203.23%25.

16 https://knoema.com/atlas/Papua-New-Guinea/topics/Economy/National-Accounts-Value-Added-by-Economic-Activity-at-constant-2015-prices-US-Dollars/Value-added-in-agriculture

17 https://blogs.worldbank.org/eastasiapacific/papua-new-guinea-improving-water-and-sanitation-land-unexpected

Direct use-value of Forest Logging

According to PNG Forest Authority, 37.7 million hectares of the country's total area (46.9 million hectares) are covered by natural forests, 52 percent (19.6 million hectares) are considered production forests. Logging plays a significant role in the development and economic growth of PNG. However, forest clearing, and logging have caused soil damage, increased vulnerability to fire, increased risk of extinction of sensitive species, and biodiversity loss. Shearman et al. (2010) found that logging was responsible for 48.2 percent of forest degradation, while subsistence agriculture accounted for 45.6 percent of forest change in PNG (Shearman et al., 2010). An earlier study by Shearman et al. (2008) found commercial logging degraded a total area of 2.9 million ha of PNG forests between 1972 and 2002, with 23 percent of this degraded forest subsequently converted to non-forest cover (deforestation of 0.9 million hectares).

The monthly average value of the log production and royalties (stumpage price) in 2020 is estimated to be K 4,490,133.74 (PNGFA, 2020). Its export value has increased from K 768 million in 2011 to K 1.2 billion in 2019 (with an export volume of 3,684,000 cubic meters) and K 911 million (and export volume of 2,891,000 cubic meters) in 2020. Since 2020 figures are distorted due to economic anomalies resulting from the COVID-19 pandemic, this report assigned the average export value between 2019 and 2020. Accordingly, the market value of logging is estimated to be K 1,055,000,000. Adopting a multiplier of 1.58, the economic value (immediate plus knock-on effects) of forest logging is equal to K1,603,600,000 (or US$ 453,191,311.3).

The intense logging, particularly in the islands region (New Britain and New Ireland), is threatening its forest resilience and biodiversity richness (Shearman et al., 2008; Bryan et al., 2015). Studies such as those by (Takeuchi & Golman 2001), Shearman et al. (2008), and Fifth National Report to the Convention on Biological Diversity (2017) argue that imprecise knowledge of the forests has led to inadequate and ineffective forest governance and natural resource management.

According to PNG's Fifth National Report to the Convention on Biological Diversity (2017), most forest products are destined for China. In 2014, China imported 3.23 million m3 of logs from PNG, up from 2.75 million m3 in 2013. In 2021, PNG remained the world's largest exporter of tropical round logs exporting close to 2.8 million m3 (which showed a slight decline of 3.6 percent from 2020), 84 percent of which was exported to China[18 19]. This is while landowners are paid as little as $4-$12 per cubic meter for logs[20] indicating an unequal distribution of wealth in society due to commercial logging activities. A recent Oakland Institute report by Mousseau (2021)[21] also warns about increased illegal logging in PNG and the loss of hundreds of millions of dollars due to tax evasion. Another issue this study points at is under-pricing compared to the other five large log exporters (Myanmar, Malaysia, Gabon, Cameroon, and Congo). The study further claims that the industry does not accurately declare its profit, and the customary landowners gain very little from commercial logging and are not protected by the Constitution and other national laws.

> *"Logging was the major driver of forest degradation responsible to 90% of the degradation occurred during the reporting period. Almost the entire (99.3%) of deforestation was due to land use conversion from forest land to cropland".* (GoPNG, 2018, p 35).

Direct (extractive) Use-value of Mining and Petroleum

The mining and petroleum sectors are the major source of government revenues in PNG. The revenue generated through these sectors opens up significant growth and development opportunities within the economy. Despite the fact that the mining and petroleum industry makes significant contributions to GDP, adverse indirect cross-boundary impacts are imminent. If not managed appropriately, these adverse effects could lead to a phenomenon known as the "resource curse" (or poverty paradox). This paradox argues that countries with rich natural assets and a high dependency on extracting finite natural resources will poorly perform economically in the long run. High dependency on finite (non-renewable) resources makes tradable goods less competitive, creating an unfavourable trade balance. This situation is also harmful to the national employment level as imports of goods become cheaper, hurting local infrastructure and manufacturing capabilities.

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18 https://www.theguardian.com/environment/2018/jul/30/bulk-of-timber-exports-from-papua-new-guinea-wont-pass-legal-test#:~:text=The%20countries'%20links%20are%20particularly,imported%20into%20China%20in%202017.

19 https://inf.news/en/economy/8228d92caa6edf2191f6372b28b3ced3.html

20 https://rainforests.mongabay.com/20png.htm

21 https://www.oaklandinstitute.org/government-papua-new-guinea-crackdowns-logging-companies

The industry is currently based on six extractive minerals: gold, copper, oil, gas, nickel, and cobalt (CEPA 2020). This report refers to the Papua New Guinea Chamber of Mines and Petroleum (2021)[22] report that provided export value data to estimate the direct use-value of the mining and petroleum industry. The report indicated that the industry contributed 26 percent of PNG's GDP and around 84 percent of the nation's export revenue, totalling K 23 billion in 2017. Using the World Bank data on GDP deflator in PNG, the market value of mining and petroleum industry in 2020 prices mounts up to K 26,220,000,000. Adopting a multiplier of 1.58, the economic value (immediate plus knock-on effects) of mining and petroleum equals K 39,854,400,000 (or US$11,263,200,173.3).

Despite the fact that the mining and petroleum industry contributes significantly to PNG's economy and its population, it is also important to note that the negative cross-boundary impacts of mining on the environment are well-known. Mining and large-scale extractive activities are responsible for pollution and runoff from tailings. Several studies directly link mining to pollution and discharge of toxic wastes in coastal ecosystems, adversely impacting the food chain, habitats and species diversity (Roche and Mudd, 2014, Storey et al., 2009). Therefore, effective monitoring should be in place to minimise the environmental and social issues arising from the extraction of minerals. A 2021 report by the Centre for International Economics prepared for the Minerals Council of Australia used economic modelling to look at the changes in Australian GDP with and without mining expansion. The report found that the mining industry is capable of cost-effectively meeting international demand without mining expansion but mostly through increasing nationwide labour productivity by 1 percent a year until 2030.

Subsequently, the valuation of extractive ecosystem services is of essential importance for two reasons. Firstly, it is necessary to validate the overall impact of extractive mining activities, including the social and environmental impacts (Damigos et al., 2015). Secondly, highlight the direct mining disturbance on land use and land cover change, which will affect the provision of extractive ecosystem services in the long run (Doley & Audet, 2013). Finally, estimation of the direct use-value of extractive ecosystem services will support decision-makers both in mining development and rehabilitation practices (Wang et al., 2020, Assumma, 2022).

Direct Use-value of Renewable Energy

In addition to the above, PNG has a wide range of resources to generate energy, such as fossil fuel (oil and gas) and renewable energy sources such as hydro, biomass, LPG gas, and geothermal. Nonetheless, only 12 percent of the country's population, mainly around urban and provincial centres, has access to electricity (generated by PNG Power Limited). The mining industry also generates electricity for its own consumption in the form of captive power (ADB, 2018). Hydropower accounts for approximately 40 percent of installed capacity in PNG[23], with power plants operating in three main power grids: Port Moresby, Ramu and the Gazelle Peninsula. The remaining 60% of energy is generated by a combination of LPG, geothermal and biomass facilities.

PNG's challenging geography has given it significant hydroelectric potential. The country's topography includes nine large hydrological drainage basins fed by a vast network of large rivers. Table 4 shows the total catchment areas of these hydrological drainage basins that could be utilised for energy production. The total amount of electricity consumed in PNG in 2019 was 4.26 TWh (terawatt-hour or one trillion Wh). Since hydropower accounts for 40 percent of installed capacity, this report postulates that 1.7 TWh (or 1.7e+9 KWh) of the consumed electricity is produced using hydrological drainage basins with a total catchment area of 189,670 km^2. The total consumption is largely reflected by population size with access to electricity and the average incomes of consumers. With the electricity tariff of about US$ 0.15 per kilowatt-hour (kWh), the market value of generated renewable energy is estimated to be US$ 2,550,000,000 or K9,023,076,784.3 in a given year, which is equivalent to US$ 134.4 /ha/yr. Adopting a multiplier of 1.58, the economic value (immediate plus knock-on effects) of renewable energy equals K13,715,076,712 (or US$3,876,000,000).

River Basins	Catchment Area
Sepik River	78,000 km^2
Fly River	61,000 km^2
Purari River	33,670 km^2
Markham River	12,000 km^2
Other rivers combined	5,000 km^2
Total	189,670 km^2 (or 18,967,000 ha)

Table 4- hydrological drainage basins in PNG and their catchment area

Source: elaborated from data provided by Oxford Business Group (2018). https://oxfordbusinessgroup.com/analysis/water-works-hydropower-leads-way-providing-renewable-energy

[22] https://pngchamberminpet.com.pg/

[23] https://www.hydropower.org/country-profiles/papua-new-guinea

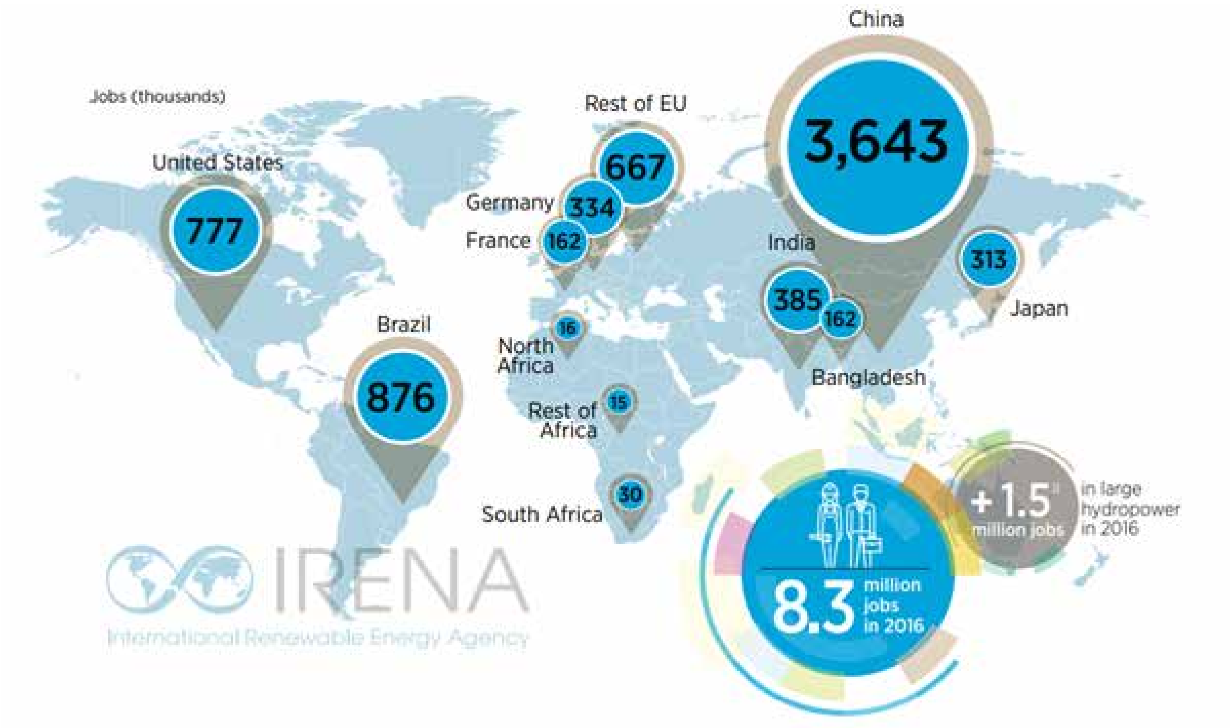

Figure 13- Renewable energy employment in selected countries, 2016 (Source: IRENA)

The promise and appeal of renewable energy have been extensively discussed in the literature, demonstrating how domestically sourced renewable energy leads to substantial environmental and economic benefits. Energy Department's National Renewable Energy Laboratory (NREL) in the US used a new method in 2015 that showed the economic potential of renewable generation has more than tripled and that renewable energy is economically viable in many palaces thanks to the recent rapid decline in technology costs[24]. NREL finds that in 2020 the economic potential equals almost half of US annual electricity demand and predicted that by 2030 lowering costs would bring that number to over 75 percent. Furthermore, the International Renewable Energy Agency (IRENA) (2017)[25] demonstrated that while China, US and Brazil are the main leaders in providing renewable energy, some Asian countries have adopted strong deployment policies and are emerging as dynamic globally competitive players. The 2017 report showed that Asian countries' share of global renewable energy employment rose from 50 percent in 2013 to 62 percent in 2016. The same report also demonstrated how the employment and occupations in the renewable energy sector are on the rise, depicting a strong global trend towards inexhaustible energy sources (Figure 13).

The Option Value of Genetic Resources:

Preserving genetic resources in agriculture is an essential aspect of biodiversity conservation. Biological resources generate income for people and government sectors that control these resources (United Nations, 1992). Underutilised protection of genetic resources can result in small gene pools or genetic erosion, leading to substantial losses to crops and other agricultural productions (FAO, 1997). Nonetheless, historically, following the common heritage principle, genetic resources have been treated as public goods and not commodities (Brush, 1996). Treating genetic resources as public goods implies that they are non-rivalrous and non-excludable. Governments often use cost-benefit analysis to decide whether to provide a particular public good and how much of it to provide to the community or for future use. This view has created a conspicuous obstacle in the economic valuation of genetic resources because market prices are absent. Therefore, economists have used survey techniques to estimate willingness to pay or accept compensations for underutilised genetic resources. Regardless, literature on the economic valuation of genetic resources in agriculture is relatively limited (Evenson et al., 1998; Rege and Gibson, 2003). Another challenge faced by economists in valuing genetic resources is the uncertainties related to the future requirements of these resources (Wale, 2008).

[24] https://www.energy.gov/eere/articles/new-report-renewable-power-economic-potential-has-more-tripled#:~:text=At%202020%20costs%2C%20economic%20potential,every%20state%20in%20the%20country.

[25] https://www.irena.org/publications/2017/Jul/Renewable-Energy-Statistics-2017

For genetic resources, three types of values could be considered:

- direct use-value
- option value
- non-use-value

The direct use-value of genetic resources refers to the production value of these resources in breeding activities. These types of information are generally unavailable. The option value, in this case, refers to individuals' willingness to pay to conserve the genetic materials for future use (such as future breeding plans or the development of new species traits), even though no use is made now. Non-use value (including the existence and altruistic values) relates to the value placed on preserving genetic resources for future generations. There is a lack of data for this value category in the literature.

Since data is not available regarding the value of genetic materials in PNG, this report adopts the benefit transfer method to assign values to these resources. This report establishes a current value of the genetic resources provided by nature-based economic valuations of similar environments drawn from a set of independent studies reported in the TEEB database. While the Philippines was selected as the study site, Table 5 shows other available valuations reported in the TEEB database.

Biome	Ecosystem Subservice	Country	Evaluation Method	Value (US$/ha/yr)
Inland Wetlands	Genetic resources	Brazil	Benefit Transfer	8.2
Forests [Temperate & Boreal]	Genetic resources	Samoa	Benefit Transfer	1.9
Forests [Temperate & Boreal]	Genetic resources	Spain	Benefit Transfer	20.0
Tropical Forest	Genetic resources	World	Benefit Transfer	1500.0
Coral Reefs	Genetic resources	French Polynesia	Benefit Transfer	240.0
Tropical Forest	Genetic resources	Australia	Direct market pricing	12.7
Tropical Forest	Genetic resources	Belize	Benefit Transfer	7.0
Tropical Forest	Genetic resources	Cameroon	Benefit Transfer	7.0
Coral Reefs	Genetic resources	Jamaica	Direct market pricing	16419.0
Tropical Forest	Genetic resources	Belize	Direct market pricing	112.1
Coastal wetlands	Animal genetic resources	United Kingdom	Direct market pricing	8.9

Table 5- The value of nature in terms of providing genetic resources

Source: TEEB database

Officially, the Republic of the Philippines is located in Southeast Asia, in the western part of the Pacific Ocean. The Philippines is a multinational state with diverse ethnicities and cultures throughout its 7,640 islands. The Philippines is also categorised as a megadiverse country in terms of species diversity. So in terms of cultural diversity and biodiversity, the Philippines strikes similarities with PNG. From a climatic point of view, and average annual rainfall, both PNG and the Philippines are very similar. In terms of economic indicators, GDP per capita in the Philippines is higher than in PNG but relatively comparable. Table 6 and Figure 14 compare key characteristics.

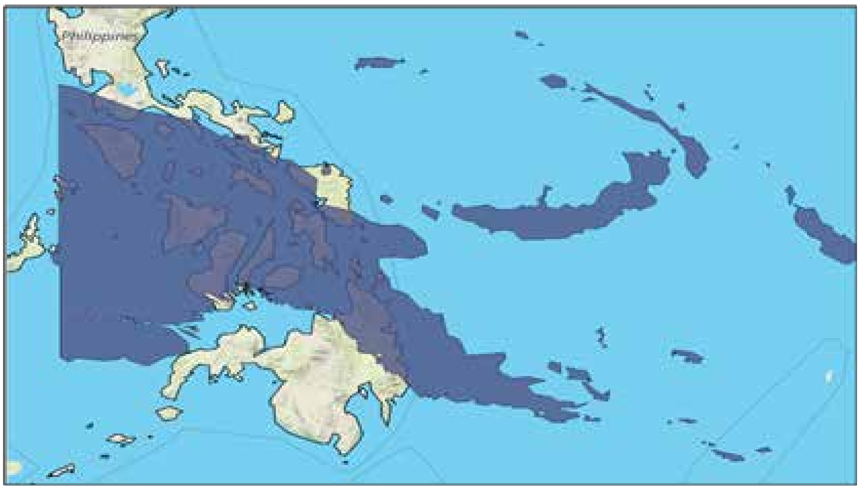

Figure 14- PNG and the Philippines compared in size-Positioning

(the outline of PNG near the middle of the Philippines) – (source: Country Size Comparison by www.mylifeelsewhere.com)

Characteristics	The Philippines	Papua New Guinea
Area	300,000 km²	462,840 km²
GDP per capita (income)	US$ 3,298.83[26]	US$ 2,636.80[27]
Climate	Hot and humid tropical climate	Hot and humid tropical climate
Average Annual Rainfall	1000 to 4,064 millimetres[28]	2,000 to 4,000 millimetres[29]
Forests	7,665,000 ha	28,726,000 ha
Coastline	36,289 km	5,152 km

Table 6- Compared characteristics between the study and policy sites

The TEEB database and a study by Samonte-Tan et al. (2007) were used to elicit the biodiversity protection value of gene pool services provided by coral reefs in the Philippines. Samonte-Tan et al. (2007) study estimated a willingness-to-pay US$ 174/ha/yr for gene pool biodiversity protection in the coral reef. Their estimation was based on Arin and Kramer's (2002) study that calculated the average willingness-to-pay as a daily entrance fee to a marine sanctuary in Panglao Island, Bohol of US$3-4 per individual per visit. Accordingly, to calculate the option value of genetic resources in marines protected areas in PNG, the unit values were adjusted using secondary data on variables such as income elasticity of WTP from already existing valuation studies

The adjustment formula that was used is:

$$WTP_p = WTP_s \, (Y_p / Y_s)^E$$

where:

WTP_p = *willingness to pay at the policy site*
WTP_s = *willingness to pay at the study site*
Y_p = *income per capita at the policy site*
Y_s = *income per capita at the study site*
E = *income elasticity of willingness to pay*

As demonstrated in the previous section, this report assumes *E* equals 0.2. Accordingly, the adjustment becomes:

$$WTP_{PNG} = WTP_{Philippines} \, (Y_{PNG} / Y_{Philippines})^E$$

where:

$WTP_{Philippines}$ = *US\$174/ ha/yr*
Y_{PNG} = *US\$ 2,636.80/yr*
$Y_{Philippines}$ = *US\$ 3,298.83/yr*
$E = 0.2$

And the WTP_{PNG}=174 (2636.80/3298.83)$^{0.2}$ = 166.38

Accordingly, WTP in PNG is estimated to be US$ 166.38 based on 2007 prices. Transferring the prices to 2020 prices, using CPI deflator indicators in PNG for the years 2007 and 2020, this report assigns US$ 276.1/ha/yr as WTP in PNG for preserving gene pools in marine protected areas. With a total area size of 354,000 hectares, the option value of preserving marine genetic resources equals US$ 97,739,400 or K 343,553,992.6.

[26] https://datatopics.worldbank.org/world-development-indicators/

[27] https://datatopics.worldbank.org/world-development-indicators/

[28] https://www.pagasa.dost.gov.ph/information/climate-philippines

[29] https://www.climatestotravel.com/climate/papua-new-guinea#:~:text=Rainfall%20typically%20ranges%20from%202%2C000,Papua%20and%20the%20Coral%20Sea.

In order to calculate the option value of terrestrial genetic resources, this report refers to Simpson & Craft (1996), as quoted in the Secretariat of the Convention on Biological Diversity report (2001), using the Philippines as the study site. According to the above studies, the social WTP per hectare of hotspot land for genetic materials is US$ 652. To calculate WTP per hectare for protecting terrestrial genetic resources in PNG, we follow our standard benefit transfer approach and adjustment formula:

The adjustment formula that was used is:

$$WTP_p = WTP_s \, (Y_p / Y_s)^E$$

where:

WTP_p = *willingness to pay at the policy site*
WTP_s = *willingness to pay at the study site*
Y_p = *income per capita at the policy site*
Y_s = *income per capita at the study site*
E = *income elasticity of willingness to pay*

As demonstrated in the previous section, this report assumes E equals 0.2. Accordingly, the adjustment becomes:

$$WTP_{PNG} = WTP_{Philippines} \, (Y_{PNG} / Y_{Philippines})^E$$

where:

$WTP_{Philippines}$ = *US$652/ ha/yr*
Y_{PNG} = *US$ 2,636.80/yr*
$Y_{Philippines}$ = *US$ 3,298.83/yr*
$E = 0.2$

And the WTP_{PNG}=174 (2636.80/3298.83)$^{0.2}$ = 166.38

Accordingly, WTP in PNG is estimated to be US$ 623.43 based on 2007 prices. The prices are then transferred to 2020 prices, using CPI deflator indicators in PNG for the years 2007 and 2020. Subsequently, this report assigns US$ 1034.5/ha/yr as WTP in PNG for preserving gene pools in terrestrial (tropical forests) protected areas. With 2.5 million hectares of the total land surface being protected, the option value of preserving genetic resources in protected tropical forests in PNG equals US$ 2,586,250,000 or K 9,090,668,792.8.

It is noteworthy that non-use values such as the existence or altruist value of genetic resources may be significant, although not computable unless survey methods are adopted to capture individuals' perceptions of these resources in PNG.

Economic Value of Regulating Services

Indirect use-value of Soil Erosion Prevention Services

Soil erosion is widespread. Soil erosion results in soil deterioration, declining land productivity (Pimentel and Kounang, 1998; Lantican et al., 2003), degradation of surface water and increased sedimentation and pollutants. Fortunately, one of the essential ecosystem services provided by terrestrial ecosystems is protecting soil from wind and water erosion (Costanza et al., 1997; Millennium Ecosystem Assessment, 2005). Moreover, vegetation restoration effectively reinforces soil erosion control (Zhou et al., 2006; Zheng, 2006; Marques et al., 2007).

Natural soil erosion prevention is in decline in Papua New Guinea (PNG). commercial logging, clearing of land for agricultural commodities, mining and the expansion of small-scale agriculture are among the main reasons behind this decline (CEPA, 2020). Soil erosion and runoff associated with land clearing and pollution associated with increased agriculture often enter the rivers and end up in the sea, damaging PNG's marine ecosystems, reducing water quality, adversely affecting subsistence fisheries and commercial fisheries' economic viability (CEPA, 2020). Under high emissions scenarios, sea levels in PNG are projected to rise between 4-15 cm by 2030 (Kiele et al., 2013), causing inundation along the coastline, particularly threatening human settlements prone to erosion.

To estimate the indirect use-value of erosion prevention services, this report used the benefit transfer method to transfer the economic values of erosion control services from the study site (the Philippines) to the policy site (PNG). In particular, this report refers to two groups of studies:

- The work of Samonte-Tan et al. (2004) estimated the economic value of erosion prevention services in coastal wetlands offered by mangroves and the TEEB database. US$ 672/ha/yr in 2004 prices or US$ 985.1/ha/yr
- The work of Hodgson and Dixon (1988), which appears in the TEEB database, provided an estimated economic value of erosion prevention services provided by tropical forests at US$ 268/ha/yr in 1988 prices (or US$ 793 ha/yr in 2020 prices) using the replacement cost method. This estimation should be interpreted with caution given the time lapse since the original research (i.e., 1988) and the uncertainty of the current expenditure estimates. There are other numerous valuation studies worldwide that estimate the value of erosion prevention offered by the tropical forest as anywhere between US$ 3 to US$1500. Accordingly, this report encourages PNG-focused research to calculate this value for the country more accurately.

Given that the mangrove-covered area in coastal wetlands in PNG is 458,600 hectares and the size of the primary tropical forest is 26,210,000 hectares[30], this report estimates the indirect use-value of erosion prevention services in coastal wetlands in PNG at around US$ 314,186,860 (or K 1,104,366,818), and the indirect-use value of erosion prevention services by the tropical forests at around US$ 20,784,530,000 (or K 73,057,623,293).

[30] https://rainforests.mongabay.com/deforestation/2000/Papua_New_Guinea.htm

Natural purification in coastal wetlands by mangroves

Mangroves are natural breeding habitats for fisheries and other marine species. Mangroves provide significant ecosystem services, including (but not limited to) protection from storm surges, high waves and soil erosion. They filter pollutants, absorb excess nutrients, and trap sediments, resulting in improved clarity and quality of waters. With a species diversity of 33-44, PNG has the second-highest number of mangrove species globally (CEPA, 2020). Furthermore, PNG mangrove-covered area comprises 57.6 percent of the total mangrove-covered area in Oceania, covering an area of 4.586 km^2 [31] or 458,600 hectares, with only 23 percent of it under protection (CEPA, 2020).

To estimate the indirect use-value of air quality regulated by mangroves in the coastal wetlands, this report refers to a currently active Asian Development Bank project around Building Resilience to Climate Change in Papua New Guinea (starting date 2015) uses an estimated value of US$ 2,697/ha/yr in constant 2014 terms for the coastal mangrove forest. This value corresponds to US$ 3,669 per hectare in 2020 prices. Accordingly, this report estimates the value of natural purification of mangrove coastlines (with an area of 458,600 hectares) at around US$ 1,682,603,400 (or K 5,940,380,825.60). It is important to note that this estimate is probably an underestimation of the economic value of natural purifications by mangroves. Moreover, as shown in Table 7, other studies have estimated different values for mangroves services for different tropical countries.

Country	Method	Year	Value (US$/ha/yr)
Malaysia	Factor Income / Production Function	1989	2,417
Thailand	Factor Income / Production Function	1998 and 2002	105.71 and 69.7
Indonesia	Direct Market Pricing	1984	93.34
Fiji Islands	Direct Market Pricing	1990	836.66
Vietnam	Factor Income / Production Function	1998	941.25
Australia	Direct Market Pricing	1990	5,846.52

Table 7- Studies that have estimated the economic values of natural purification by mangroves

Air quality regulated by the tropical forest:

To estimate the indirect use-value of air quality regulated by tropical forests through capturing fine dust, this report refers to Curtis (2004). Curtis focused on North Queensland, wet tropics world heritage area, Australia. Using direct market pricing, the study estimated the economic value of a wide range of ecosystem services. The study found the value of air quality regulated by the tropical forests in North Queensland was at around A$ 16.195 (or US$ 11.3) in 2004 prices equivalent to US$16.5. If the total size of tropical forests in PNG is considered (i.e., 28,726,000 hectares), the value of air quality regulated by the forest would be at US$ 473,979,000 or K 1,666,036,193 per year. If only protected areas are considered (i.e., 2.5 million hectares), then the value of air quality regulated by 53 nationally registered managed areas would be around US$ 41,250,000 or K 144,993,750.7.

Indirect use-value of Pollination services

According to the U.S Forest Services, pollination comprises 1,400 food crops and plant-based industrial products grown globally. Almost 80 percent require pollination by animals and insects[32]. Bees are considered significant pollinators in crop pollination by substantially adding value to the quantity and the quality of crops and contributing to the production of approximately one-third of the human dietary supply. Nonetheless, a few studies indicate that honey production in PNG has been declining in the past four decades (Government of PNG, 2010; Orlegge & Gonapa, 2011; Clarke, 2014; Lloyd et al., 2019; Schouten et al., 2020), implying that the number of bees may be declining. Factors such as limited technical skills, lack of funding and provision of educational materials, and poor understanding of honeybees have contributed to this decline (Orlegge & Gonapa, 2011; Clarke, 2014). The beekeeping industry in PNG is concentrated in the Eastern Highland, with an investment value of approximately PNG K 2.1 million (US$ 614,838), excluding government inputs in training and extension (Schouten & Lloyd, D., 2019; Schouten et al., 2020).

[31] The reported total mangrove-covered area size varies. In CEPA (State of Environment Report) (2020), this area once is stated to be 5,399 km^{2}and in two other instances (in the same report) the area is stated to be 4,586 km^2 and 4,159 km^2. This report assumes 4,586 km^2 as the correct area size. The percentage coverage under protection is also stated differently. This report used 23% coverage associated with 4,586 km^2.

[32] https://www.fs.fed.us/wildflowers/pollinators/importance.shtml

Data is not available on pollination services provided by nature in PNG, nor does any study provide value estimates. Subsequently, to estimate the value of pollination services in PNG, this report first inspects the list of major crops in PNG and their insect-mediated pollination dependency, as shown in Table 8.

Crop	Insect Dependency	Crop	Insect Dependency
Coffee	20-40%	Melons/watermelons	>90%
Coconut, cashew nut	10-40%	Wide variety of vegetables (e.g., Broccoli, cauliflower, cabbage, soybeans, etc.)	10%-50%
Fruits (e.g. Guava, Mango, passionfruit, rambutan, etc.)	50-90%	Oil palm fruit and copra	10-40%

Table 8- List of PNG's main crops that are dependent on insect-mediated pollination

Source: various, including Gordon and Davis, 2003; Roubik, 2002; Freitas, 2005; Klein et al., 2007.

The next step is deciding the contribution of the pollination services to agricultural production in PNG. To do this, we refer to several existing case studies. From the reviewed literature, this report finds that most of the pollination services valuation studies have focused on temperate or arid zones, with only one case study in the tropics.

A study in New Zealand by Gibbs and Muirhead (1998) found that pollination services contribute around 16 percent of the total agricultural production value, while Khalifa et al. (2021) found that Animal-based pollination contributes to 30 percent of global food production. This contribution was found to be 33% in Eastern Amazon (Borges et al., 2020), 7 percent in Australia (Gordon and Davis, 2003), and 5 percent in Canada (Winston and Scott, 1984). It is estimated that pollination services globally are worth more than US$ 3 trillion and, in the US alone, is US$ 10 billion annually[33]. In the Netherlands, the value estimates of the pollination service range from 1 percent to 16 percent of the market value of agricultural production (Hein, 2009). Another study focused on bees found that 5–8 percent of all global crop production would be lost (Khalifa et al. (2021)). A study in Mexico focusing on bats pollination services found that bats contribute around 40 percent of gross income across cactus fruits producers (Tremlett et al., 2021). The only study that was found pertinent to the tropical forests was the work of Ricketts et al. (2004), focusing on coffee farms in tropical forests in Costa Rica, which found that pollination services contributed an average of 7 percent of total farm income in 2000–2003.

Regarding species interaction within pollination systems, it is important to pay attention to differences between tropical networks compared to non-tropical ones. Tropical communities, on average, contain higher functionally pollination systems (e.g. bees, birds, beetles, flies, bats, etc.) and higher modularity (Vizentin-Bugoni et al., 2018) than other climatic zones. With much higher species richness and biodiversity, the tropics, and more importantly, PNG, is expected to have higher modularity and interactions of pollinators. Accordingly, this report postulates that ecosystem pollination services in PNG contribute between 16-30 percent of the overall market value of agricultural products, yielding an annual value of K 430,128,000-K 806,490,000 (or US$ 122,581,662-US$ 229,840,617).

Indirect Use-value of Carbon Sequestration

An assessment completed by Bryan et al. (2015) estimated 71 percent forest cover nationally, while a report by the United States Agency for International Development (USAID, 2020) suggested a forest coverage of 90 percent of the landmass in PNG. USAID (2020) indicated that it is probable that the discrepancies between the two studies are due to different definitions of the forest. Regardless of precise land coverage, PNGs forests conserve a large amount of carbon dioxide (CO2), and they have international importance because of their carbon status. Figure 15 shows PNG's land cover, including different types of forests. The map is produced by the research team using FAO's landcover data.

To show the significance of forests in carbon sequestration, the CEPA (2020) report on the state of the environment illustrated that if all four million hectares of Special Agriculture Business License (SABL) are cleared, 1.2 GtCO2e-will be emitted into the atmosphere. This amount would be equivalent to around 30 years of emissions. Therefore, the climatic consequences of degrading natural forests would be colossal. As mentioned in previous sections, logging and mining in PNG are causing significant forest degradation and deforestation. Some argue that forest regeneration will offset most of these adverse impacts; however, the regeneration of the forest may take up to between 50 years (Hunt, 2002) and 200 years (Lamb, 1990). The regeneration rate, in terms of the carbon fixed, is constant at one-fiftieth of the original loss (Hunt, 2010).

In terms of the cost of carbon released into the atmosphere, globally, numerous studies have attempted to estimate the cost of carbon sequestration in forests. Estimations range between US$ 10 to US$ 200 per tonne (Richards and

[33] https://ecga.org/Post/Pollinators-We-Cant-Live-Without-Them

Figure 15- Land cover in PNG- 300m resolution (2008) (Source: authors)

Stokes, 2004). In a PNG focused study, Hunt (2010) followed Fankhauser's (1995: 64) and used once-and-for-all costs per tonne of US$20 for the years 1991-2000; the cost amount raised to US$ 22.8 in 2010 and was projected to reach US$ 25.3 by 2050. Accordingly, this report assumes an average value of US$ 24.05 per tonne, using the estimated costs per tonne for 2010 and 2050. Soil and biomass carbon stock data was obtained from Sam et al. (2021) study. The study found that the total carbon stored in PNG's forests is around 11,733 × 10^6 (or 11,733,000,000) tonnes, with 66 percent stored in the soil and 34 percent in the biomass. Accordingly, the indirect use-value of carbon sequestration by PNG forests is estimated to be around US$ 282,178,650,000 or K 997,922,840,794.16.

Indirect Use-value – Disturbance Moderation (Flood Control)

Flood protection is one of the most essential regulating services that ecosystems provide. The value of such services is amplified in times of climate change and intensified extreme weather events. Flood protection services supplied by nature reflect the ecosystem's capacity to lower flood threats caused by heavy precipitation events and reduce runoffs.

Inland flooding is on the rise in valleys, mountains and wetlands in PNG. The economic and livelihood losses from floods have increased considerably recently. Some of the reasons behind increased socio-economic losses from the flood are increased economic activities in flood zones combined with climatic conditions such as increased rainfall intensity (Arnell and Gosling, 2016). Increased rainfall intensity and land-use change trigger landslides in the highlands and rugged terrains. These events have caused significant damages to local communities and impacted mobility across affected areas. In addition, the adverse impact of inland flooding amplifies the deforestation rate (CEPA, 2020).

Coastal flooding is triggered by both heavy rainfalls and rising sea levels. Globally, the global mean sea level has been rising at a rate of approximately 3.2± 0.4 mm per year (CSIRO et al., 2015; Fasullo & Nerem, 2016), and it is projected to continue to rise through 2100 (CEPA, 2020). Coastal flooding adversely impacts local and regional communities. GoPNG's (2018) report indicated that more than five catastrophic coastal flood events had affected some 8,000 people in the past two decades, making some areas uninhabitable. In PNG, the sea level is predicted to rise by up to 0.5m in northern Small Islands Developing States (SIDS) and up to 0.6m in eastern SIDS (CEPA, 2020). However, CEPA (2020) has estimated the cost of annual damage caused by flooding in inland areas to be between US$ 8-12 million and US$ 10-20 million.

In economics, the cost of replacing ecosystem services provides useful estimates of the values of those ecosystem services. This is based on the assumption that if society incurs costs to replace the affected ecosystem services, then those services must be worth at least what society should pay to replace them. In this case, flood protection services cannot be directly replaced, so this method would not be helpful. The assessment of an ecosystem's capacity to provide flood protection is often based on biophysical methods (Nedkov and Burkhard, 2012), such as water retention functions (Nedkov et al., 2013) and the capacity of floodplains (Posthumus et al., 2010). Another method includes estimating benefits (i.e. economic welfare) ensuing from reduced flooding by reducing deforestation (Kramer et al.

1997). To the best of the research team's knowledge, this information is not available for PNG. Accordingly, this report resorts to the benefit transfer method to estimate the indirect use-value of flood prevention services offered by nature. The study site selected for this exercise is Laos, in Southeast Asia. While the country is landlocked and so significantly different from PNG in that sense, it has similar climatic features, including being a tropical land and influenced by the monsoon patterns (as shown in Table 9 and Figure 16). The average annual rainfall is similar between the two countries, and socio-economic indicators are comparable.

Figure 16- PNG and Laos compared in size- Positioning the outline of Laos near the middle of PNG (source: Country Size Comparison by www.mylifeelsewhere.com)

Characteristics	Laos	Papua New Guinea
Area	236,800 km²	462,840 km²
GDP per capita (income)	2,630.20 [34]	US$ 2,636.80 [35]
Climate	mainly tropical climate	Hot and humid tropical climate
Average Annual Rainfall	1200 to 3,000 millimetres [36]	2,000 to 4,000 millimetres [37]
Forests	12,500,000 ha	28,726,000 ha
Coastline	No coastline	5,152 km

Table 9- Compared characteristics between the study site and the policy site

Recommended by the TEEB database, the study by Rosales et al. (2005) was selected as the point of reference. The study used the avoided cost method to compute how much it would take to prevent floods in Laos's Sekong region if actual dams were built. The study found that the avoided cost (value of watershed protection services) is approximately US$ 92.3 per forest hectare per year. The direct beneficiaries of flood protection services are people living and/or operating within the watershed catchment areas. Considering that 28,726,000 hectares of PNG's landmass are forested, the value of flood protection services provided by the forest is estimated to be around US$ 2,651,409,800 (based on 2005 prices). To obtain 2020 values, the CPI deflator for PNG was used for 2005 and 2020. Accordingly, the final value of flood protection services is estimated to be around US$ 3,967,131,191 or K 13,944,466,202.

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[34] https://datatopics.worldbank.org/world-development-indicators/

[35] https://datatopics.worldbank.org/world-development-indicators/

[36] https://www.pagasa.dost.gov.ph/information/climate-philippines

[37] https://www.climatestotravel.com/climate/papua-new-guinea#:~:text=Rainfall%20typically%20ranges%20from%202%2C000,Papua%20and%20the%20Coral%20Sea.

Economic Value of Supporting Services

The option value of biodiversity maintenance

In 1998, Conservation International rated PNG and 17 other countries as “mega-diverse”. PNG hosts between 6–8 percent of the global species in less than 1 percent of the world’s land area. The country is home to more than 18,894 plant species, 719 birds, 271 mammals, 227 reptiles, 266 amphibians, 341 freshwater fish species, 600 species of coral and 3,000 species of reef fish. The total number of species is unknown but estimated to be around 200,000-1,000,000, making PNG a global hotspot in species diversity and endemism. Figure 17 shows species richness based on the IUCN Red List of Species. Furthermore, the number of species under extinction threat is rising due to development activities, human exploitation, invasive species, and climate change (Figure 18). Therefore, the value of maintaining biodiversity and species richness in PNG is exceptionally high by international standards (Independent State of Papua New Guinea, 2014).

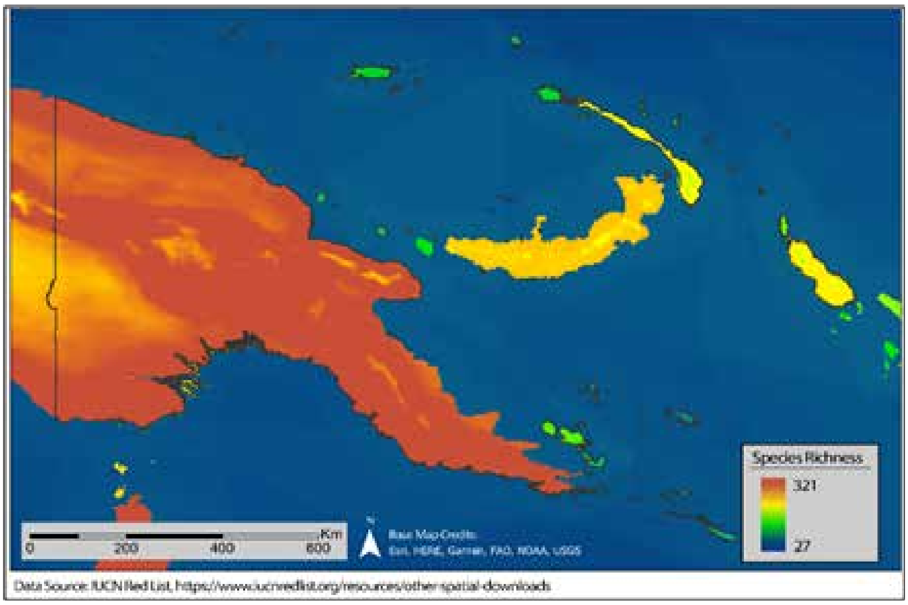

Figure 7- Species Richness- (Source: authors, using the IUCN Red List of Species,2017)

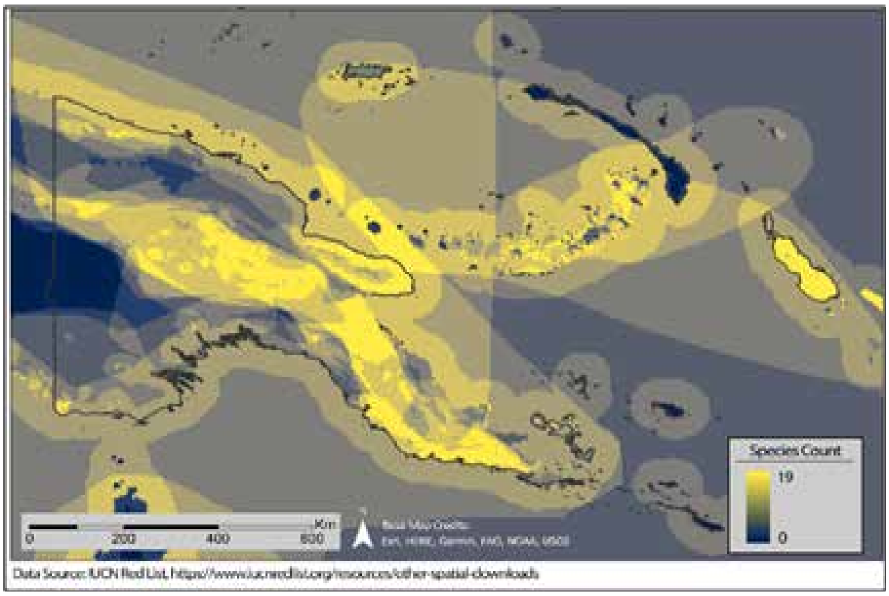

Figure 18- Threatened, Endangered and Critically endangered species (Source: authors, using the IUCN Red List)

Nonetheless, only 53 nationally registered managed area that encompasses about 4 percent (2.5 million hectares) of the total land surface are protected. In addition to terrestrial protected areas, several small marine conservation areas are scattered near-shore marine habitats encompassing less than 1 percent (3,540 km²) of the seascape (CEPA, 2020). Figure 19 shows coral reef, seagrass and protected areas distribution.

PNG's new Protected Area Classification System follows the IUCN category system tailored to suit the PNG context (as shown in Table 10). This classification includes both marine and terrestrial protected areas owned and operated by customary landowners, all levels of public and private sectors, and NGOs.

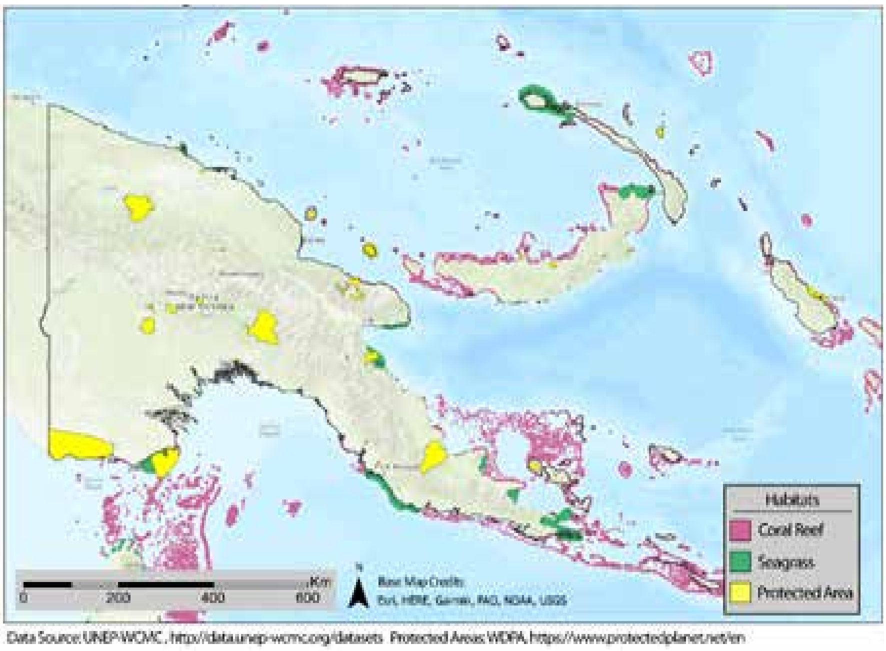

Figure 19- Distribution of coral reef, seagrass and protected areas (Source: research team, using the UNEP-WCMC database)

Class	IUCN Category	Group
National Park (NP)	II	National
National Heritage Area (NHA)	III	National
Special Management Area (SMA)	IV	National
Community Conservation Area (CCA)	V	Regional
Locally Managed Marine Area (LMMA)	V	Regional
Marine Sanctuary (MS)	IV (with zones)	National

Table 10- Protected area classes for PNG
Source: Papua New Guinea Policy on Protected Areas (n.d.)

There is a lack of information on the management structure of protected areas in PNG. However, a 1999 review for the World Bank/WWF Alliance for Forest Conservation and Sustainable Use showed that of the 53 protected areas, 73 percent have minimal or no management structure, 16 percent had no management at all, 8 percent had a management structure, but there were serious gaps. Only 3 percent of the protected areas were well managed with good infrastructure (IUCN 1999:26). More recently, Leverington et al. (2017) visited the managing structure of protected areas as part of the process to improve management effectiveness. Using the Management Effectiveness Tracking Tool (METT) analysis, the study found that "only four protected areas are rated as achieving very good progress. A further three protected areas are rated as having good progress, although with some concerns. The remainder of the protected areas is struggling to deliver even basic management[39]". Figure 20illustrates the managing structure of PNG PAs and its improvement since 1999.

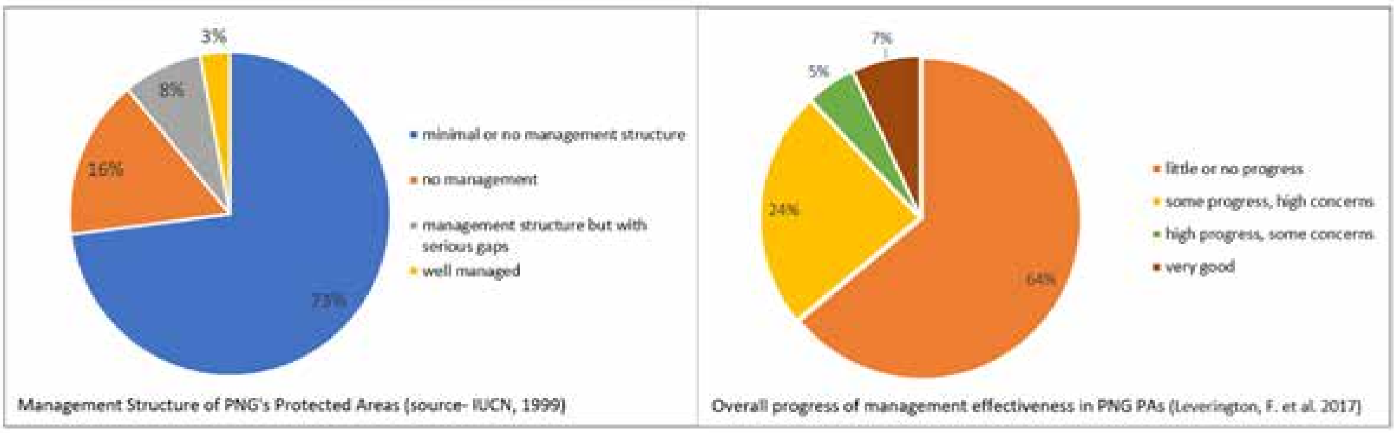

Figure 20- Management Structure of PNG's Protected Areas

4th Goal: Papua New Guinea's natural resources and environment should be conserved for the collective benefit of all and should be replenished for future generations

[38] https://mpatlas.org/countries/PNG

[39] The analysis shows decline in the management of most PAs across the country, for example, the McAdam National Park in Bulolo Morobe province is completely decimated by gardening and forest fires and within the park

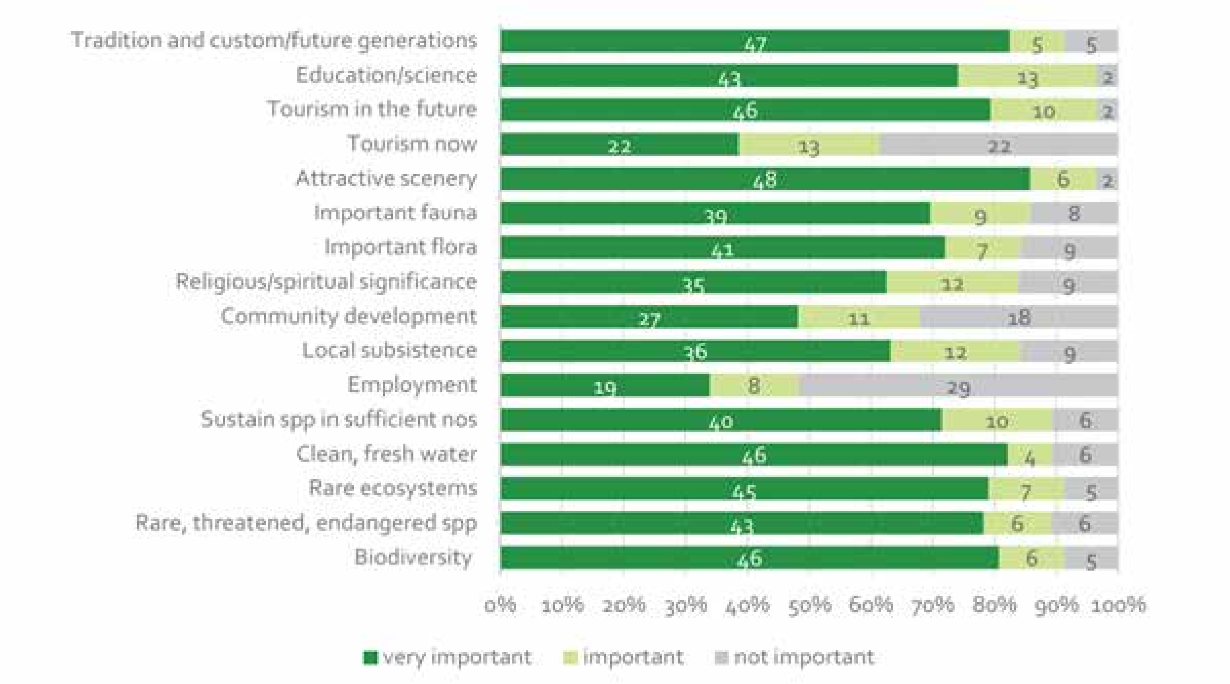

Figure 21- Perception of benefits around PNG's PAs (Source: Leverington et al. 2017)

Furthermore, there are also issues such as inefficient management of protected areas and a lack of clarity around the national legal definition of protected areas in PNG, which has resulted in disputes surrounding how much of the country's land and seascapes should be protected (IISD, 2020). The Papua New Guinea Policy on Protected Areas was introduced in 2014 to provide an implementation framework to achieve the 4th Goal of the National Constitution. The PA Bill has been completed and is due to be passed in 2022.

A Key Performance Indicator (KPI) for achieving the 4th Constitutional Goal, as outlined in Vision 2050 is the existence of "Professional competence and world standard research programs on environment and climate change" (Vision 2050 page 42). Leverington et al. (2017) urge the national government and the international community to act promptly and provide support to PAs before the situation deteriorates to the point of no return. The study also conducts questionnaires and workshops with PNG stakeholders, asking about protected area values and the condition and trend in these values over time. The participants listed a total of 290 values for the 58 protected areas. The study found that: 93 percent of the protected areas nominated natural values, 88 percent listed socio-economic values (livelihood and commercial), 71 percent listed cultural values 10% had historical values. However, there are very close links between 'natural', cultural and 'livelihood' values.

Most protected areas in PNG are highly valued by customary landowners as places where nature and culture are relatively intact. People still perceive a close relationship between nature, culture and livelihoods where animals and plants are respected for their own value, but more often as important resources for food, medicines, building material and cultural practices (Figure 21).

The Protected Area policy is built on five pillars for an effective protected area network:

1. Protected Areas, Governance and Management;
2. Sustainable livelihoods for communities;
3. Effective and adaptive biodiversity management;
4. Managing the Protected Area network;
5. Sustainable and equitable financing for Protected Areas.

Pillar four and pillar five recommend the development of a Biodiversity Trust Fund to support the Protected Area Network through mechanisms such as biodiversity and ecosystem services offsets, green contributions such as levies and taxes, and donations and philanthropic contributions; and will develop small grant programmes to deliver funding directly to support local communities in the establishment and management of Protected Areas.

Furthermore, CEPA (2020) recommends increased funding to conduct conservation work and calls for a need for proper Environment Impact Assessments (EIA), monitoring and training programs. CEPA report indicates that while key data and data sources may have been identified by academic institutions or organisations such as National Research Institute (NRI), World Wide Fund for Nature (WWF), and government agencies, including CEPA, NAQIA, NARI, and NFA, there is still a need for data sharing and data accessibility.

The National Biodiversity Strategy and Action Plan or NBSAP (2020) by CEPA for 2019-2024 is considered the PNG's roadmap to mainstreaming and integrating nature conservation. The plan includes national strategies and priority actions to ensure conservation and environmental sustainability in line with obligations under international agreements. For example, according to NBSAP action plans, by 2022, the country will have:

- ensured the protection and conservation of around 17.9 percent of terrestrial and freshwater ecosystems as protected areas (aka Aichi Target 11)
- conserved at least 9 percent of coastal and marine areas
- reduced primary forest depletion from 9 percent to 5 percent

According to the IPBES definition, the option value of biodiversity is the value of maintaining living variation in order to deliver future uses and benefits (IPBES 2018a and b). Therefore, the existence value of biodiversity refers to the benefits from including a sense of well-being, of simply knowing biodiversity exists, even if it is never utilised or experienced. The option value of biodiversity maintenance refers largely to maintaining the capacity of ecosystems, habitats, and species to support a good quality of life. Due to lack of information and inventory research around maintaining capacity and functionality of ecosystems in PAs, option value of biodiversity was not calculated in this report.

Existence Value of Tropical Rainforest

The only study found that provides valuation information about the existence value of tropical rainforests in PNG is Manoka (2011). The study compared the existence value of the tropical forests in PNG and Portland in the US. This study is used in this report as a point of reference for the non-use value of the forest. Manoka (2011) focused on the existence value of forests in PNG held by residents in Port Moresby by measuring the mean economic willingness to pay (EWTP) to preserve an additional 5 percent of the tropical rainforests in PNG. The average WTP per household ranged between K16.53 and K40.30, and the average EWTP ranged between K 10.02 and K 22.45. The study then generalised the result to the general population and found that total EWTP ranged between K 11.3 million and K25.2 million. Transferring these values to 2020 prices, the estimated existence value of tropical rainforest in PNG would be between K 16,343,870 (or US$ 4,649,749.7) and K 36,448,276 (or US$ 10,369,353).

Existence Value of Marine Biodiversity Conservation

Papua New Guinea has a total sea and ocean area of 3.12 million square kilometres and a total coastline of 17,110 kilometres which encompasses the coastal peripheries of the mainland and the islands of fifteen of its provinces. While the country's focus has been on land utilisation, the ocean environment has not been developed, mainly because of the poor understanding of ecosystems that offered new challenges (Vision 2050, page 50).

The fisheries sector in PNG comprises subsistence and commercial fishing. This sector is the third largest renewable resource sector contributor to Papua New Guinea's export earnings, after agriculture and forestry (Vision 2050, page 51).

PNG has extensive and valuable fisheries resources, ranging from inland river fisheries, aquaculture, coastal Bêche-de-mer and reef fisheries to the prawn trawl and large-scale deepwater tuna fisheries. Commercial fishing is carried out by licensed medium-sized domestic prawn and tuna long-line operators and large international fleets in the deep-water tuna fishery (PNG Development Strategic Plan 2010-2030, page 92). s. At the national level, PNG's fisheries industry contributes an estimated PGK 350-400 million annually to the country's economy (National Biodiversity Strategic Action Plan 2020, page 11). however, due to the lack of data available regarding the value of marine biodiversity conservation, this report resorted to the benefit transfer method to compensate for missing values. In particular, the "unit value" transfer method was selected to express values for ecosystem services. The Philippines was selected as the study site.

Relevant unit values from the Philippines were obtained from a selected study by Charmaine et al. (2018). The study estimated the WTP biodiversity value using the underwater visual census (UVC) survey and literature data. The study found that the willingness-to-pay (WTP) to visit marine protected areas (MPAs) ranged from 0.07 to 9 million US $/yr or 33 to 175,000 US$/ km^2/yr; however, on average, the study estimated the final WTP of US$ 2,234/ km^2/yr (i.e., the unit value of study site). Once this unit value (or WTP) was obtained, it was multiplied by the number of pertinent units of PNG (as the policy site). Then, the unit values were adjusted to reflect differences (e.g., income and price levels) between the study and policy sites. After obtaining the option values (wherein the possible direct and indirect use value of the ecosystem in the future is accounted for) of marine biodiversity conservation from the Philippines related studies, adjustments to unit values were using secondary data on variables such as the income elasticity of WTP (e.g. from already existing valuation studies).

The adjustment formula that was used is:

$$WTP_p = WTP_s \, (Y_p / Y_s)^E$$

where:

WTP_p = *willingness to pay at the policy site*
WTP_s = *willingness to pay at the study site*
Y_p = *income per capita at the policy site*
Y_s = *income per capita at the study site*
E = *income elasticity of willingness to pay*

The data on the income elasticity of WTP for environmental improvement is not readily available. However, most of the relevant studies find that this elasticity is typically less than one (Kriström and Riera 1996; Ready et al. 2002; Hökby and Söderqvist 2003; Jacobsen and Hanley 2009; Czajkowski and Ščasný 2010). Also, Barbier et al. (2017) found that the income elasticity of WTP for environmental improvement is between 0.1–0.2 for low-income respondents and reaches 0.6–0.7 for the highest income levels. Since both Papua New Guinea and the Philippines are ranked as lower to middle-income countries, following Barbier et al. (2017), this report assumes E equals 0.2. Accordingly, the adjustment becomes:

$$WTP_{PNG} = WTP_{Philippines} \, (Y_{PNG} / Y_{Philippines})^E$$

where:

$WTP_{Philippines}$ = *US$2,243/ km²/yr*
Y_{PNG} = *US$ 2,636.80/yr*
$Y_{Philippines}$ = *US$ 3,298.83/yr*
$E = 0.2$

And the WTP_{PNG}=2243 (2636.80/3298.83)$^{0.2}$ = 2144.7

Accordingly, this report assigns US$ 2,144.7/km²/yr as WTP in PNG for marine biodiversity conservation based on 2018 prices. Transferred to 2020 prices, the WTP equals 2,338.3 /km²/yr or US$ 23.38/ha/yr. Therefore, the existence value of the current 3,540 km² (or 354,000 hectares) of marine protected areas equal to US$ 8,277,582. Should the 10 percent territorial waters and coastline target (2025) be achieved under PNG Policy on Protected, marine protected area's existence value will significantly improve.

Direct Use-value- Cognitive development

PNG continues to be a popular research and education site by local and international academic institutes. The financial and economic values should reflect benefits arising from research projects and publications. However, this valuation of the benefits is complex. Some of the main components would include (but are not limited to):

- Research with direct commercial application
- Part of the research that induces commercial results
- Research that improves management to avoid the cost
- The financial cost of the research (expenditure for field works, primary data collection etc.)
- Educational benefits from books, excursions, commercial tours etc

Some existing studies could provide financial information on the cost of research for the value transfer method (including Samonte-Tan et al. (2007), and Van der Ploeg, S. and R.S. de Groot (2010) /TEEB database); however, due to the absence of other critical information around research in PNG, the application of value transfer method would not be possible in this case.

The cost of conducting studies reflects the willingness to pay for access to natural resources with research value. And while some values related to research activities listed above can be available on records, tracing all educational benefits (e.g. existence values of protected areas) would be very difficult. Wildlife Conservation Society in PNG has provided some information on the cost of conducting marine research which includes:

1. Cost of Sea Cucumber (Bêche-de-mer) research equals K 10.366 per trip, including boat fuel, accommodation, meals, slates, survey materials, and other supplies.
2. The cost of a Coral Reef survey, which equals K 33,094 per trip, includes boat hire, accommodation, meals, flex, survey materials and other supplies.

No information regarding the number of trips per year is available. So broader measures are used to provide an overall estimate of the cognitive development value of nature in PNG. The only data which are relatively easy to collect are the financial costs of research & development (R&D). Accordingly, the research team looked at the national expenditure on R&D, which is a key indicator of government and private sector efforts to obtain a competitive advantage in science. Estimates of the resources allocated to R&D are collected from the UNESCO Institute for Statistics[40], which looks at the Gross Expenditure in Research and Development (GERD) as a percentage of the GDP. GERD is the total internal expenditure on R&D performed in PNG national territory during a specific reference period expressed as a percentage of PNG's GDP. The measure excludes R&D expenditures financed by domestic firms but performed abroad[41]. GRED is only calculated for PNG in the reference year of 2016, which reveals an estimate of 0.03 percent of the country's GDP in 2016. For comparison, the world average in 2016 based on 54 countries is 0.87 percent indicating a much higher allocation to research as a percentage of GDP. GERD of 0.3 percent would be equal to US$ 7,080,000 based on the country's GDP in 2020. Adopting a multiplier of 1.58, the economic value (immediate plus knock-on effects) of nature in regard to cognitive development becomes US$ 11,186,400 (or K 39,390,715.80) in total or US$ 0.24/ha/yr. Table 11 provides a comparison between the use-value of nature in terms of providing cognitive development benefits.

Biome	Ecosystem Subservice	Country	Valuation Method	value (US$/ha/yr)
Coral reefs	Science / Research (Cognitive)	Samoa	Benefit Transfer	0.04
Coral reefs	Science / Research(Cognitive)	The Philippines	Other	53
Coral reefs	Education (Cognitive)	USA	Direct market pricing	5365
Coral reefs	Science / Research (Cognitive)	French Polynesia	PES	117
Coral reefs	Science / Research (Cognitive)	Ecuador	Direct market pricing	2.73
Estuaries	Science / Research (Cognitive)	Netherlands	Direct market pricing	16
Coral reefs	Science / Research (Cognitive)	Caribbean	Benefit Transfer	35
Forest [unspecified]	Education (Cognitive)	Portugal	Travel Cost	0.49
Coral reefs	Science / Research (Cognitive)	Australia	Direct market pricing	61.03
Coral reefs	Science / Research (Cognitive)	South-East Asia	Direct market pricing	1.2
Coral reefs	Science / Research (Cognitive)	USA	Direct market pricing	120.87

Table 11- The use-value of nature in terms of providing cognitive development opportunities
Source: TEEB database

The option value of Subsidised Eco-forestry

Within the context of Total Economic Value (TEV), the concept of "option value" is anchored in the expected utility theory. Implying that if an ecosystem service (or an element of it) has no use-value today, it may have a future value (option value). In this sense, the option value of nature's conservation is comparable to an "insurance premium" (Perrings, 1998; Turner et al., 2003; and Balmford et al.,2008), which individuals or businesses are willing to pay today in order to reduce a potential loss tomorrow. While the provision of forest ecosystem services could be uncertain

[40] http://data.uis.unesco.org/

[41] The fields of science and technology used to classify R&D according to the Revised Fields of Science and Technology Classification are: 1. Natural sciences; 2. Engineering and technology; 3. Medical and health sciences; 4. Agricultural sciences; 5. Social sciences; 6. Humanities and the arts. The data is obtained through statistical surveys which are regularly conducted at national level covering R&D performing entities in the private and public sectors. https://www.indexmundi.com/facts/papua-new-guinea/indicator/GB.XPD.RSDV.GD.ZS

now, its value is constantly expected to increase Bulte et al. (2002). Activities such as deforestation of primary forests are recognised to have an irreversible negative effect on the provision of such services. In such a scenario, the option value of maintaining the nation's primary forests is directly related to the investment in the nation's natural capital. The uncertainty surrounding the provision of forest ecosystem services emanates from uncertain demand for forest conservation or possible substitute services in the future, all of which would affect preferences. To estimate the option values, this report explored the ecosystem service's capacity to maintain a sustained flow of benefits in the face of variability and disturbance.

Eco-forestry has been defined as a selection of forestry and restoration forestry holistic practices in order to maintain, protect, or restore the forest to its original standards where it can still be sustainably harvested for products. Under the eco-forestry approach, maximising economic productivity is not the primary goal; instead, it is the protection of the ecosystem to increase the survival likelihood of the forest against human disturbances.

When it comes to the economic valuation of the forest, the option value of the forest becomes increasingly important, especially in developing countries where basic human needs and traditional economic growth are the dominant concerns, and deforestation becomes the leading cause of depletion of the forest resources (Chopra 1993 and van Wilgen et al. 1996). Unfortunately, however, measuring the option value of the forest is challenging as the future benefits of the forest are difficult to quantify (i.e. unsubstantiated by quantitative proof), and the values, when measured, can be controversial. Nonetheless, a study by Hunt (2002) uses Net Present Value (NPV) techniques to assess the financial benefits of 1,000 hectares of forest to the PNG community. The study finds that both subsidised and unsubsidised eco-forestry practices generate positive NPVs.

The economic results of the study revealed that, at the discount rate of 0.08, on a per hectare of forest basis, and a 50 percent level of avoidance of carbon release, the benefits of subsidised eco- forestry (to replace logging) is positive and equal to US$ 313/ ha in 2002 (or $ 731/ha in 2020 prices). The study found the NPV becomes negative at a lower discount rate of 0.03. With around 100,000 hectares committed to eco-forestry practices (Hunt, 2002), the overall value of eco-forestry to replace logging is considered to be US$ 31,300,000. Under the same scenario, subsidised direct conservation to replace eco-forestry generates an NPV of US$ 268 / ha in 2002 (or US$ 625/ha in 2020 prices). Indicating the net present value of eco-forestry would still exceed the benefits generated from direct forest conservation. Therefore, eco-forestry should be preferable to direct conservation (i.e. restoring or preserving biodiversity where needed). The study does not include the cost of labour since it postulates that the community as a whole both pays and receives wages under the scenario. In addition, the study pointed out that committing to subsidised eco-forestry will also result in foregone government revenues that would have been earned otherwise in the form of export log tax (log levy)[42]. Converting 2002 prices to 2020 prices at the discount rate of 0.08, on a per hectare basis, the NPV of 100,000 hectares already committed to eco-forestry equals US$ 73,100,000 or K 256,946,501[43].

It is important to note that apart from the net present value of eco-forestry being higher than direct conservation, eco-forestry allows for the extraction of only a small proportion of timber minimising forest disturbance. Hunt (2002) compares logging that removes 30,000 m3 from 1000 hectares that cause significant ecological disturbances vs eco-forestry practices that extract 375m3 of logs per year from the same area. A practice that sets carbon and environmental losses at zero.

[42] Over the last decade, Papua New Guinea has become the largest exporter of tropical timber (Oakland Institute, https://www.oaklandinstitute.org/government-papua-new-guinea-crackdowns-logging-companies)

[43] Under the assumption that the opportunity cost of labour equals to the wage cost of eco-forestry

Economic Value of Recreation/Cultural Services

Direct Use-value of Tourism

According to FAO (2010), the total forest area of Papua New Guinea (PNG) is approximately 28,726,000 ha, with high mountains and lowland and more than 70 percent of its total land area (ibid.). Moreover, the country has 600 smaller islands with substantial coastal plains and coral reefs. This geographical diversity has offered a considerable foundation for tourism development (Basu 2000; ETTF & ATIBT 2018).

The tourism industry in PNG is growing, and it represents an opportunity for diversified economic growth. The industry has successfully created jobs and supported small businesses, particularly in regional and rural areas. Globally, PNG has a number of comparative advantages in the niche market. According to International Finance Corporation (2018) from the World Bank Group, Part I, PNG:

- is the most biodiverse country in the world and is known as the paradise of species
- is the most culturally diverse country in the world, with over 844 living languages and tribal diversities
- has an unspoiled natural environment
- has a variety of terrains and climates
- has numerous historical attractions and relics from WWII
- has numerous marine assets and wrecks
- is an uncrowded and unspoiled destination

Niche market segments for PNG tourism include cultural tourism, birdwatching, soft adventures, historical tourism and divining. International Finance Corporation (2018) conducted a scenario analysis to explore niche market potentials in tourism between 2016 and 2027 (as shown in Table 12). Under the mid-growth scenario, the report found that if the government invest US$20 million in facilitating investments to attract more niche visitors, the corresponding tourist expenditure will reach US$ 209,200,000 by 2027. Under the high-growth scenario, if the government invest US$ 78 million in essential tourism infrastructure and services, corresponding tourist receipts will reach US$ 286 million per

[44] which equals an additional 41,350 visitors and $117 million in tourist receipts per year compared to business as usual

annum by 2027[44]. Cultural and historical tourism offer unique experiences in a range of tours, particularly village tours, cultural expressions, and festivals (Imbal 2009; Kau 2014; PNG TPA 2006), belonging to the people of particular localities. The expected size of this market category aligns well with PNG's cultural assets and the market positioning as a destination with a diverse and intangible cultural heritage and cultural industries. Soft adventure tourism includes activities such as hiking, fishing and kayaking. According to International Finance Corporation (2018), this tourism category has a large global base, and it is expected to grow by 20 percent by 2027. Although, given the current global impact of the Covid-19 pandemic on tourism worldwide, this growth may not be entirely achieved by 2027.

Category of activity	Base case scenario- 2016 (US$)	Mid growth scenario- 2027 (US$)	High growth scenario- 2027 (US$)
Cultural Tourism	35,000,000	87,000,000	90,000,000
Birdwatching	3,300,000	4,700,000	5,800,000
Soft adventure[45]	32,200,000	63,400,000	129,200,000
Historical	16,200,000	40,900,000	47,700,000
Dive	6,900,000	13,200,000	13,400,000

Table 12- PNG Niche market size & value data
Source: International Finance Corporation (2018), World Bank Group, Part I, based on 2016 data

To estimate the direct use value of tourism, this report sets out to look for data reflecting immediate and secondary benefits offered by the tourism, hospitality and leisure sectors. Immediate benefits primarily mirror the economic activity generated directly due to tourist arrivals, tourism activities, and direct employment in the sector. However, the broader benefits (secondary benefits) are gained from investment in the tourism and hospitality sector, immediate consumption throughout the supply chain, induced income and employment in leisure and other related industries.

In 2019, the country received 210,000 international visitors generating total expenditures of K1.5 billion (US$ 427,267,950), which showed a significant increase of 7 percent compared to 2018 (PNG TPA, 2019). Since a large portion of PNG visitors are business and employment-related (54 percent) (with only 25 percent holidaymakers), the genuine tourist spending related was estimated to be K715 million (US$ 203,664,390) (Sumb, 2020; PNG TPA 2019). Following hosting the 2018 APEC leaders' Summit in Port Moresby, long-term benefits for the tourism industry was expected as the summit placed the country under the international spotlight and accelerated development in the capital. However, after the Covid-19 pandemic and cancellation of overseas travel into PNG, this sector seems to be one of the last sectors to recover . Nonetheless, investment in tourism-related infrastructure seems to continue gradually. Accordingly, the 'genuine' value of tourist expenditure in 2019 of K 715 million is assigned to the direct value of the tourism sector. Adopting a multiplier of 1.58, the economic value (immediate plus knock-on effects) of tourism expenditure equals K1,086,800,000 (or US$307,139,135). This value equates to 1.3 percent of the country's GDP in 2020. This finding is supported by the World Travel and Tourism Council, which predicted the total contribution of recreational Travel & Tourism to GDP in PNG to be around 1.4 percent in 2020, supporting the valuation findings.

Finally, to estimate the non-market value of cultural tourism in PNG, this report refers to a study by Ezebilo (2016) published by the Canadian Center of Science and Education that estimates the bequest value of the cultural and historical site of Mount Wilhelm, the highest mountain in PNG. The bequest value refers to the value of the current generation's willing to pay to maintain resources, ensuring they would be available for future generations. Ezebilo (2016) used the contingent valuation method (CVM) to elicit urban residents and landowner's preferences by asking people how much they would be willing to pay for the maintenance of Mount Wilhelm to avoid a decrement in the future. The study found that 92 percent of the respondents were willing to pay an average of 7.4 Papua New Guinea Kina (US$ 2.5) each year. The study also found that a group of respondents willing to give up land for conservation were more than four times likely to pay more than 10 Kina a year. Furthermore, it was found that respondents with high school education and those who value forest highly were more than three times likely to pay more than 10 Kina a pear. The study also explored the possibilities of designing an ecotourism strategy that could benefit locals.

Since the above study is the only study in PNG to estimate the non-market value of tourism, and there are no other studies to examine and compare, this report resorts to generalisation and extension of the research findings to the entire population at large. It is noteworthy to add that while the reliability of this extension is not absolute, it is statistically probable. Accordingly, this report uses the average WTP of 7.4 Kina per year for 92 percent of the total population of 8.947 million, resulting in a bequest value of 60,911,176 Kina (i.e. US$ 17,350,262) for tourism sites.

[45] hiking, fishing, & kayaking

The Option Value of Recreational Fishing

Marine recreational sector and fish discard (i.e. catch and release) in PNG accounts for 3 percent of the total catch of 2.4 million tonnes from 1950-to 2010 or 72,000 tonnes (CEPA, 2020). This figure excludes unreported catches that amount to 1.8 million tonnes in the subsistence sector, equivalent to 66 percent of the total catch of 2.4 million tonnes from 1950–2010. No further information about PNG recreational fishing (or hunting) is available. CEPA (2020) also calls for more research collaboration and capacity building to enhance data availability. Therefore to calculate the direct use-value of recreational fishing, this report resorts to the benefit transfer method, using the Philippines as a study site. The selected study for this exercise, Ahmed et al. (2007), surveyed local respondents and applied a contingent valuation method[46] to estimate the economic value of recreational fishing in coral reefs in Bolinao, Philippines. The study estimates a mean WTP of 4.2 US$ per hectare per year (also reported in the TEEB database). The study acknowledged the low local WTP for nature, but it argued that the finding was not unusual in developing countries where the population is concerned with other immediate priorities.

To calculate WTP per hectare for protecting terrestrial genetic resources in PNG, we follow our standard benefit transfer approach and adjustment formula:

The adjustment formula that was used is:

$$WTP_p = WTP_s \, (Y_p / Y_s)^E$$

where:

WTP_p = *willingness to pay at the policy site*
WTP_s = *willingness to pay at the study site*
Y_p = *income per capita at the policy site*
Y_s = *income per capita at the study site*
E = *income elasticity of willingness to pay*

As demonstrated in the previous section, this report assumes E equals 0.2. Accordingly, the adjustment becomes:

$$WTP_{PNG} = WTP_{Philippines} \, (Y_{PNG} / Y_{Philippines})^E$$

where:

$WTP_{Philippines}$ = *US\$4.2/ ha/yr*
Y_{PNG} = *US\$ 2,636.80/yr*
$Y_{Philippines}$ = *US\$ 3,298.83/yr*
$E = 0.2$

And the $WTP_{PNG} = 4.2\,(2636.80/3298.83)^{0.2} = 4.01$

Accordingly, this report assigns US$ 4.01 per hectare for WTP for recreational fishing in PNG reefs, which, based on 2020 prices, this value equals US$ 6.65. With 1,384,000 hectares (or 13,840 km^2) of coral reefs, the option value of recreational fishing is estimated to be around US$ 9,203,600 or K 32,350,654.

Non-use value of cultural diversity

In the past couple of decades, economists have been paying attention to understanding cultural diversity, heterogeneity of preferences, and heuristics for economic development (Yong, 2019). Economists have also proposed several methods of measurements in the past couple of decades; this includes the works of Alesina et al. (2003, 2013,

[46] Participants were asked about the purpose of the trip, number of persons included in the trip, length of stay, number of visits made to the recreation site, point of origin, and expenditures incurred during the trip.

2016), Audretsch et al. (2010), Easterly and Levine (1997), Fearon (2003), and Posner (2004). This literature, however, has disproportionately focussed on one aspect of the subject: migration and multiculturalism. Accordingly, this report acknowledges that this cohort of literature and the proposed measurements do not necessarily correspond to the cultural diversity of the indigenous population in PNG. Instead, this report suggests cultural diversity is the source for a wide range of direct use-values and non-use values.

In terms of direct use-values, cultural diversity is proven to result in more significant economic outcomes such as higher incomes and greater export volumes particularly the export of ethnic products. These tangible and direct use-values are calculated under the "Cultural Tourism" category under "Cultural Services". In addition to these tangible outcomes, cultural diversity may also contribute to generating intangible (non-market) less-quantifiable yet significant economic values.

For example, language is important in every aspect of human life, such as:

- expressing identity
- daily interactions
- making a livelihood
- accessing services

Therefore, distinguishing and using languages provides many economic benefits for various groups and communities. People speaking indigenous languages are likely to earn 6-11 percent more income from arts and crafts and other cultural activities (Dinku et al., 2019). Furthermore, the literature offers clear evidence indicating that indigenous language use is positively associated with social capital formation (Dinku et al., 2019).

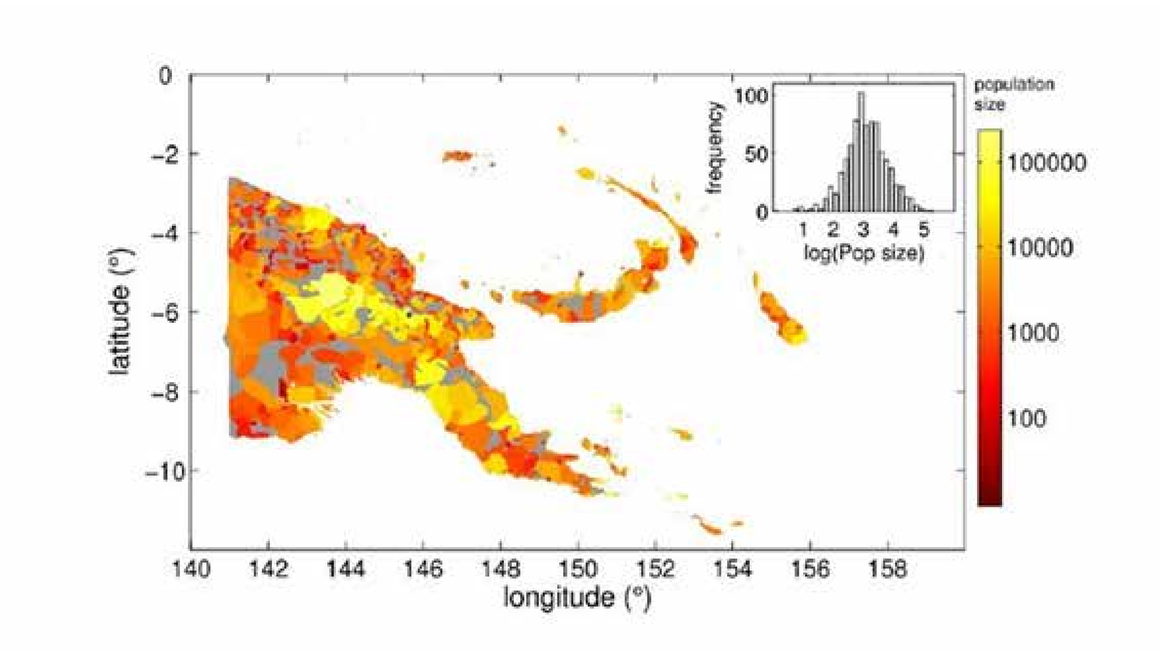

Figure 22- Linguistic diversity in PNG and surrounding islands (Source- Manrubia et al. (2012). (CC BY 4.0))

PNG is the most linguistically diverse country in the world. Figure 22 shows the linguistic diversity in PNG and surrounding islands. The map was produced by Manrubia et al. (2012) to show how the territory is fragmented into different linguistic groups. The index values are coloured according to the scale on the right, indicating the total size of the group speaking each language. The grey areas on the map refer to the uninhabited landmass.

There are over 831-851 living languages in PNG. Languages with statutory recognition are Tok Pisin, English, Hiri Motu, and Papua New Guinean Sign Language. A significant proportion of these languages are under threat or endangered, as shown in Table 13.

Current living spoken languages	Count	831-851
Languages in day-to-day use	Count	843 to 1020
Extinct	Percentage	1
Critically endangered	Percentage	6
Endangered	Percentage	16
Vulnerable	Percentage	29
Least concern	Percentage	48

Table 13- Status threat data
Source: CEPA (2020). State of the Environment Report for Papua New Guinea.

PNG languages are inseparable from localised culture and form the basis for interacting with others. Maintaining, revitalising or reawakening PNG languages are essential for safeguarding these languages, and multiple actions may be required to achieve this.

Economic benefits	**Benefits of language diversity**
Arts and culture	Indigenous language speakers are more likely to receive an income from the sale of arts and crafts and doing cultural activities.
Living off the lands and seas	Indigenous language speakers are more likely to participate in traditional harvesting activities
Women's participation	Cultural diversity provides opportunities for women, at all levels, to participate in the local and the greater economy
Cultural tourism/ language tourism	A clear connection is established between language diversity and tourism in the form of cultural tourism. Cultural tourism enhances visitors' experiences, empowers local communities, and leads to higher employment and community well-being.
Land and sea management	Tribal knowledge of the environment developed over thousands of years of interacting with land, sea, and ecosystems. These environmental practices can lead to community-controlled resources.
Social benefits	**Benefits of language diversity**
Cultural identification and community connection	Social connectedness and sense of identity through spoken languages
Positive emotional and physical health	Tribal traditions and interactions lead to social capital formation, often creating emotional support for the community members, resulting in healthy and happy communities
Community resilience	Tribal connections foster collective resilience, support networks and increase trust amongst the community
Natural benefits	**Benefits of language diversity**
Less decline in nature	Nature declines less rapidly in areas that are managed by indigenous and tribal communities

Table 14- Socio-economic and environmental benefits from living languages in PNG
Source: researcher's adaptation from National Indigenous Languages Report, Government of Australia (2020)[47]

While a growing body of literature emphasises the importance of tribal culture and language diversity in economic development, applied research in valuing this diversity is minimal. Languages carry tribal and cultural knowledge, and language loss indicates the loss of culture, sense of identity and connectivity. A conceptualisation is provided in Table 14. Therefore, instead of looking for economic values, this report explored literature and reports on the compensation for the loss of tribal languages. For example, in 2019, the High Court of Australia awarded Ngaliwurru and Nungali people in Northern Territory A$ 2.5 million for the extinguishment of their native title. A$ 1.3 million judgment was for an intangible cultural loss, and the rest was for economic loss (including interest).

[47] https://www.arts.gov.au/what-we-do/indigenous-arts-and-languages/national-indigenous-languages-report

This compensation assessment was based on 50% of the market value of freehold estates[48]. As a result, traditional owners were awarded A$15,000 in compensation per hectare for economic and emotional damages. In May 2018, the Canadian Federal Court approved a C$ 875M settlement approved for the "60s Scoop" survivors. This award was purposed to split between roughly 20,000 survivors separated from their indigenous communities in childhood. Each survivor would have received over C$ 43,000 (US$ 34,469). While compensation monies will not fully capture the negative impact of cultural losses, they are frequently used to address the losses experienced by tribal and indigenous communities. In an interview with The Australian in 2011, Professor Zuckermann from Adelaide University mentioned that indigenous languages could quantify at A$100 million (US$ 71.8 million) each.[49] A New Zealand study by Awatere (2005) finds that Maori communities hold a holistic view of the environment and nature. Regardless of the level of income, Maori's WTP (willingness to pay) to protect the environment was found to be higher than non-Maori individuals.

Government practices: Bliss (2018) report claims that the global issue for disappearing languages is not a lack of community interest or willingness but rather the absence of government support and funding. Many countries that are home to indigenous languages do not have a strong history or standing for providing public support for Indigenous Language Revitalisation (IRL) initiatives.

The task of translating the socio-economic and cultural impacts of indigenous languages into financial figures is exceptionally challenging. Nonetheless, environmental economics provides an analogy under which language is treated as the same as ecological assets such as air, water, and diverse species (Grin, 1996). Like endangered species, languages need protection for intrinsically non-market reasons (Karuss, 1992). Accordingly, there is a justification for calibrating government expenditure to maintain and revive endangered languages from an economic perspective. Accordingly, Bliss's (2018) report investigates costing models for different countries investing in Indigenous IRL programs. The report also reveals levels of government expenditure on a per-capita basis on ILR initiatives for ten selected countries. As Table 15 demonstrates, the expenditures are expressed in per-capita amount and percentage of GDP for each country. The expenditure on ILR initiatives varies significantly between these countries, ranging from 0.0001 percent (Sweden) to 0.17 percent (Spain) of GDP. The total per-capita (indigenous) amount as part of ILR public investment ranges from US$ 0.09 (Mexico) to US$ 1,329.77 (Spain).

Country	Number of languages	Degree of endangerment	Per-capita (indigenous)	Per-capita (total)	% of GDP
Spain	4	vulnerable to definite	US$ 1,329.77	US$ 58.37	0.17%
Norway	4	definite to severe	US$ 783.38	US$ 8.14	0.008%
Scotland	2	definite	US$ 526.45	US$ 8.45	0.018%
New Zealand	1	vulnerable	US$ 267.06	US$ 40.25	0.08%
Wales	1	vulnerable	US$ 108.85	US$ 19.58	0.059%
Brazil	178	mostly vulnerable, some severe/critical	US$ 47.83	US$ 0.20	0.002%
Sweden	5		US$ 29.03	US$ 0.09	0.0001%
Australia	120	Mostly severe/critical	US$ 18.82	US$ 0.51	0.0008%
United States	169	mostly severe/critical	US$ 5.64	US$ 0.14	0.0023%
Mexico	68	mostly vulnerable, some severe/critical	US$ 0.09	US$ 0.02	0.0002%
PNG	844-1020	23% endangered to critical	Nil	Nil	Nil

Table 15 - Governmental expenditures on Indigenous language revitalisation (ILR)
Source: adapted from Bliss (2018). A Global Perspective on Costing Indigenous Language Revitalization. http://fpcc.ca/wp-content/uploads/2020/07/Bliss-Global-ILR.pdf

[48] https://eresources.hcourt.gov.au/downloadPdf/2019/HCA/7

[49] https://www.firstlanguages.org.au/news/693-92compensation-for-lost-languages

With four indigenous languages and a vulnerable degree of endangerment, Spain spends the highest per-capita (indigenous) amount (US$ 1,329.77) on ILR initiatives, which also forms the highest percentage of the country's GDP compared to the rest of the group. On the other hand, with 120 indigenous languages that are most severely or critically endangered, Australia spends a minimal amount of US$ 18.82 per capita, which forms a negligible % of the country's GDP (0.0008 percent). On average, these ten countries spend 0.03 percent of their GDP on ILR initiatives.

So, given that 23 percent of PNG languages are endangered, how much is the cost of preventing the loss of a language in PNG? Due to research limitations, this report does not conduct non-market valuation techniques to estimate the non-use value of cultural/language diversity in PNG. Furthermore, due to the absence of empirical studies on the economic value of languages and cultural diversity elsewhere, the benefit-transfer method could not be utilised to estimate the value of these cultural services. Subsequently, and solely for accounting purposes, this report resorts to "export opinion" of value, where the allocation base is not likely to be accurate.

Since, on average, the ten countries listed above spend 0.03 percent of their GDP on ILR initiatives, the allocation for the cost of preventing loss of tribal languages in PNG, following Bliss (2018), could be 0.03 percent of GDP in PNG. With the country's GDP at US$ 23.59 billion, this report demonstrates that the opportunity cost of losing indigenous languages equates to US$707,700,000. It is also important to note that direct comparisons, in this case, may not be valid, given differing notions of 'community' across countries. Moreover, it is essential to consider linguistic variables such as the number of tribal languages in PNG and their diversity compared to other countries. In order revitalise indigenous languages, if the PNG government budgeted the minimum level from Table 15 (0.0002 percent of GDP budgeted by Mexico) this would provide PGK 16.5 million per annum. This should be considered the absolute minimum and accounts for neither the importance nor diversity of PNG languages relative to other countries.

Total Economic Value

Section 2.1.3 of this report explained that one of the early steps in calculating Total Economic Value (TEV) should be disentangling 'intermediate' and 'final' ecosystem services. This is an important exercise since the TEV framework includes ecosystem services in the final calculation that flow directly to and are directly used or appreciated by humans in various ways. Subsequently, intermediate services are excluded from final calculations since they already have provided contributions to the final ecosystem services. This report follows the recommendations from Millennium Ecosystem Assessment (MEA).

As per MEA guidelines, provisioning and cultural services are considered final ecosystem services. Supporting services are considered intermediate, while regulating services could be intermediate or final ecosystem services. So, while the decision is straightforward for provisioning, cultural and supporting services, distinctions need to be made for different types of services within regulating services.

In this report, the list of regulating services in PNG include:

- Erosion prevention (forest and wetlands)
- Natural purification (coastal wetlands)
- Air quality
- Pollination
- Carbon sequestration
- Disturbance moderation (flood control)

Soil erosion prevention: Soil erosion diminishes agricultural land values through physiochemical and nutrient losses. The agricultural soil is highly concentrated with crop nutrients, and soil erosion adversely affects crop production and properties. Subsequently, soil erosion prevention services support crop and plants' growth and contribute to the production of provisioning services like food (Smith et al. 2012; Raudsepp-Hearne, 2010; Vihervaara et al., 2010). Accordingly, the economic value of soil erosion prevention (while estimated) is not included in the calculation of TEV.

Pollination: Most relevant studies seem to agree that pollination is an intermediary service (examples include Boyd & Banzhaf, 2007; Saarikoski et al., 2015). However, other studies suggest pollination in the context of small-holder agriculture can be legitimately viewed as a final service (i.e. the contribution that natural pollination makes to human well-being) (Garibaldi et al. 2016). Accordingly, in the initial TEV calculation in this report, pollination is regarded as an 'intermediate' service and excluded from TEV calculation. However, since the status of pollination services critically depends on stakeholders' analytical perspective, the status can be updated (if needed) upon receiving feedback.

Air quality: Air quality services provided by nature, while regulating, is regarded as a final service as it significantly also contributes to society's well-being. Especially with a global air pollution magnitude regulating air quality has become one of the major concerns, particularly in urban areas. Accordingly, the economic value of air quality services is included in the calculation of TEV.

Carbon sequestration: Carbon sequestration services is another critical function played by ecosystems. Carbon accounting has drawn the attention of policymakers globally. Like other ecosystem services, this service is also understood to benefit human society (directly and indirectly) significantly. Carbon sequestration service provides a sink for greenhouse gasses and thus limits climate impacts nationally and globally. The beneficiary of this important service is the PNG population and the global community more broadly. Nonetheless, carbon sequestration of forests is a controversial topic (van der Gaast et al., 2016).

Carbon sequestration provided by oceanic and coastal ecosystems can be a clear example of an 'intermediate' ecological process such as reducing acidifying deposition to oceans, preventing coral reef damages, and improving fish habitats. On the other hand, forest carbon accounting has become a very important component in TEV estimates. Carbon markets are well established, and carbon storage is almost always a part of ecosystem value measures and is most commonly studied. (Egoh et al., 2012; Martínez-Harms and Balvanera, 2012). To unscramble the intermediate and final components of carbon sequestration services, an additional research exercise is required to:

a. identify and quantify all relevant benefits, including life-sustaining benefits from carbon storage function in PNG
b. identify and quantify all bio-geophysical processes and functioning

The above information is obviously scarce due to the complexity of such interactions. Accordingly, this report regards carbon sequestration services provided by tropical forests as final ecosystem services and as a component of TEV. However, as mentioned earlier, the status of regulating ecosystem services critically depends on stakeholders' analytical perspective; and the status can be updated upon receiving feedback.

Finally, as mentioned earlier in this report, TEV can be expressed by a simple formula:

$$TEV=UV+NUV=(DUV+IUV+OV)+(XV+ABV+OV)$$

Where:

UV: Use value
NUV: Non-use value
DUV: Direct use value
IUV: Indirect use value
OV: Option value
XV: Existence value
ABV: Altruistic and Bequest Value

The total magnitude of final components entering TEV calculations, TEV calculation, percentage of each ecosystem services in TEV, and TEV per hectare calculations in both Kina and US dollars are presented in Table 16.

TEV components	Economic Value (Kina)	Economic Value (US$)	% of TEV
Food (Marine)	2,226,344,000	629,184,184	0.20
Food (Terrestrial)	4,086,216,000	1,154,800,192	0.37
Water	3,159,865,505	893,005,483	0.29
Logging	1,603,600,000	453,191,311	0.15
Mining and Petroleum	39,854,400,000	11,263,200,173	3.65
Energy	13,715,076,712	3,876,000,000	1.26
Genetic Resources (Terrestrial)	9,090,668,792.80	2,586,250,000	0.84
Genetic Resources (Marine)	343,553,992.60	97,739,400	0.03
Natural Purification	5,940,380,825.60	1,682,603,400	0.54
Air Quality	1,666,036,193	473,979,000	0.15
Carbon Sequestration	997,922,840,794.16	282,178,650,000	91.5
Flood Control	13,944,466,202	3,967,131,191	1.29
Recreational Fishing	32,350,654	9,203,600	0.003
Commercial Tourism	1,086,800,000	307,139,135	0.10
Cognitive Development	39,390,715.80	11,186,400	0.004
Cultural Tourism	60,911,176	17,350,262	0.01
Cultural Diversity	2,484,506,502	707,700,000	0.23
TEV= UV+NUV			
TEV	1,097,257,408,065 (K)	310,308,313,731 (US$)	100.00
TEV per hectare	23,707 (K)	6704 (US$)	

Table 16- TEV components and corresponding economic values
NB: exchange rates used in this report is based on the rates of 1 K= 0.29 US$ (rates published in Jan 2022). The presumed size of the GDP multiplier is 1.58. The effect of the GDP multiplier is included in the calculation of all direct use-values. The total area is calculated as land area and water (452,860 km^{2}and 9,980 km^2)[50] and converted to the hectare.

As seen in the table, the total economic value of ecosystem services in PNG is estimated to be that is over several times the value of the country's GDP. It is important to remember that the GDP only looks at the market value of transacted goods and services, so it largely ignores the non-consumptive values of ecosystem services and option values or existence values. So apart from direct use values, the economic valuation in this exercise deals with "beyond-GDP" indicators. Furthermore, in PNG, 80 percent of the economic activities are 'subsistence' and therefore not accounted for in GDP, resulting in 'deflated figures'. Costanza et al. (2014) show that the value of global ecosystem services was estimated to be about 4.5 times the value of Gross World Product (GWP) in the year 2000 (in his 1997 study, this was estimated to be twice as much).

As also seen in the table, the largest component of the TEV is the Carbon Sequestration which forms over 91 percent of

[50] https://web.archive.org/web/20171207094959/http://www.worldatlas.com/articles/which-are-the-island-countries-of-the-world.html

the total economic value of nature in PNG. The main reason for that is that the Tropical Forest covers some 93 percent of the country's landmass (ranked No.9 in the world), so it is expected that benefits from Carbon Sequestration services form the largest TEV component. The second-largest TEV component is the Mining and Petroleum Industry. It is important to note that percentages do not reflect the relative importance of ecosystem services but their magnitude share in the total economic value. The last row of the table shows the total economic values of nature per hectare, which is equivalent to US$ 6,704 per hectare in 2020 prices. This result is comparable with the findings of Costanza et al. (1997) (also shown in Figure 23), indicating the value of ecosystem services tends to be the greatest (and up to US$ 10,000/ha/yr in some places) in highly diverse warm, low-latitude regions (locations found between the Equator). The findings of this report are also comparable with the work of Costanza et al. (2014), that found the TEV of tropical forests to be US$ 5,264/ha/yr.

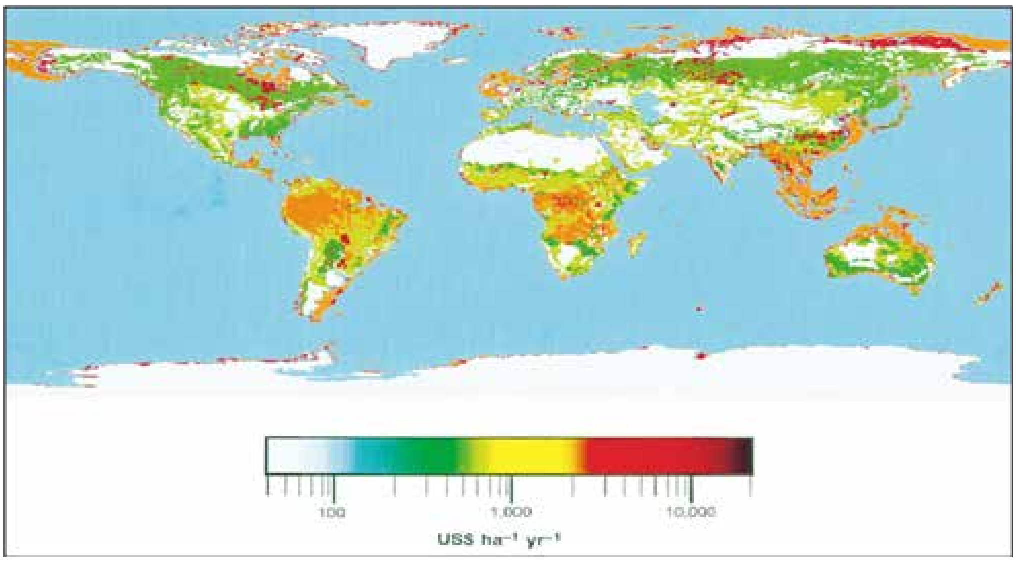

Figure 23- Global map of the value of ecosystem services. (Source: Costanza et al., 1997)

Finally, Table 17 provides a detailed summary of valuing nature in PNG. The table shows the economic values of all ecosystem services, including all intermediate and final services, their descriptions, unit values, and the types of economic values pertinent to each service. The blue coded cells in Table 17 refer to intermediate services, and while the economic value of these services is presented in the table, they have not been included in the calculation of the TEV. Table 17, in conjunction with Table 1 of this report, provide stakeholders with quick access to main sources of the information, degree of uncertainty, the economic value of ecosystem services, and their contribution to the total economic value of nature in PNG.

As explained in section 2.1.3 and section 7, the ecosystem services under the provisioning and cultural services are all considered final services. Within these two categories, all direct use-values of services are regarded to have a multiplier effect (explained in section 2). The presumed size of the GDP multiplier is 1.58 (as per estimation in section 2 of this report). All the prices in all categories are considered 'current'[51]. All prices older than 2019 were converted to 2020 prices (i.e., inflated to 2020 dollars) to produce a single long-running series representing changes in consumer prices. The exchange rates used in this report are based on the rates of 1 K=0.29 US$ (i.e., 'current' rates published in January 2022).

[51] 2020 is the selected year for the analysis

Ecosystem Services	Description	Physical Indicators	Units or Prices	Total Value (Million PGK)	Total value as % of TEV	Type of value
Provisioning Services (FINAL)						
Food	Food extracted from Marine resources	Mg (t) (2020)	Not available	*K 2,226,344,000 Or US$ 629,184,183.6*	0.20	Direct use value
Food	Food extracted from terrestrial resources	Mg(t) (2020)	Not available	*K 4,086,216,000 Or US$ 1,154,800,191.7*	0.37	Direct use value
Water	Precipitation, surface water, groundwater	2.5% of TVA (US$ 23,657,000,000)	Not available	K 3,159,865,505 Or US$ 893,005,482.5	0.29	Direct use value
Raw Materials	Forest Logging- Timber log export value (Ave 2019-2020)	export volume- cubic meters	Not available	K 1,603,600,000 Or US$ 453,191,311.3	0.15	Direct use value
Raw Materials	Mining & Petroleum	Trade data (2017) (2020 prices)	Value of exports	K 39,854,400,000 Or US$ 11,263,200,173.3	3.65	Direct use value
Renewable energy	Hydroelectricity from river basins	Direct Market (Consumer) price	US$ 134/ha/yr	K 13,715,076,712 Or US$ 3,876,000,000	1.26	Direct use value
Genetic resources	Conservation of Genetic Resources/ Bioprospecting	Benefit Transfer from (the Philippines) TEEB (2007) (2020 prices)	Marines: US$ 276 /ha/yr Terrestrial: US$1034.5/ha/yr	Marines: K 343,553,992.6 or US$ 97,739,400 Terrestrial: K 9,090,668,792.8 or US$ 2,586,250,000	0.86	Option value
Regulating Services (FINAL or INTERMEDIATE)						
Erosion prevention (coastal)	Erosion prevention in coastal wetlands (Replacement Cost method)	the size of the mangrove-covered area of 458,600 ha	$US 985.1/ha/yr (2020 prices)	K 1,104,366,818 or US$ 314,186,860	Estimated but not included in the TEV calculation	Indirect use-value
Erosion prevention (forest)	Erosion prevention in Tropical Forest (Factor Income / Production Function)	The size of the primary forest of 26,210,000 ha, according to FAO	US$ 793/ha/yr (2020 prices)	*K* 73,057,623,293 Or US$ 20,784,530,000	Estimated but not included in the TEV calculation	Indirect use-value
Natural Purification (Coastal wetlands)	Value of mangrove nurseries based on the mangrove-covered area of 458,600 ha	economic value of mangrovesin PNG (2014)	$3,669/ha/yr (2020 prices)	*K* 574,186,922.5 or US$ 163,353,320	0.50	Indirect use-value
Air quality	Air quality regulated by tropical forests by capturing fine dust- area 28,726,000 ha	BT (Wet Tropic Forests in Australia)- Shadow Market Price	US$16.5 /ha/yr (2020 prices)	*K* 1,666,036,193 Or US$ 473,979,000	0.15	Indirect use-value
Pollination	market value of agricultural products depended on pollination	16-30% of the market value of agricultural production	US$/yr	K 430,128,000- K 806,490,000 or US$ 122,581,662- 229,840,617	Estimated but not included in the TEV calculation	Indirect use-value
Carbon Sequestration	Soil and biomass carbon stock data (2019) and based on data from FAO (2005)	Total carbon in PNG's forests. 66% stored in soil & 34% in biomass	11733 x 10^6 tonnes. Value is based on a rate of $ US24.05 tonne	K 997,922,840,794.16 Or US$ 282,178,650,000	91.40	Indirect use-value
Disturbance moderation	Flood protection	Avoided cost method, BT (Laos)	Not available	*K* 13,944,466,202 or US$ 3,967,131,191	1.28	Indirect use-value
Supporting Services (INTERMEDIATE)						
Provision of Habitat	Tropical Rainforest	An increase in the area of tropical forest set aside for preservation by 5% (2001)	Mean WTP per household (2020 prices)	K 16,343,870 - K 36,448,276 Or US$ 4,649,749.7- US$ 10,369,353	Estimated but not included in the TEV calculation	Existence value
Provision of Habitat	The existence value of Marine Protected Area (MPA) is currently at 354,000 hectares	WTP- BT (Philippines) TEEB (2018)	US$ 2,338.3/ ha/yr (2020 prices)	K 29, 095,701 US$ 8,277,582	Estimated but not included in the TEV calculation	Existence value
Eco-forestry	Suggested benefit by subsidised eco-forestry based on currently 100,000 ha committed	Net Present Value (NPV) at 0.08 discount rate	$US 731/ha (2020 prices)	K 256,946,501 or US$ 73,100,000	Estimated but not included in the TEV calculation	Direct use- value
Cultural Services (FINAL)						
Recreational Fishing	contingent valuation method (CVM)- local respondents	WTP- BT (Philippines) TEEB	US$ 6.65/ha/yr (2020 prices)	*K* 32,350,654 or US$ 9,203,600	0.003	Option value
Commercial Tourism	Total benefits of the tourism sector	Tourist expenditure data	Not available	*K1,086,800,000 Or US$ 307,139,135*	0.10	Direct use-value
Cognitive development	Benefits to education and research (coral reef)	BT- fieldwork, primary data	US$ 0.04 /ha/yr	US$ 11,186,400 or K 39,390,715.80	0.004	Direct use-value
Cultural tourism (direct benefits)	Residents willingness to pay (WTP) for the maintenance of cultural and historical sites	The aggregate annual value of WTP per year	US$ 2.5/yr or K 7.4/ yr per person	*K* 60,911,176 Kina Or US$ 17,350,262	0.01	Bequest value
Cultural diversity	Cultural diversity (860 indigenous languages)	Languages- Threat status data	0.03% of GDP in PNG	*K* 2,484,506,502 Or US$707,700,000	0.23	Non-use value

Table 17- The overall summary of economic values of ecosystem services in PNG
**BT= Benefit Transfer method is used to transfer the value*
NB: exchange rates used in this report is based on the rates of 1 K= 0.29 US$ (rates published in Jan 2022). The presumed size of the GDP multiplier is 1.58. The effect of the GDP multiplier is included in the calculation of all direct use-values.

Limitations, Caveats, and Further Work

This report contributes to the public-land management for conservation targets by providing knowledge to construct ecosystem service accounts based on internationally accepted environmental standards. Nonetheless, our attempt to estimate the total current economic value of ecosystem services is limited for three main reasons, including:

Absence of PNG-focused studies:

- Although this report has attempted to calculate as much economic value as possible, the final estimate leaves out many ecosystem service categories because they are not adequately studied, resulting in a significant absence of data. Accordingly, as more information becomes available, the total estimated value of nature in this report is expected to increase. It is important to note that estimated values are significantly underestimated.
- In transfer benefit cases where the WTP of the individuals in the study sites is used to estimate the economic values of ecosystem services, respondents who face hypothetical choice problems may not act the same way in an actual situation. Furthermore, the respondents' preferences may not include social fairness. So those values are likely to be underestimated.

Lack of Access to Government Databases

- Due to a lack of public information regarding the size of the GDP multiplier in PNG, this report has used the national dependency ratio as a proxy for marginal-propensity-to-save (MPS) to estimate the GDP multiplier. If the value of the GDP multiplier is updated to capture more accuracy, the economic value of provisioning services will increase or decrease (depending on the size of the multiplier).
- Due to the absence of cost data, this report has not used any cost-related methods such as "damage cost avoided" or "replacement cost" in the evaluation. While these methods do not provide strict economic value measures and often underestimate them, they provide useful information in situations where ecosystem services can be replaced or restored by market goods. The research team could not source any of the above information in the PNG context.
- Current prices, which are used to form the basis of direct or indirect economic values, are likely to be distorted as they exclude household labour and the subsistence economy, which is quite significant in PNG. Nonetheless lack of data around "market noise", it was not possible to create metrics of misalignment between prices and fundamental value.
- This report has resorted to using benefit transfer of values from study sites such as the Philippines and Laos, where the data was absent from PNG. So, access to government departments' databases to enable further research work on those ecosystem services' values is needed to acquire a more accurate country-specific estimate.
- Although, as the first assessment, this report provides both indicative and conservative estimates of the benefits of natural assets in PNG, further collaborative research and data sharing are recommended in developing useful tools for environmental resource management and policy decisions about protected areas and environmental targets.
- This report provides the first attempt to quantify the value of nature in PNG. Due to a lack of data and the absence of evaluation studies in PNG, marginal values (which indicate the incremental benefit/cost expected from an improvement or a reduction in the delivery of ecosystem services) are not computed. Marginal values are to inform prioritisation, policies and project options. Accordingly, further work is required in this space.
- The research team postulates that, in addition to the fisheries value estimated in this report, the option, existence, and aesthetic values of the coral reefs in PNG are significantly high. Although due to the absence of pertinent information, this report was unable to estimate a comprehensive economic value for the coral reefs in PNG. In the recent body of literature, the estimated value of coral reefs in different regions of the world has increased from previously estimated at US$ 8,000/ha/yr to an astounding US$ 352,000 /ha/yr. This increased economic value is owed to studies that included coral reefs' role in storm protection and erosion protection functions. For example, a recent study by Costanza et al. (2021) looked at damage avoided by coastal wetlands for storm protection for 71 countries. It estimated a global average of $US 11,000/ha/yr (with significant variations between the countries). Due to the high degree of variations in the current estimates in the literature, this report recommends conducting further collaborative research that includes the multifaceted functionality of coral reefs in PNG to estimate a more accurate economic value for this ecosystem service.

Theoretical Challenges

- The valuation approach undertaken in this report is at the national level and assumes no discrepancies or discontinuities. This is not always the case. Therefore, the estimations can only be regarded as a crude first approximation.
- This report has not incorporated the economic value of ecosystems' natural' or 'ecological' infrastructure, leading to TEV underestimation. While this concept is becoming more popular in the literature, information about the non-human-made structural landscape is scarce, particularly in PNG. Research is required to capture the essential landscape elements and spatial and cultural patterns significant to conservation. The provision of such information is expected to increase the economic value of ecosystem services significantly.
- In most cases, this report has avoided complex issues involved with discounting the future by only focusing on the flow values. This is largely due to two reasons: a) TEV evaluation only focuses on the value of the flow of natural assets at the time of evaluation, and doesn't reflect their changes over time, so basically, it doesn't change the benefits (and costs). Therefore, no discounting is applicable under this approach; b) discounting weighs future costs and benefits differently than current costs and benefits when summing over time. Discounting is applicable when conducting a cost-benefit analysis. However, due to the complete absence of cost data, conducting a cost-benefit analysis was not possible in this report. However, some of the literature used in this evaluation has used discounting to calculate the net present value (NPV).

Conclusion and Policy Recommendations

The "measurement" of monetary values that reflect the social importance of ecosystem services is seen as a prerequisite for better management decisions. Ecosystem services can provide a comprehensive platform for discursive governance, co-creation of knowledge and stakeholder involvement in eliciting urban ecosystem services values.

The ecosystem services framework has great potential to serve as a bridge between science and policy in the context of development planning and environmental governance. Ecosystem services involve improving the quality of life by affecting proper environmental planning for sustainable societies. Moreover, valuing ecosystem services helps in the decision-making; for example, guiding land-use planning and efficient budgets for maintaining and reviving endangered languages, supporting forestry restoration, creating renewable energy projects, as well as strengthening sustainable livelihoods and ensuring the protection and conservation of terrestrial and freshwater ecosystems as protected areas. Ecosystem accounting can provide information for tracking changes in the ecosystem and linking those changes to economic and other human activities.

Identifying the values associated with ecosystem services will allow the consideration of those values in decision support frameworks such as Cost-Benefit Analysis and Natural Capital Accounting, which can be used to develop Green National Accounts. This will allow decisions to be made that support the long-term sustainability of the PNG economy and the population's well-being. The findings will inform important investment and other decisions around the economy and the environment in a country where people largely depend on jobs that depend on nature – such as in forestry, agriculture, tourism, and fisheries. The main goal of evaluation is to develop policies that improve the contribution of ecosystem services to human well-being, including social and economic well-being. Human well-being is a multidimensional concept affected by various factors and indicators, measuring most of which are beyond-DGP indicators and require subjective evaluation methods. The well-known Index of Economic Well-Being (IEWB), which measures economic well-being as a "command over resources" developed by Osberg and Sharpe (1998), and the UNDP Human Development Index (HDI) are powerful examples of why well-being matters within the context of economic growth.

Goossense et al. (2007) provide a comprehensive definition of human well-being, at the core of which sits a "strict" notion of economic well-being that can be captured with standard GDP and other economic indicators (as demonstrated in Figure 24). A broader definition considers the environment as one of the important factors affecting human well-being, and it measures "command over resources" (Osberg and Sharpe, 1998). Finally, the third dimension of well-being comprises "command over agency freedoms" (Brugnoli et al. (2009)), which concerns the richness of social relations and personal satisfaction. Understanding the multiple dimensions of well-being enables policy-makers to identify problems that are not fully understood in current systems of national accounting. Green national accounting systems are required to better understand economic activities' environmental and social effects.

Capturing values

An insufficient emphasis on identifying the correct economic value of environmental goods and services affects planning and decision-making processes. It translates into distorted prices (e.g. pollution fees, water tariffs, etc.) and incentives. This, in turn, leads to the inefficient use of available natural resources and makes it harder to ensure sustainable use. Capturing value involves the introduction of mechanisms that incorporate the flow of benefits from ecosystems into decision-making through policy incentives and price signals.

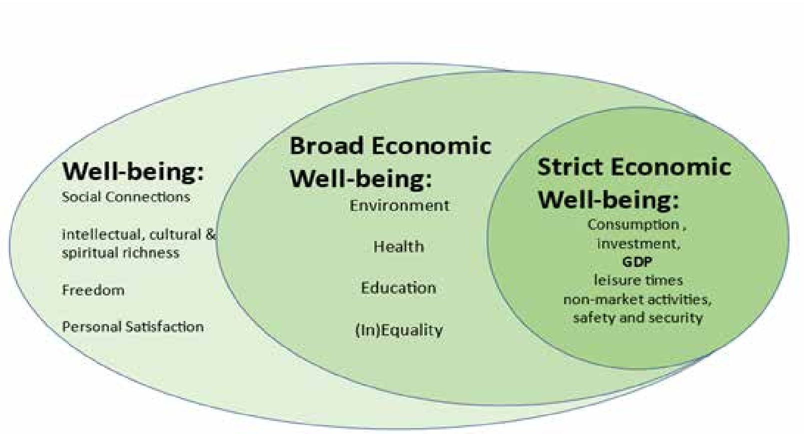

Figure 24- Multidimensional components of well-being, adapted from Goossense et al. (2007)

Area-based conservation is the most effective way that we have to conserve biodiversity. When scaled up, well-connected systems of protected areas and other effective area-based conservation measures allow for the retention of the integrity of natural ecosystems. To guarantee a future success, efforts have to be made to effectively meet global environmental and sustainability goals to prevent ecosystem losses and retain the most-intact ecosystems.

PNG National Constitution

4th Goal: Papua New Guinea's natural resources and environment should be conserved for the collective benefit of all and should be replenished for future generations.

Key Recommendations

This report demonstrated that the TEV of ecosystem services in PNG is over several times the value of the country's GDP. It is important to remember that the GDP only looks at the market value of transacted goods and services, so it largely ignores the non-consumptive values of ecosystem services and option values or existence values. So apart from direct use-values, the economic valuation in this exercise deals with "beyond-GDP" indicators (as per figure 24). Furthermore, in PNG, 80 percent of the economic activities are 'subsistence' and therefore not accounted for in GDP, resulting in 'deflated figures'. Moreover, considering the long-term benefits gained from ecosystem services, this report demonstrates the positive effects of environmental protection policies on economic outcomes.

Specific recommendations

- Curbing pollution and environmental degradation are essential in safeguarding the benefits gained from the ecosystems in inducing sustainable growth and well-being in the long term. Hence, environmental protection policies are vital in setting national structural reform priorities in PNG. Such reforms and policies should aim to simultaneously protect the environment and grow the economy.
- The PNG government is recommended to integrate environmental sustainability and synchronise environmental policies with economic policies.
- This report, in particular, demonstrates the colossal benefits of PNG from natural resources and, particularly, area-based conservation. To guarantee the sustained flow of benefits from the ecosystem, the government must secure adequate financing, prepare mitigation and adaptation plans for climate change, and make environmental protection a stronger priority in the land and sea management policies.
- Furthermore, there are also issues such as inefficient management of protected areas and a lack of clarity around the national legal definition of protected areas in PNG, which has resulted in disputes surrounding how much of the country's land and seascapes should be protected (IISD, 2020).
- While the mining and petroleum sectors are the major source of government revenues in PNG, adverse indirect cross-boundary impacts are impending. If not managed appropriately, these adverse effects could lead to a phenomenon known as the "resource curse" (or poverty paradox). High dependency on finite (non-renewable) resources makes tradable goods less competitive, creating an unfavourable trade balance. This situation is also harmful to the national employment level as imports of goods become cheaper, hurting local infrastructure and manufacturing capabilities. Furthermore, infrastructure investment priority should be given to environmental protection, explicitly targeting access to renewable energy, forest regeneration, water and conserving genetic resources.
- The intense commercial logging in PNG is threatening the resilience of its natural assets and biodiversity richness. Commercial logging degraded a total of 2.9 million ha of PNG forests between 1972–and 2002, with 23 percent of this degraded forest subsequently converted to non-forest cover (deforestation of 0.9 million hectares). The government is required to take immediate action to slow down the rate of deforestation that will lead to loss of habitat, accelerated soil erosions and increased threats of severe flooding.
- Most forest products are destined for overseas, particularly in China. This is while the customary landowners are paid as little as US$ 4-US$ 12 per cubic meter for logs indicating an unequal distribution of wealth in society due to commercial logging activities. Furthermore, the industry does not accurately declare its profit, and the customary landowners gain very little from commercial logging. The Constitution and other national laws are required to protect the economic well-being of customary landowners.
- This report refers to a study by Hunt (2002) showing that at the discount rate of 0.08, on a per hectare of forest basis, the NPV of subsidised eco- forestry (to replace logging) is positive and equal to US$ 731 (in 2020 prices). Under the same scenario, subsidised direct conservation to replace eco-forestry generates an NPV of US$ 625/ha (in 2020 prices). Indicating the net present value of eco-forestry would still exceed the benefits generated from direct forest conservation. So, synergies between eco-forestry and protected areas management practices must be explored further to ensure that any government's conservation investment results in a positive return on investment.

- In terms of loss of cultural diversity, this report refers to the fact that of 851 living languages in PNG 23 percent of PNG languages are endangered, with another 29 percent being vulnerable. This report finds that PNG languages are inseparable from localised culture and form the basis for interacting with others. Maintaining, revitalising or reawakening PNG languages are essential for safeguarding these languages, and multiple actions may be required to achieve this. This report recommends that a minimum level of PGK 16.5 million per annum should be allocated. This should be considered the absolute minimum and accounts for neither the importance nor diversity of PNG languages relative to other countries.
- Persistent shortfalls in ecological representation and management effectiveness can diminish the potential role of area-based conservation in stemming biodiversity loss. Therefore, there is a need to pay attention to the qualitative elements of Aichi Target 11.
- The Protected Area Policy Implementation Plan (PAPIP) is estimated to be approximately PGK55,298,000 (K55.3 million) over the ten years (2018-2028), as shown in Table 18. Currently, the PNG government contributes 54 percent of the total implementation costs (or K30 million) of PAPIP principles. This leaves a funding gap of 46 percent (K25,298,000 or K25.3 million). It is envisaged that this funding gap will be sourced from development partners/donors and the business community. While the adoption and implementation of PAPIP at the national level are estimated to be just over 55 million Kina, this report estimates the net benefits gained from nature to be over 1 trillion Kina. This indicates that the implementation of the PA Policy is not only essential (considering the colossal benefits gained from nature) but also very cost-effective, an investment that will result in huge returns.

Goal	Goal Area	Cost (Kina)
1	Governance and management of protected areas	10,805,000
2	Sustainable livelihood for communities	14,200,000
3	Effective and adaptive biodiversity management	11,530,000
4	Managing the protected areas network	8,248,000
5	Sustainable and equitable financing	10,515,000
	Grand total	K 55,298,000

Table 18- cost of PAPIP (2018-2028)

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