

Timor-Leste's Budgetary Prioritization for Nature-Based Solutions: A Comparison of Public Spending in Important Ministries

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ABSTRACT

This study investigates how Nature-Based Solutions (NbS) are prioritized within Timor-Leste's public finances by looking at spending from 2019 to 2024 across four important ministries: Health, Agriculture and Fisheries (MAF), Public Works (MOPW), and Finance (MoF). The study uses a mixed-methods approach, combining qualitative descriptive analysis with quantitative analysis of secondary data sources, including national statistics, international reference frameworks (WHO, FAO, UNDP, UNEP, World Bank), and the General State Budget (OGE). The budgetary capacity and institutional preparedness for integrating NbS were evaluated by comparing budget allocations to key health and environmental indicators, including child malnutrition, maternal mortality, access to sanitation, malaria incidence, and forest cover. The results show that infrastructure is a major focus. With implementation rates as high as 90%, the MOPW consistently received the largest allocations (USD 138–234 million annually). However, less than 5% of spending went to vital NbS-related sectors like housing, water, and sanitation, with the majority going toward energy and transportation. MAF financing varied from USD 7.6 to USD 28.8 million, with implementation rates of 70–95%, despite minor investments in forestry, watershed management, and food security. Despite a lack of financing that hindered NbS-related and preventative actions, the Ministry of Health managed USD 60–80 million annually. There was still minimal cross-sector integration, notwithstanding the MoF's influence on budgetary governance. The continuing problems of child hunger, forest destruction, and sanitation coverage below 60% have not been resolved by modest budget increases.

Keywords: Nature-Based Solutions, Public Budget, Fiscal Prioritization, Health, Agriculture, Infrastructure, Climate Resilience.

1. Introduction

Since its independence in 2002, Timor-Leste has faced significant challenges in long-term development and post-conflict reconstruction, relying mainly on petroleum revenues to fund government spending. According to Dal Poz (2018) and Harmadi and Gomes (2013), oil and gas extraction has provided over 90% of government revenue. The great obstacle is long-term fiscal sustainability, economic diversification, and inter-generational equity. The Timor-Leste government uses the Orçamento Geral do Estado (OGE) as its main tool to allocate limited resources across sectors that support long-term resilience, environmental sustainability, and social welfare.

The role of NBS (Nature-Based Solutions)-like reforestation, watershed protection, sustainable agriculture, and ecosystem-based climate adaptation for cost-effective interventions that simultaneously provide environmental, social, and economic benefits has been increasingly highlighted in global policy discourse. NBS can reduce climate risks and improve public health, such as nutrition, reduce infectious diseases, improve water and sanitation outcomes, and enhance ecosystem services (IUCN, 2020; WHO & IUCN, 2024; Wellmann et al., 2023). The government of Timor-Leste should integrate the NBS into public health to address challenges in this nation, including high rates of child malnutrition, elevated maternal mortality, limited access to improved sanitation in rural areas, and widespread vulnerability to climate shocks.

Timor-Leste has made some progress in health, such as immunization and antenatal care, since its independence. There are still issues with nutrition, the environment, and infectious diseases in Timor-Leste. These challenges are closely intertwined

with climate variability, environmental degradation, and inequitable access to essential services. NBS offers a more effective integrated response to environmental and public health challenges, and analysis of OGE spending from 2019 to 2024 helps assess alignment with integrated policy goals. The government's public spending focuses on physical infrastructure, like roads, but how ecological resilience and nature-based solutions (NBS) are incorporated into national budgets, particularly those that support health and social outcomes, is still unclear. The government's public spending focuses on physical infrastructure, such as roads, but it is still unclear how ecological resilience and nature-based solutions (NBS) are included in national budgets, especially in those that support health and social outcomes.

Examining Timor-Leste's public expenditure allocations to key ministries between 2019 and 2024, such as Finance, Health, Agriculture, Fisheries, Livestock and Forestry, and Public Works can provide an important basis for evaluating public spending trends. Although some resources have been allocated to physical infrastructure, like roads and electricity expansion, it is still unclear how much ecological resilience and nature-based solutions (NBS) interventions have been prioritized in national budgets, particularly in terms of health and social outcomes.

A poor health system, environmental degradation, high vulnerability to natural disasters, such as the 2021 Dili floods, and persistent social inequalities necessitate the need for policies that integrate environmental management, public health, and social protection. Because these challenges are interconnected rather than isolated, integrated budget planning is essential.

We wish to investigate "Timor-Leste's Budgetary Prioritization for Nature-Based Solutions: A Comparison of Public Spending in Key Ministries (2019–2024)," which looks at how

NBS has been incorporated into budget execution planning across these ministries, based on the earlier justification problem. This study aims to assess how budgetary allocations affect community welfare, environmental sustainability, and social justice by looking at spending on child feeding, maternal health, sanitation, malaria control, and forest regeneration.

This study is innovative since it explicitly integrates fiscal analysis, public health implications, and environmental resilience within a tiny, resource-dependent economy. Despite the fact that NBS has been thoroughly examined from an ecological or project-based perspective, little is known about how national budget allocations influence the extent, persistence, and effects of NBS interventions. Instead, then focusing on environmental intervention, this study offers new empirical insights into how fiscal policy might promote NBS as a fundamental development approach by emphasizing public spending as a major policy.

In the conclusion, this study adds to the conversation about sustainable development in resource-dependent countries by emphasizing how NBS inclusion in national budgets supports important environmental goals in addition to public health and social objectives. Timor-Leste may promote more resilient, equitable, and sustainable development by incorporating NBS into national budgeting, guaranteeing long-term advantages for present and future generations.

Finally, by demonstrating that giving NBS top priority in national budgets is not only a public health and social investment but also an environmental requirement, the study adds to larger conversations on sustainable development in resource-dependent nations. Timor-Leste may move toward more egalitarian, resilient, and sustainable development that is consistent with the long-term welfare of current and future generations by incorporating NBS into fiscal planning. The following research questions serve as the basis for this investigation:

- a. How much of Timor-Leste's OGE allocations between 2019 and 2024 went toward natural solutions?
- b. What is the relationship between changes in community health indicators including maternal health, child nutrition, and sanitation coverage and OGE allocations to important ministries?
- c. What is the relationship between financial allocations and environmental outcomes such as catastrophe risk reduction, watershed management, and forest conservation?
- d. What shortcomings in the way resources are currently allocated restrict NBS's ability to effectively address environmental and health issues?

This study aims to assess the extent to which Nature-Based Solutions (NBS) are prioritized in Timor-Leste's General State Budget (OGE) and to look at how related public spending affects community health, environmental resilience, and social justice. In particular, the research aims to:

- a. Examine spending in important ministries, such as Finance, Health, Agriculture, Fisheries, Livestock and Forestry, and Public Works, between 2019 and 2024.

- b. Find out how money has been allocated to NBS-aligned projects in relation to key health indicators like vaccination coverage, maternal mortality, access to improved sanitation, and child malnutrition.
- c. Analyze the impact of budgetary prioritizing on environmental metrics such as catastrophe risk reduction and watershed management.
- d. Identify the opportunities and deficiencies in the existing public funding that could enhance NBS's capacity to support sustainable development and community resilience.

2. Theoretical Frameworks

2.1. Nature-Based Solutions (NBS)

To address social, environmental, and economic issues while promoting biodiversity and human well-being, NBS interventions preserve, manage, restore, or sustainably use natural ecosystems and ecological processes. Early research shows that NBS is still a broad and somewhat unclear concept despite its increasing popularity. Its use is not restricted to ecosystem services or natural capital; in certain situations, it even encompasses methods that merely take inspiration from nature without making a direct contribution to the preservation of biodiversity. This conceptual breadth has raised important concerns about whether NBS is a truly unique approach to management and policy or if it essentially repackages concepts like ecosystem-based adaptation, ecosystem-based solutions, and nature-based interventions (Rizvi et al., 2015; Andrade et al., 2011). However, some contend that NBS's strength is precisely in how it is framed. The idea has been successful in conveying the importance of ecosystems to urgent social issues including food security, water shortages, and climate resilience by highlighting the practical yet interdependent interaction between humans and nature. In this way, NBS might not supplant current ideas but rather offer a cohesive story that connects the goals for growth, conservation, and climate change (EC, 2015).

Wellmann et al. (2023) investigate how tools that incorporate social, ecological, and technological (SET) characteristics can enhance nature-based solutions. According to the study, a lot of current NBS programs don't work well because they prioritize ecological results over social demands and technology support systems.

NBS offer several co-benefits, such as carbon sequestration, flood mitigation, biodiversity protection, and improved public health, but they can come with hazards and trade-offs if poorly planned or managed, according to recent research. Unequal access to resources, the loss of local livelihoods, and decreased efficacy due to climate change are some of these issues. As a result, contextual analysis, transparent effect measurement, and protections against negative social outcomes must all be included in systematic NBS assessment (Seddon et al., 2020; IUCN, 2020).

With a focus on their implications for social fairness, Thompson et al. (2023) thoroughly examine finance and financing options for ecosystem services and nature-based solutions.

According to the study, NBS is supported by a variety of financial tools, including public funding, payments for ecosystem services (PES), private investment, philanthropy, green bonds, and public-private partnerships. However, the majority of these tools put efficiency and ecological results ahead of equity considerations.

2.2. The Role of Public Budget in NBS Implementation

The transformation of political pledges on NBS into long-lasting, scalable results is mostly dependent on public budgets. Most NBS rely on public or donor funding because private funding rarely supports long-term maintenance, governance, and equitable goals (Thompson et al., 2023). Similarly, Mulder (2021) concludes that in order to reach climate and biodiversity targets, global NBS investment must triple by 2030, with public finance serving as the foundation for funding and facilitating private investment. When taken as a whole, these studies show that without steady public funding, NBS cannot advance from pilot initiatives to equitable, long-term implementation.

Effective NBS funding requires a whole-life-cycle budgeting approach that includes planning, implementation, maintenance, and monitoring. The study found that a persistent problem that endangers long-term effectiveness and the provision of ecosystem services is a shortage of running funding after initial investment. Performance-based budgeting frameworks and monitoring metrics that promote ongoing public spending are necessary to close this gap (Favero & Hinkel, 2024; Thompson et al., 2023).

Public budgets can stimulate private investment in addition to providing direct funding by lowering risk through co-financing techniques, fiscal incentives, guarantees, and blended finance instruments. The potential, co-benefits, and limitations of Nature-based Solutions (NBS) in addressing climate change and other global concerns are thoroughly evaluated (Seddon et al., 2020). However, the authors stress that these benefits are very context-specific and rely on ecological integrity, appropriate scale, and long-term management. In order to transcend institutional silos and match public spending with fair and long-lasting NBS outcomes, both sources stress the importance of cross-sectoral coordination.

2.3 Relationship Between NBS, Health, and the Environment

By targeting key environmental determinants of health, NBS are increasingly recognized in the literature as effective interventions for improving public health. To minimize cardiovascular, respiratory, and heat-related health risks result from urban green spaces, ecosystem restoration, and forest conservation, which also improve water quality, lower air pollution and heat stress, and promote physical activity and mental health (Hartig et al., 2014; Markevych et al., 2017; Gascon et al., 2016). According to Patz et al. (2004) healthy ecosystems, wetland restoration, and improved watershed management can lower exposure to water-borne and vector-borne diseases, even though these results depend on local ecological and socio-environmental factors.

NBS can help mitigate and adapt to climate change by strengthening water regulation, increasing soil fertility, decreasing erosion, increasing carbon sequestration, and protecting biodiversity (Seddon et al., 2020). Because of these interrelated advantages, NBS is increasingly being presented as a cross-sectoral policy instrument that connects environmental sustainability, social well-being, and public health.

2.4. NBS in Timor-Leste

NBS for ecosystem-based resilience and sustainable development because of Timor-Leste have natural diversity, which ranges from coastal mangroves to upland forests, as well as its significant exposure to climate change, land degradation, and livelihood fragility. Ecosystem-based strategies, such as mangrove conservation, forest restoration, and watershed management, are effective in lowering climate risks, regulating soil erosion, promoting food and water security, and maintaining ecosystem services under conditions of limited infrastructure and high environmental stress. NBS and tropical regions (Munang et al., 2013; Duvat et al., 2020; Seddon et al., 2020). The assertion that NBS aligns well with Timor-Leste's environmental and socioeconomic context is supported by these findings.

The introduction of NBS aligns well with Timor-Leste's environmental and socioeconomic context is supported by these findings. The incorporation of NBS and Ecosystem-based Adaptation (EbA) into national development and climate frameworks aligns with global best practices at the policy level. Combining NBS into national adaptation plans, forestry, agricultural, and coastal policies enhances policy coherence, bolsters institutional legitimacy, and makes it easier to obtain funding for development and climate change (Nalau et al., 2018; Wamsler et al., 2016). As we can see in Timor-Leste, this policy alignment creates a favorable climate for interventions like watershed rehabilitation, agroforestry, and mangrove restoration carried out in collaboration with development organizations. Although community-based (NBS) initiatives can promote local resource governance and successfully repair damaged ecosystems, their long-term impact is often constrained by their small scale, short funding cycles, and reliance on outside funding (Kabisch et al., 2016).

2.4 Research Gap

The majority of international research on NBS concentrates on wealthy nations or areas with robust budgetary capacities. There are still a few studies on how NBS is incorporated into fiscal policy in developing nations, especially Timor-Leste. To close this gap, this study evaluates public budget priorities for NBS-related sectors and links them to sustainable development, health, and environmental indicators.

3. Research Methods

To place fiscal trends within broader socio-environmental settings, the research takes into account national variables from the Direção-Geral de Estatística, such as child malnutrition, maternal mortality, vaccination coverage, access to

sanitation, malaria prevalence, and forest cover. Policy and analytical studies from international organizations, such as the World Bank, FAO, UNDP, UNEP, and WHO, were also analyzed in order to compare Timor-Leste's fiscal orientation with international standards for sustainable funding and NBS implementation. Public spending was categorized as NBS-related using a theme coding system based on IUCN and UNEP guidelines. Ecosystem conservation and restoration, ecosystem-based climate adaptation, sustainable land and water management, and connections to environmental health were all supported via NBS-aligned budget lines. Expenditures without a clear link to ecosystem processes were eliminated, increasing openness and replicability while realizing that some budget items may serve several objectives.

An integrated longitudinal database was created from budget data, and both descriptive and exploratory quantitative analyses were carried out. Analytical techniques included trend analysis of changes in capital and operating expenditures over time, cross-sectoral comparisons to assess the relative prioritization of NBS-related spending, and simple descriptive-correlational analysis (using Pearson correlation coefficients) to look into connections between public investment and particular socio-environmental indicators. The results were contextualized within institutional capacity limitations, policy frameworks, and implementation realities using qualitative interpretation. To help with understanding, correlation matrices, trend lines, and charts are used to present the results. The study offers an analytical mapping of fiscal alignment, revealing important trends, gaps, and opportunities to increase the role of public finance in supporting NBS and their co-benefits to the environment and public health, even though it does not prove causal causality.

4. Results

4.1. Overview of Budget Trends and Execution

The Ministry of Health, Ministry of Agriculture and Fisheries, Ministry of Public Works, and Ministry of Finance are the four major ministries whose public spending trends between 2019 and 2024 are depicted in Figure 1.



Figure 1. General trend overview

Timor-Leste's major ministries saw an overall increase in budget allocations between 2019 and 2024, which was accompanied by continuously strong execution rates. The Ministry of Health increased its budget from USD 46.16 million to USD 140.26 million while maintaining a high level of execution (84.0–93.9%). While maintaining good execution (82.0–95.9%), the Ministry of Agriculture and Fisheries had significant growth and unpredictability in appropriations, rising from USD 14.71 million to USD 32.71 million. The Ministry of Finance had smaller and more erratic budgets, with execution rates ranging from 76.1% to 85.5%, while the Ministry of Public Works handled the biggest budgets, growing from USD 158.34 million to USD 224.28 million with consistently above 87.8% (Government Health Expenditure, Timor-Leste, 2023).

4.1.1. Ministry-Specific Expenditure Trends

Table 1 shows that execution rates were continuously high for MAF's budget (82.0–95.9%). However, execution fell to 82.0% when allocations reached a peak of USD 32.71 million in 2024, indicating limitations in absorptive capacity at times of substantial budget expansion.

Table 1. Ministry of Agriculture and Fisheries (MAF)

Year	Total Budget (USD)	Real Spending (USD)	Execution %
2019	14,709,250	12,635,239	88.5%
2020	7,637,970	7,046,584	95.3%
2021	28,563,111	25,742,512	90.1%
2022	18,329,758	17,580,322	95.9%
2023	25,875,452	24,208,400	93.5%
2024	32,709,133	26,834,583	82.0%

Table 2 demonstrates that MoH's overall budgetary allotments increased steadily, with a significant rise from 2022 to 2023. Execution rates were continuously higher than 84.0%. 2023 had the largest allocation (USD 161.84 million), with 93.8% execution. In 2024, both allocation and execution slightly decreased.

Table 2. Ministry of Health (MoH) – NBS-related programs

Year	Total Budget (USD)	Real Spending (USD)	Execution %
2019	46,156,625	42,163,192	92.2%
2020	44,523,226	41,785,959	93.9%
2021	52,541,124	46,903,627	89.3%
2022	57,193,475	52,508,528	91.8%
2023	161,839,651	151,745,086	93.8%
2024	140,256,249	117,825,357	84.0%

MoPW kept the biggest budget over the research period, as Table 3 demonstrates. With the exception of a brief budget cut in 2023, execution rates were steadily high (87.8–95.5%). This trend shows consistent implementation performance across all infrastructure-related expenditures.

Table 3. Ministry of Public Works (MOPW)

Year	Total Budget (USD)	Real Spending (USD)	Execution %
2019	158,339,377	138,231,871	87.8%
2020	195,423,435	183,888,853	93.8%
2021	234,436,377	223,112,465	95.5%
2022	219,084,915	195,154,377	95.3%
2023	138,422,516	124,061,764	92.0%
2024	224,279,372	207,410,913	95.3%

According to Table 4, the MoF's budgetary allocations varied somewhat, and its implementation rates were lower than those other operational ministries. The lowest performance was recorded in 2023, with execution ranging from 76.1% to 85.5%..

Table 4. Ministry of Finance (MoF)

Year	Total Budget (USD)	Real Spending (USD)	Execution %
2019	22,651,806	17,282,149	78.1%
2020	16,513,335	13,259,405	85.2%
2021	31,773,990	21,954,820	80.4%
2022	34,039,489	27,037,071	85.5%
2023	25,592,651	17,981,315	76.1%
2024	27,056,532	21,279,867	83.2%

Table 5. MoPW Infrastructure for Health Resilience

MoPW Directorate (Examples, 2019–2024)	Execution Highlights	Health/NBS Relevance
Direcção Geral de Água e Saneamento	57–97% execution	Safe water reduces diarrhea & cholera
Direcção Geral de Obras Públicas	81–93%	Roads improve access to health posts
Electricidade	97–99%	Critical for rural health infrastructure

4.1.2. Interpretation for NBS Alignment -Expanded Analysis

According to the observed spending patterns, MoH and MoF made indirect contributions through the provision of health services and fiscal management, whereas MoPW and MAF accounted for the biggest shares of spending directly related to land, water, and infrastructure systems. While MoPW coupled big allocations with consistently good execution, MAF's high execution rates contrast with its erratic budget levels. MoF showed middling performance and lower budget volumes, but MoH showed consistent budget growth and excellent execution. These trends point to inconsistent financial stability within ministries, which has consequences for the continuation of long-term programs.

4.2. Sectoral Contribution to Health & Resilience

Between 2019 and 2024, sectoral investments concentrated on health services (MoH), food and agricultural systems (MAF), infrastructure and WASH (MoPW), and fiscal coordination (MoF). Although Nature-Based Solutions weren't explicitly

identified in budget classifications, spending patterns across these sectors show indirect connections to health, food security, water access, and environmental management.

Table 6. Timor-Leste's public investment between 2019-2024

Ministry	Development Role	Relevance to Health	NBS Relevance
MoH	Health services & disease control	Maternal health, malaria, TB, dengue, nutrition	Nature-based vector control
MAF	Food systems, irrigation, fisheries	Nutrition & food security impact stunting & anemia	Agroforestry, catchment protection
MoPW	Water, sanitation, road access	Rural health access, WASH	Watershed & flood protection
MoF	Budget management & policy	Multi-sector financing	Can enable NBS tracking & tagging

Source: Portal transparency elaborated by the Authors (2025)

MoH consistently allocated and executed funds for maternal health, disease control, and nutrition programs. MAF investments supported food production, irrigation, and fisheries, while MoPW spending focused on roads, water, sanitation, and electricity infrastructure. MoF provided cross-sector budget administration and oversight.

4.2.1. Directorate-Level Insights-MoPW Infrastructure for Health Resilience

The Ministry of Public Works (MoPW) plays a major role in climate-health resilience and NBS-linked investments through water and road systems.

Directorate-level data (Table 6) show high execution across MoPW units between 2019 and 2024. The water and sanitation directorate (Direcção Geral de Água e Saneamento) recorded execution rates between 57.7% and 97.0%, while the public works directorate (Direcção Geral de Obras Públicas) ranged from 81.9% to 93.5%. The Electricity Directorate consistently exceeded 97% execution. These results show strong implementation capacity across infrastructure-related directorates.

4.2.2. Ministry of Finance (MoF)-Support for Cross-Sector Delivery

Between 2019 and 2024, MoF execution rates ranged from 76% to 85% at the ministry level, with stronger performance in Corporate Services and External Resource Management units. Treasury and Planning-related functions showed more variability. Budget data show MoF's central role in allocating funds across the health, agriculture, and infrastructure sectors, though we found no formal expenditure tagging system for environmental or NBS-related activities.

4.2.3. Health Outcomes Influenced Four Ministries

During the study period, total sectoral investments and key health indicators both improved. Maternal mortality decreased

from 184 to 138 per 100,000 live births, while child stunting decreased from 47% to 45%. These advancements coincided with improved access to infrastructure, increased assistance for agriculture, and higher health care spending (Figure 2). The timing points to a relationship between multi-sector investment patterns and the health improvements we saw, even though we are unable to prove causation.

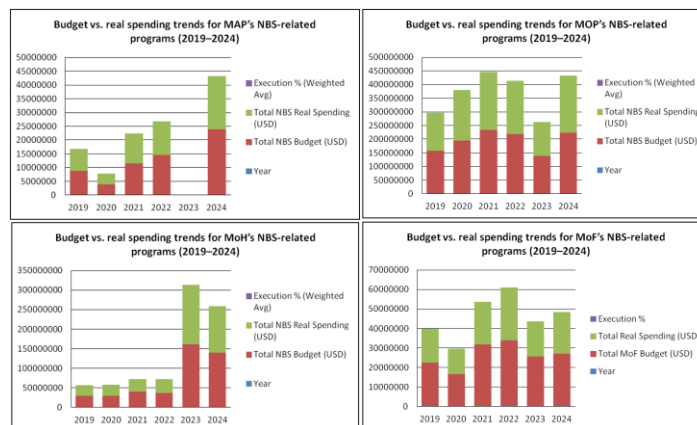


Figure 2. Health Outcomes Influenced by MAF, MoPW, MoH and MoF’s Investment

4.3. Fiscal Prioritization and Environmental Indicators

Fiscal priorities differed among environmental domains, as Table 7 illustrates. Budget uncertainty affected MAF's forest-related spending, but MoPW's consistently excellent execution rates supported watershed management. Spending on disaster risk mitigation was mostly centered within MoPW, with indirect assistance from MoF's fiscal oversight.

4.4. Opportunities and Gaps to Improve NBS Performance

- a) The findings point to four significant empirical gaps: MAF financing exhibits significant annual variation.
- b) Activities pertaining to the environment or NBS do not have an expenditure labeling system.
- c) There is little budget cooperation between ministries.
- d) In certain years, financial reporting is irregular or lacking, especially when it comes to timeliness. Significant absorptive potential is indicated by high execution rates in MoH, MoPW, and certain MAF districts, which may facilitate more integrated, multi-sector investment strategies.

Table 7. Fiscal Prioritization and Environmental Indicators

Indicator	Ministry Linkage	Fiscal Observation	Environmental Implication
Forest Cover	MAF	Budget instability (2019–2024) weakens consistent forestry management	Risk of inconsistent reforestation and watershed protection programs.
Watershed Management	MoPW, MAF	High MoPW execution (90%+) supports water-related infrastructure; MAF can complement via upstream interventions	Strong potential for NBS-based water conservation if integrated.
Disaster Risk Mitigation	MoPW, MoF	MoPW’s large and effective budgets could fund flood control, erosion prevention, and resilient infrastructure	High potential for NBS through engineered–natural hybrid systems (e.g., green <i>Portal transparency elaborated by the Authors</i> flood barriers).

5. Discussion

5.1. Expenditure Trends, NBS Effectiveness, and Political Economy Factors

Timor-Leste's spending trends reflect the intricate interactions among institutional capacity, political priorities, and broader political economy dynamics. The Ministry of Public Works (MoPW) and the Ministry of Health (MoH) have excellent execution rates, which are consistent with theories of effective public sector management that emphasize program efficacy through stable budgets and robust delivery capabilities. The Ministry of Agriculture and Fisheries (MAF), on the other hand, has extremely erratic budgets, which is in line with findings from other SIDS, where agricultural and ecosystem programs are vulnerable to outside shocks like donor-dependent financing, climate events, and abrupt policy changes (FAO, 2020; UNEP, 2022).

Political-economic issues account for a major portion of this instability. Multi-year planning for NBS is disrupted by MAF's strong reliance on Official Development Assistance, which exposes it to donor uncertainty and conditionalities. These difficulties are made worse by governance limitations that make it difficult to convert budgets into quantifiable results, such as poor interministerial cooperation and a lack of monitoring capability. Similar dynamics can be seen in other SIDS, like Vanuatu and the Solomon Islands, where budget volatility and imple-

mentation delays in donor-driven agricultural programs are often caused by institutional misalignment and changing policy priorities (ADB, 2021; Robinson, 2017; Gotsadze et al., 2019).

Even though political and economic limitations like donor dependence, limited fiscal autonomy, and conflicting policy agendas continue to affect the efficacy of NBS implementation, the consistently high execution rates in MoH and MoPW show institutional competency as a crucial facilitator. The Results-Based Management (RBM) paradigm, which emphasizes converting inputs into results, is supported by these findings. But they also demonstrate that both capability and the ability to negotiate difficult governance situations are necessary for successful execution (OECD, 2024; Walshe & Garrow, 2021). Additionally, proactive management of donor relations and political dependencies is necessary for NBS in Timor-Leste to implement effective fiscal policies.

5.2. Health and Environmental Co-Benefits

The integration of ecological and social results is a key component of nature-based solutions, and global development frameworks are increasingly reflecting this idea. Investment patterns in MAF (such as climate-smart agriculture) and MoH (such as WASH and maternal and child health) are consistent with tactics employed in other SIDS where ecosystem-based initiatives simultaneously address nutrition, illness prevention, and climate resilience (UNDP, 2021; IPBES, 2022).

The Planetary Health hypothesis, which holds that human health is essentially dependent on the integrity of natural systems, is highly supported by these findings (Whitmee et al., 2015). In line with this perspective, Lo et al. (2019) contend that enhancing population health, lowering disease burdens, and boosting resilience all depend on public investment in environmental public goods including clean water, sanitation, and healthy ecosystems. Their study also shows that preventative, ecosystem-based treatments improve adaptive ability to environmental shocks and climate change, are affordable, and increase health equity.

Ecosystem-based interventions are becoming more prevalent in agricultural and health policy frameworks in developing nations and Small Island Developing States, where similar integration of environmental and health objectives has been recorded (Seddon et al., 2020; Wellmann et al., 2023). In order to continuously maximize social, health, and environmental returns, it is crucial to include NBS concepts into public investment and budgeting mechanisms, supported by cross-sectoral coordination and performance monitoring.

5.3. Fiscal Enablers for NBS

The Ministry of Finance's (MoF) role as a fiscal facilitator in Timor-Leste is representative of a broader global trend in which finance ministries are crucial to incorporating Nature-Based Solutions (NbS) and climate goals into national planning. In order to foster long-term resilience, Atteridge and Canales (2017) discover that climate finance to Pacific SIDS is primarily grant-based and project-oriented, with little budget support. This highlights the need for better expenditure tracking and

stronger alignment with national planning. Climate budget tagging is a mechanism that can improve strategic budgeting, promote climate governance, and increase accountability for public spending connected to climate change at both the national and local levels (Mutiarra et al., 2020).

The MoF Timor-Leste's execution rates are moderate, between 76–85% demonstrate progress in fiscal management, but also highlighting issues that are common to finance ministries in developing countries, such as fragmented coordination across line ministries, limited analytical capacity, and administrative complexity (Cangiano et al., 2013; Hemming et al., 2013). The effectiveness and impact of public spending on NbS can be significantly increased by institutionalizing NbS and climate budget tagging, as well as by enhancing accountability systems and analytical capabilities for climate-risk screening (Sakrak et al., 2022; Lo et al., 2019). Investments in NbS risk fragmentation and siloing without these mechanisms limiting their ability to deliver cumulative environmental, social, and health co-benefits across sectors.

5.4. Strategic Recommendations

International experience clearly supports the suggested strategy pillars: stronger green budgeting within MoF, development of ecosystem-based engineering in MoPW, integration of nutrition-sensitive programming between MoH and MAF, and multi-year budgeting for MAF. In countries such as Ethiopia and Nepal, Medium-Term Expenditure Frameworks (MTEFs) for agriculture have been shown to stabilize financing for ecosystem restoration (OECD, 2024). In a similar vein, the implementation of ecosystem-based infrastructure in SIDS has decreased long-term maintenance costs while increasing resistance to coastal erosion and floods (UNEP, 2023).

The actual application of the Nexus Approach (water, food, and energy) and Planetary Health concepts, which are increasingly recognized as best practices for optimizing NbS co-benefits, is evident in the integration of health, agriculture, and environmental investments. In this sense, Timor-Leste is in a better position than many of its peers due to its institutional ability in important operational ministries. However, the Ministry of Finance must spearhead intentional fiscal coordination and policy coherence in order to realize this potential.

All things considered, Timor-Leste's issues, budget volatility, distributed funding, and insufficient environmental monitoring are not unique when seen in the broader context of developing countries and SIDS. Concurrently, the country's excellent infrastructure and health delivery capabilities offer a solid basis for growing Nature-Based Solutions via integrated public finance management reforms.

6. Conclusion

In order to determine how well the Ministries of Public Works, Agriculture and Fisheries, Health, and Finance aligned with Nature-based Solutions (NBS), this study looked at public spending trends in Timor-Leste from 2019 to 2024. In relation to budget allocation patterns, execution performance, and fiscal governance systems, the efficacy of NBS and its co-benefits for

public health, agricultural sustainability, and infrastructure resilience were investigated.

The results show how MoPW consistently and successfully apply grey-green infrastructure and ecosystem-based catastrophe risk reduction. The significant budget volatility of MAF, which is mostly caused by donor dependence and external shocks, emphasizes the necessity of multi-year planning and fiscal predictability. Climate-smart agriculture and watershed management depend on MAF. Health and nutrition programs that meet NBS goals are made possible by MoH's excellent execution and steadily increasing funding, while MoF provides essential budgetary oversight. However, MoF's poor performance suggests that cross-ministerial coordination and green budgeting could be strengthened.

This study shows that MoH and MoF create favorable conditions through governance, financial planning, and health initiatives; ecological and social benefits rely on the operational capacity of MoPW and MAF. Strengthening institutional capacity, reducing sectoral volatility, institutionalizing green budgeting, and promoting interministerial cooperation are some of the policy's advantages. These adjustments can enhance NBS mainstreaming, encourage climate resilience, and maximize co-benefits for health, ecosystem sustainability, and food security. The results show that Timor-Leste still does not include the NBS in public finance execution in four key ministries, providing a route to community resilience and sustainable development in this nation.

7. Recommendations

Stabilizing financing for the Ministry of Agriculture and Fisheries (MAF) to support long-term Nature-based Solutions (NBS) is a top suggestion. Adopting multi-year budget commitments that provide steady funding for key initiatives such as watershed management, mangrove restoration, and climate-smart agriculture will help achieve this. Because these ecological interventions need to continue in order to provide long-term benefits to community resilience and the ecosystem, sustained investment is crucial. Simultaneously, increasing domestic financing mechanisms, such as national climate funds and green budget allocations, and reducing MAF's reliance on erratic donor funding will enhance financial certainty and enable MAF to more effectively plan and carry out NBS projects.

A second suggestion is to incorporate Nature-based Solutions into national building and infrastructure planning, using the Ministry of Public Works (MoPW) as a catalyst for ecosystem-based infrastructure development. Increasing investment in grey-green infrastructure, which combines man-made structures with natural systems, is necessary to achieve this. Examples of such infrastructure include riverbank vegetation for flood reduction, mangrove buffers for coastal protection, and hillside replanting for erosion control. In addition to lowering climatic risks, incorporating ecological functions into public works projects will increase the longevity of infrastructure assets. At the same time, MoPW should promote climate-resilient, ecologically friendly construction methods, making sure that all major

projects incorporate sustainability standards, environmental safeguards, and landscape restoration elements.

To enhance the cross-sectoral integration of Nature-based Solutions (NBS), a third recommendation is to increase collaboration between important ministries, especially the Ministry of Agriculture and Fisheries (MAF) and the Ministry of Health (MoH). Collaborative programming across various sectors can link nutrition-sensitive agriculture with public health activities to address problems including food insecurity, maternal undernutrition, and child malnutrition using ecosystem-based methods. For example, communal agroforestry and a variety of home gardens can improve soil health and water retention while increasing food diversity. Positive social and ecological outcomes can also result from coordinated efforts to protect watersheds, lower the risk of disasters, and enhance water, sanitation, and hygiene (WASH). Combining these programs will improve community resilience to health and climate shocks, reduce resource duplication, and increase efficiency.

To ensure sustainable and accountable funding for Nature-based Solutions (NBS), a fourth suggestion is to institutionalize green budgeting and strengthen fiscal oversight through the Ministry of Finance (MoF). The MoF's ability to apply green budgeting frameworks and climate-risk screening tools throughout the national budgeting process must be strengthened in order to integrate environmental and climate resilience factors into public investment decisions. By integrating these methods, MoF can ensure that programs that provide ecological and social benefits are given priority in secondary budgets, especially in MAF and MoPW. Furthermore, to promote effective budget execution across sectors, minimize funding duplication, and align NBS spending with national development targets, greater interministerial coordination mechanisms led by the MoF are crucial. By using this strategy, the government will be able to increase openness, mobilize private funding, and integrate NBS into fiscal policy.

The next piece of recommendation is to strengthen monitoring and evaluation (M&E) mechanisms to monitor the effectiveness of Nature-based Solutions (NBS) investments across ministries. To do this, a coordinated, results-driven M&E structure that links public investment to measurable outcomes related to ecology, health, and disaster resilience must be established. Ministries like MAF, MoP, and MoH can show the true impact of their interventions by incorporating NBS indicators, such as improved nutrition or WASH outcomes, reduced flood risk, watershed health, and forest cover restoration. Evidence-based decision-making will be facilitated by regular reporting and data exchange within sectors, ensuring that funding are allocated to the most successful and scalable NBS activities. Additionally, by using M&E data to support adaptive management, programs can be changed over time for greater efficacy, accountability, and long-term community resilience

8. Limitations

This study's primary drawback is its extensive dependence on secondary data, which might not fairly represent donor-funded efforts, off-budget expenditures, or community-based

Nature-Based Solutions (NBS) projects conducted outside of official government channels. The accuracy of expenditure mapping to particular NBS-related programs was further hampered by differences in reporting formats and inconsistent budget classification across ministries. Additionally, although the research offers valuable information regarding expenditure trends from 2019 to 2024, it does not assess program-level implementation quality or spending efficiency due to a lack of disaggregated performance data. The lack of qualitative perspectives from important stakeholders such as ministry spokespeople, local communities, and development partners that could have improved understanding of institutional goals and limitations is another drawback. Lastly, the study may underrepresent cross-sectoral dynamics because it concentrates on four ministries, particularly those pertaining to the environment, tourism, education, and disaster management sectors, all of which are crucial to the advancement of NBS.

9. Future Research

Future research should expand to include program-level financial tracking and performance evaluations in order to gauge the effectiveness, efficiency, and long-term effects of NBS investments. Combining quantitative budget analysis with qualitative techniques like stakeholder interviews would improve understanding of institutional, political, and budgetary constraints. The use of spatial technologies (such as GIS) is recommended to connect NBS investments with ecological fragility and high-risk sites, even if longitudinal studies are necessary to link spending to quantifiable outcomes, such as flood prevention, soil restoration, food security, and child nutrition. Timor-Leste may find useful policy benchmarks from comparative studies with other Small Island Developing States (SIDS). Lastly, to identify sustainable investment models that reduce reliance on petroleum revenues and improve fiscal resilience, future research should examine financing options for NBS, such as climate funds, green bonds, and public-private partnerships.

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