



Circular GHG mitigation opportunities **Lao PDR**

A metabolic approach

COLOPHON

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UNDP's work on climate change spans more than 140 countries and US\$3.7 billion in investments in climate change adaptation and mitigation measures since 2008. With the goal to foster ambitious progress towards resilient, zero-carbon development, UNDP has also supported implementation of the Paris Agreement on Climate Change by working with countries to achieve their climate commitments or Nationally Determined Contributions (NDCs).

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The NDC Support Programme provides technical support for countries to pursue a 'whole-of-society', integrated approach that strengthens national systems, facilitates climate action and increases access to finance for transformative sustainable development. The programme helps countries address these financial barriers by deploying a structured approach for scaling up sectoral investments and putting in place a transparent, enabling investment environment. Beyond direct country support, UNDP facilitates exchanges and learning opportunities on nationally determined contribution implementation at the global and regional level by capitalizing on our close collaboration with the UNFCCC and other strategic partners.

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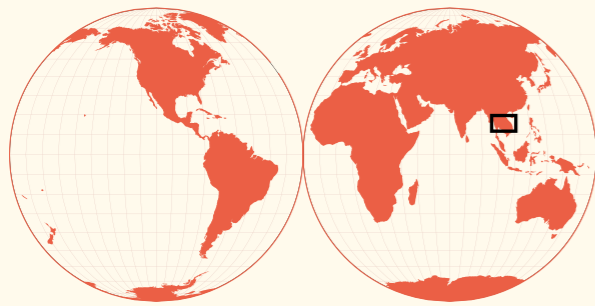
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November 2021

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Lao PDR

Lao PDR is strategically located in the heart of Southeast Asia and is a vital part of the regional economic fabric. It supplies its own industries and consumers with food and resources, while also exporting large volumes of crucial raw materials to surrounding countries.

Lao PDR is a country with abundant national resources.¹ Its fertile soils support large forestry and agricultural systems, while deposits of gold, copper, zinc, lead, tin, iron, aluminium, potash, limestone, gypsum and coal lie beneath them.² The country's surface area is comparable to that of Romania or Ghana, but those countries' populations are three and four times larger than Lao PDR's, respectively.³

Located at the crossroads of three major Asian economies – China, Vietnam and Thailand – Lao PDR is surrounded by large and demanding markets. It serves them primarily through the extraction and export of raw materials such as metal ores, wood and electricity from hydropower.



7.17 million
The population of Lao PDR was 7.17 million in 2019



Hongsa lignite power plant (1,878 MW)



Xayaburi dam (1,285 MW)



58%
58% of the export value stems from mining products and electricity

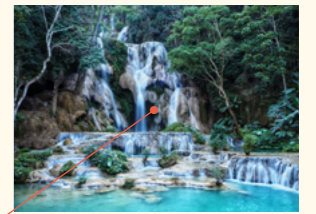
Vientiane-Boten railroad



Luang Prabang



Tat Kuang Si waterfalls



Vang Vieng karst landscape



Phou Hin Poun National Biodiversity Conservation Area

Vientiane



Phou Khao Khouay national park



Mekong river

Executive Summary

Signatories to the Paris Agreement face the dual challenge of achieving development while curtailing their a footprint with negative impacts on climate and the natural environment. At the same time, for low- and medium-income countries, economic growth is often essential if they are to be able to build up critical infrastructure and institutions.

By moving towards a circular economy, Lao PDR is pursuing both the objective of reducing global greenhouse gas (GHG) emissions, while securing the growth that will which allow the country to build up its material 'stock' of produced goods to meet societal needs, such as shelter, nutrition, mobility, healthcare and education. The transition to a circular economy involves a fundamental change in the current economic model: shifting to a system where materials are used such that they can be cycled indefinitely and on the smallest scale possible, durable products are designed to last longer and used more intensively; and development and well-being are decoupled from the use of natural resources. This makes it possible to reduce reducing emissions while supporting prosperity for current and future generations alike.

This report supports the next update of Lao PDR's Nationally Determined Contribution by deploying circular economy interventions. The latest NDC update was submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in March 2021. This NDC lists the country's voluntary GHG mitigation commitments under the Paris Agreement up to 2030.

UNDP has supported the development of this report through the NDC support programme⁴. Lao

PDR is the third country (after The Gambia⁵ and Vanuatu⁶) to adopt a metabolic analysis in order to raise its GHG ambition. South Sudan⁷ and Uganda are also using similar approaches to include circular economy options in their NDC. However, in addition to adopting a metabolic analysis, the government of Lao PDR also requested a detailed policy analysis and a long-term low- carbon development strategy. Further, it asked the project partners' consortium to create a private sector Community of Practice. In this community, a coalition of circular economy frontrunners jointly explored and addressed key barriers to circular economy initiatives. This report brings all of these developments together, highlighting the most promising circular economy opportunities, while exploring their business potential, long-term prospects and the policy opportunities that could pave the way for a country-wide transition to a low-carbon, circular economy.

Material use for domestic consumption in Lao PDR is 27 percent circular

The circularity of Lao PDR has been calculated by identifying 332 national material flows and determining whether each is circular or linear. The consumption-based circularity gap for Lao PDR specifies the share of domestic consumption from renewable or secondary resources, and for which materials are recovered at the end-of-life phase. Consumption in Lao PDR is estimated to be 27 percent circular. This is attributed primarily to sustainable agriculture, management of food waste throughout food value chains and the use of renewable firewood. The share of recycling of metals and minerals is negligible.

Box 1 Key messages

Lao PDR's most recent NDC aims to reach net carbon neutrality by 2050. This report examines how supplementing the NDC with 17 circular economy GHG mitigation and sequestration interventions can contribute to achieving or, even, raising that ambition. It also presents the business cases supporting these interventions for the private sector in Lao PDR.

Net carbon neutral by 2040 within reach

Lao PDR can become net carbon neutral by 2040 by adopting a circular economy approach. With the measures proposed in the NDC, it can reduce its GHG footprint from 106 to 58 million tCO_{2e}/year in 2040. The circular GHG mitigation interventions can reduce it further to net zero. Most of the circular mitigation and sequestration potential lies in wood-based construction, improving livestock efficiency, prioritizing active, shared, public and electric transport and reducing food losses. By adopting circular economy strategies within Lao PDR, the country would also reduce the import of carbon-intensive products. This creates additional GHG emission reductions in other countries of approximately 2.2 million tCO_{2e}/year.

The circular economy can add \$16 billion per year to the GDP by 2050

These interventions can reduce solid waste disposal by 86 percent and reduce an additional 2.6 million tonnes of food waste and losses. The gross domestic product (GDP) from the circular economy in Lao PDR could reach \$16 billion by 2050, while the number of jobs in the circular economy could reach 1.6 million by 2050. The Lao PDR workforce totalled 3.9 million in 2020, of which around 16 percent in circular jobs.

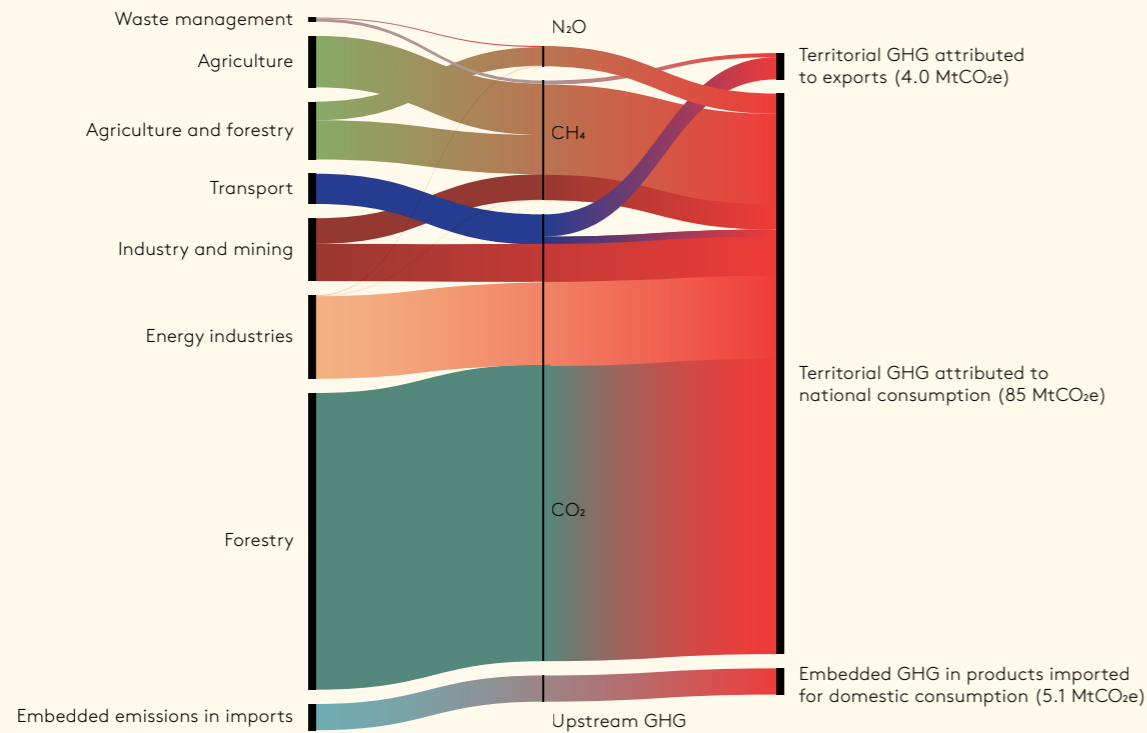
89 percent of the mitigation potential has a positive NPV

According to business case estimates, the circular economy is a viable business opportunity for Lao PDR. Eighty-nine percent of the circular GHG mitigation and sequestration potential has a positive net present value and 82 percent provides a payback in less than 2.5 years. When introducing a carbon price of \$25 per tonne, 98 percent of the circular mitigation and sequestration potential has a positive return, or negative marginal abatement costs.

Circular GHG mitigation requires a \$4.1 billion investment

The transition to a circular, net zero carbon economy requires an investment of \$4.1 billion in the period 2022-2036. That is in addition to the \$4.7 billion required between 2020 and 2030 to implement the NDC. In comparison, the new Boten-Vientiane railroad requires investment of \$5.95 billion. To realize investments in a low-carbon and circular future, regulatory and institutional barriers must be overcome for circular ventures so that they have access to investment capital, for example.

FIGURE 1



Territorial GHG emissions from Lao PDR and GHG emissions embedded in imported and exported goods and materials

GHG emissions from land use change, agriculture and food processing industries all refer to linear value chains. In addition, most imported products follow a linear trajectory. The Laotian waste management system is ill-equipped to handle many products when they are discarded after use. Imported fossil fuels are also identified as linear because they contribute to GHG emissions. Finally, substantial amounts of organic materials are lost through the solid waste management and sewage system.

Production in Lao PDR – estimated at 16 percent – is considerably less circular than consumption. When analysing the circularity of production, imports are excluded and only products from Lao PDR are accounted for, including those that are exported. The circularity of production is lower as the large mining sector in Lao PDR predominantly support exports.

Imported goods and materials account for 5.6 percent of the consumption-based GHG footprint

Analysing the carbon footprint of consumption in Lao PDR helps to identify interventions that can reduce GHG emissions, regardless of whether they occur in Lao PDR or elsewhere. For 2019, territorial GHG emissions were estimated at 89 million tCO₂e. The majority of them are CO₂ emissions from deforestation and coal combustion in recently commissioned coal fired power plants and cement kilns (Figure 1). Upstream emissions generated during the production of imported goods and materials were around 5.1 million tCO₂e. Lao PDR imports relatively carbon-intensive products, such as construction materials, vehicles and fossil fuels. In addition, the fossil fuels used in Lao PDR also have an upstream carbon footprint before they are imported and contribute to domestic GHG emissions when they are combusted.

Approximately 4.1 million tCO₂e (4.5 percent) of territorial emissions are related to the production of goods and materials that are exported to serve consumers in other countries; some of them are re-exports. When quantifying the consumption-based emissions, emissions generated in Lao PDR from the production of products that benefit consumers abroad may be deducted from territorial emissions. On the other hand, the emissions embedded in imports of products consumed in Lao PDR should be added. This results in a consumption-based carbon footprint of 91 million tCO₂e, of which 5.6 percent consists of the upstream emissions related to the production of imported products.

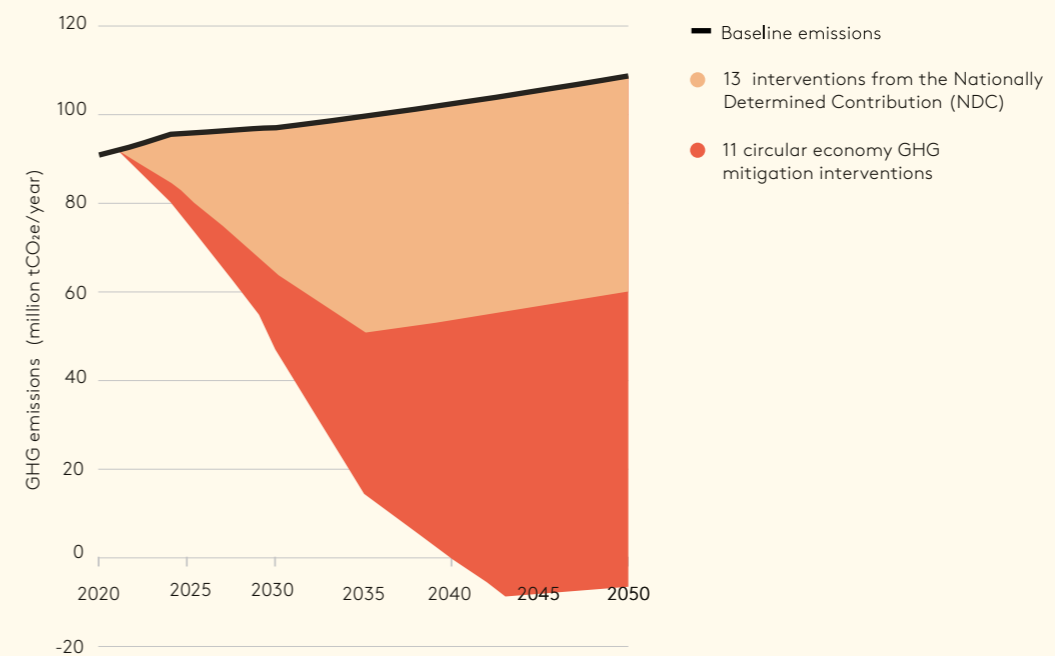
When identifying circular GHG mitigation opportunities, all these emissions are within scope. Altering consumption patterns in Lao PDR can reduce both territorial emissions and GHG emissions embedded in imports. On the other hand, when altering production methods or prioritizing low-carbon materials in products, territorial emissions can also be reduced when these products are eventually exported. Finally, when Lao PDR exports products that allow other countries to substitute

carbon-intensive materials of domestic origin, Lao PDR supports its trade partners in reducing their own carbon footprint. This is the case, for example, when Lao PDR exports hydropower to countries with a largely fossil-fuel based power supply or when it exports wood-based construction materials to substitute for carbon-intensive materials such as reinforced concrete in other countries.

Looking ahead: From baseline emissions of 112 million tCO₂e by 2050 to net carbon neutrality by 2040

According to our model of long-term GHG emissions, emissions from Lao PDR will reach 112 million tCO₂e/year in 2050.⁸ The interventions proposed in the NDC aim to make Lao PDR net carbon neutral by 2050. When extrapolating their impact to the period 2030-2050, the NDC measures can reduce Lao PDR's territorial emissions to 63 million tCO₂e/year in 2050. When adding circular economy GHG mitigation interventions to the efforts already described in the NDC, net carbon neutrality comes within reach by 2040 (Figure 2).

FIGURE 2



Estimated GHG mitigation potential in the updated NDC and in the circular economy (CE) mitigation opportunities identified in this report (corrected for overlap)

Roughly 90 percent of the mitigation potential in the NDC is from forestry related interventions such as reducing deforestation and increasing forest cover. The government of Lao PDR labelled eight percent of the mitigation potential in the NDC as not conditional on international support such as like finance, capacity building and technology transfer. The remainder is part of the country's own voluntary contribution to the objectives of the Paris Agreement.

The impact of the NDC and circular economy interventions in forestry will not be experienced fully by 2030. If Lao PDR reduces deforestation rates gradually and begins to restore forest cover to 70 percent, the forests will need time to become fully grown. In addition, interventions that rely on changes in consumer behaviour, like changing the mobility habits of large parts of the population, also take time to be realized. That does not occur overnight. Consequently, the mitigation potential of the NDC and circular economy interventions will only reach their full potential by 2040, after which the forecasted sectoral growth will slowly push emissions up again.

Overall, forestry-related emissions reductions and CO₂ sequestration make up the lion's share, responsible for around 40 percent of GHG carbon footprint reduction by 2040 and 2050. In addition to reducing domestic GHG emissions in Lao PDR, circular economy interventions also help reduce the carbon footprint of the country's trading partners. By reducing the import of carbon-intensive products, circular economy interventions in Lao PDR can help reduce foreign GHG emissions by an additional 2.2 million tCO_{2e}/year by 2030.

After 2042, emissions are predicted to increase gradually but with all interventions in place, they will remain negative until at least 2050.

The negative emissions indicate that the annual amount of CO₂ sequestered and stored in newly established forests and wood-based construction materials exceeds the total amount of annual GHG emissions. Annual emissions will increase after 2042 because as the economy continues to grow, residual GHG emissions from fossil fuel use also increase. In addition, the reforestation effort supports CO₂ sequestration when forests grow,

but CO₂ uptake slows when these forests mature. Lao PDR can remain at or below net zero emissions beyond 2050 by:

- rejecting all investments that are inconsistent with a net zero ambition, following Costa Rica's example.⁹ This implies that Lao PDR should stop issuing licences for new fossil fuel-based industries and infrastructure for fossil-fuel based vehicles; and,
- continuing to implement new GHG mitigation and sequestration options. The long-term emissions trajectory includes mitigation measures taken as part of the NDC in the period 2022-2030 and circular interventions implemented in the period 2022-2040. Beyond 2040, Lao PDR could continue to decarbonize its industries and its agriculture and transport sectors, eventually substituting all fossil fuel imports with low-carbon energy sources of domestic origin. This would bring its GHG emissions down to zero. By continuing to store carbon in harvested wood products from sustainably managed plantations, it would remain a net sink of GHG emissions.

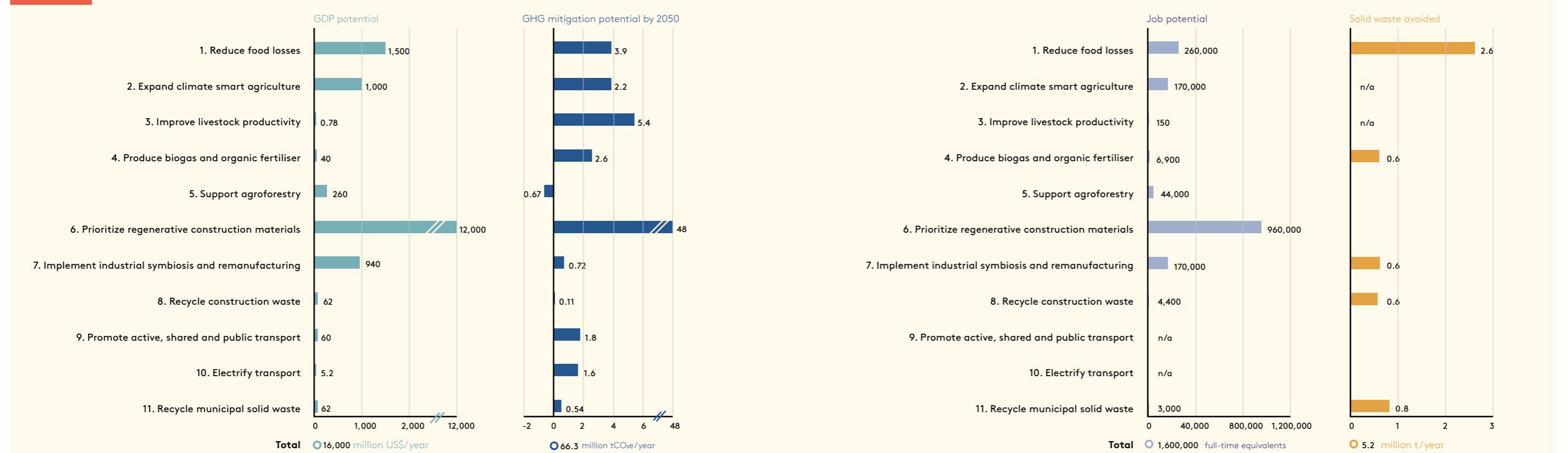
The NDC and circular economy interventions together require an investment of \$9.7 billion

Lao PDR's NDC requires total CAPEX (capital expenditure) of \$4.7 billion¹⁰ in the period 2022-2030. The circular economy interventions require additional CAPEX of an estimated \$4.1 billion. To put these two figures into perspective, the Vientiane-Boten railway, a major infrastructural project in Lao PDR that is part of the Belt and Road Initiative, requires investment of \$5.95 billion.¹¹

The circular economy can also reduce waste disposal and create over 1.6 million green jobs by 2040

Circular economy interventions can reduce waste disposal volumes by recycling and reusing secondary resources from households and industries. Solid waste volumes of minerals and metals sent to landfill can be reduced by 86 percent, while an additional 2.6 tonnes of organic waste and losses from food value chains can be avoided. The full implementation

FIGURE 3



Circular GHG mitigation opportunities and their environmental and socio-economic impacts

of these circular economy strategies requires a workforce of 1.6 million people by 2040 onwards (Figure 3). That growth in circular jobs can provide job opportunities to those currently working in linear value chains. Depending on the extent to which circular jobs replace jobs in linear value chains, the transition to a circular economy could require investing in human skills and creativity to improve labour productivity and per capita income. Five of the 17 circular GHG mitigation opportunities identified are in food value chains or products that expire. These can be implemented in a relatively short time, with an immediate effect on GHG emissions. In 2030, they will represent 52 percent of the territorial circular mitigation potential. Three interventions in products that last – specifically in the construction sector – will take more time to implement and reach their full potential. They represent 35 percent of the 2030 mitigation potential, but their share increases to 72 percent in 2050. That growth comes at the expense of the impact of products that expire, whose impact decreases to 20 percent.

The remaining 14 percent of the 2030 mitigation potential and 8 percent in 2050 comes from products that flow. These refer to interventions in short-lived products such as packaging, fossil fuel use and consumables including cosmetics, cleaning agents and healthcare products. The opportunities identified are structured by the type of products to which they relate and, then, ranked by their GHG mitigation potential within both Lao PDR and international value chains. The co-benefits covered include GDP potential, waste reduction and green job creation.

Six enabling interventions support the realisation of the eleven core interventions in products that expire, last or flow. These relate to, tax reform, ecotourism, circular procurement, policies, education and finance. The impact of the six enabling interventions overlaps with the impact attributed to the eleven core interventions. The policy and cross-sectoral Interventions 12-17 facilitate the implementation and adoption of the technologies specified in Interventions 1-11. Although their mitigation potential does not make a unique contribution to the total, they play an important role in enabling the earlier interventions and provide a different angle to ensure that these GHG emission reductions are achieved.

Policy opportunities

Figure 3 lists eleven interventions in sectors that directly contribute to a quantifiable environmental impact. Interventions 12-15 are policy interventions that have an important role in creating the enabling conditions for the first eleven interventions to mature. These interventions stem from a detailed review of the regulatory framework in Lao PDR, building on the Ellen MacArthur Foundation's five universal policy goals.¹²

This policy review concludes that Lao PDR has already made significant progress in its transition to a circular economy and in integrating the circular economy concept in the 9th National Socio-Economic Development Plan (NSEDP), Establishing a National Green Growth Steering Committee and taking this initiative with UNDP to integrate circular economy principles into the NDC mark new milestones in the transition to a circular economy. Lao PDR could further strengthen the regulatory framework for the transition to a circular economy by:

- expanding the mandates for the National Green Growth Steering Committee and the National Green Growth Promotion Centre to include the circular economy transition;
- developing a detailed circular economy roadmap that outlines the steps in the circular economy transition and that defines the roles of important stakeholders;
- developing a taxonomy for circular economy businesses and activities, aligned with international best practices, that enables specific support, including improved access to financing, for circular economy transition efforts;
- exploring the feasibility of carbon pricing and broader tax reform to prioritize labour-intensive activities and services over the exploitation of natural resources; and
- developing performance indicators and targets for the circular economy transition and instructing the Lao Statistics Bureau to collect, analyse and publish environmental data to support a transition to a circular economy.

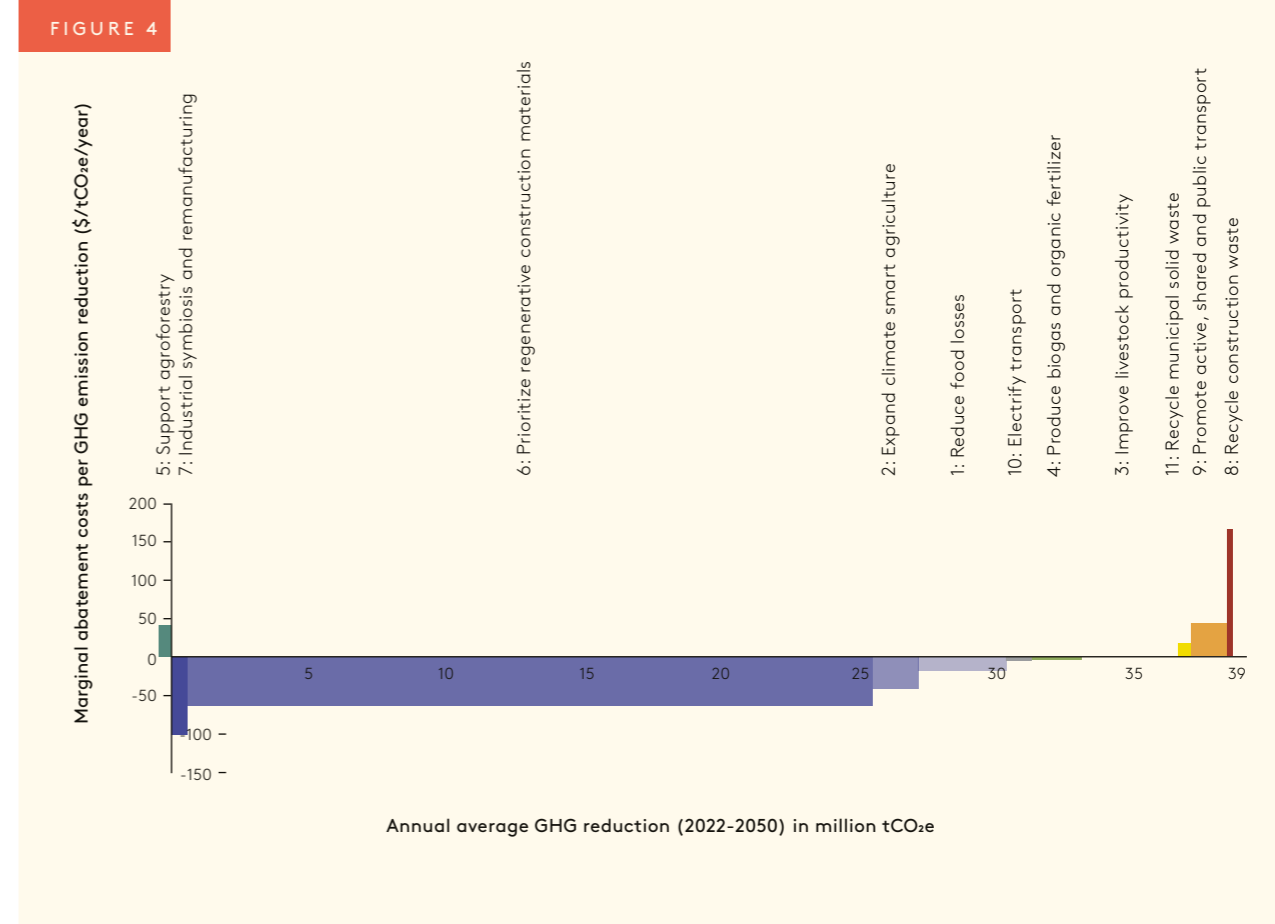


Figure 4 Marginal abatement cost curve with the economic and climate impact of the eleven core circular interventions

Six out of eleven circular interventions are commercially viable

In addition to assessing the socio-economic and environmental impacts, the business potential of the eleven core circular interventions were also assessed. Each intervention has been plotted on a marginal abatement cost curve to show the combined impact climate and economic returns (Figure 4). Each intervention below the x-axis is expected to yield both positive climate and economic returns, since negative costs are actually revenues. As a result, six out of the 11 interventions are commercially viable, even as they reduce GHG emissions. The interventions involve:

- reducing losses and waste in food value chains;
- expanding climate smart agriculture combined with organic certification;
- producing biogas and organic fertiliser at smallholder and industrial scale;
- prioritizing and producing industrial wood-based construction materials;

- implementing industrial symbiosis and remanufacturing; and,
- accelerating the electrification of the transport sector with service models.

The remaining measures may need price support, for example, through policies that account for negative externalities of products and their use. Take the example of a carbon price: in the marginal abatement costs curve, a carbon price would effectively move the x-axis upwards, increasing the number of interventions that are financially attractive without additional financial support. The production of agricultural commodities from agroforestry systems (5) is an outlier as it yields net returns/tonne CO₂e emitted, it is an exception amongst the interventions since it actually increases rather than reduces emissions. It has been added nonetheless since it provides valuable benefits in improving rural livelihoods and improves the climate resilience of agricultural production.

When investors consider a business context to be relatively risky, they often look at the payback, seeking to keep the time to recover their investment as short as possible. Eighty-five percent of the circular GHG mitigation potential offers a payback of less than six years.

The methodology: Systems analysis to link climate action to key development priorities

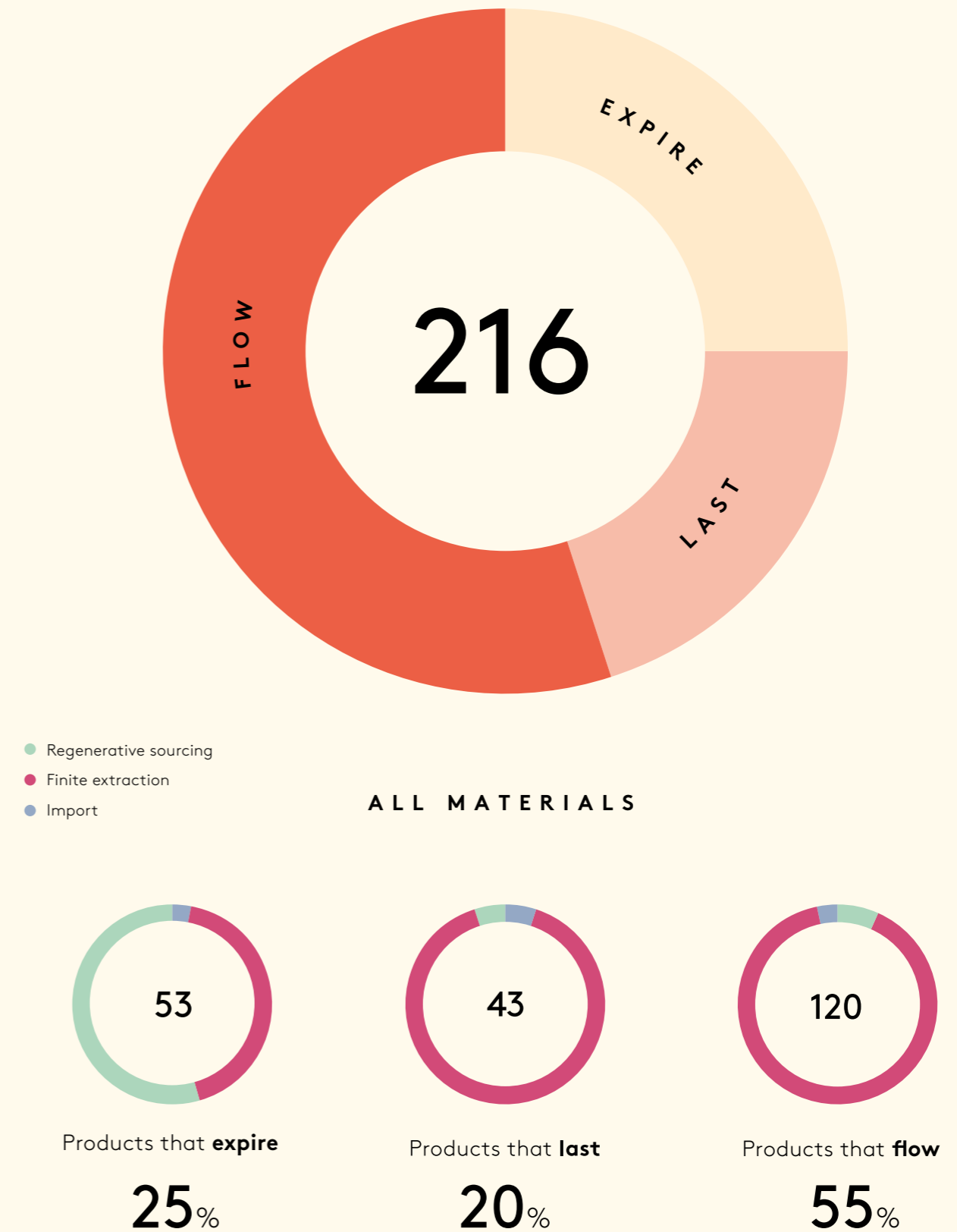
Development is too often accompanied by a gradual decrease in the quality of ecosystems and the deterioration of natural resources such as soils, marine environments, fish stock and forest standing stock. The identification of circular economy opportunities for Lao PDR combines an analysis of material use and flows with an analysis of trends in the quality and volume of natural assets. The analysis of stocks sheds light on whether the extraction and disposal of materials have a positive or negative effect on the ability of the country's natural assets to regenerate and serve future generations. This report refers to that combined review of both flows and stocks as a metabolic analysis, while material flows are analysed both in material tonnes and in their embodied GHG footprint in tonnes of CO₂ equivalents (tCO₂e). In the metabolic analysis, the flows and stocks of materials are considered a system.

The metabolic analysis for Lao PDR showed that organic material flows play an important role, in addition to flows from mining operations. The agriculture sector provides subsistence to an estimated 71 percent of the population. With agriculture, forestry and food industries responsible for 75 percent of territorial GHG emissions, organic resource extraction and organic waste management and land use were identified as focus areas for circular mitigation action.

The identification of circular GHG mitigation opportunities has also been aligned with the country's environmental and socio-economic development priorities. Those development priorities are to continue sustainable economic growth, improve people's material well-being and food security, improve the quality of human resources, and invest in infrastructure development. The proposed interventions for an accelerated transition to a circular economy are aligned with these socio-economic development priorities.

Sourcing by product type

million tonnes/year



1 Current situation, developments and ambitions

1.1 Reader's guide

This report describes Lao PDR's current situation, trends and development ambitions and relates them to circular economy opportunities. Because Lao PDR already has a relatively low carbon and material footprint, the analysis seeks to respond to a broader set of development aspirations. It prioritizes circular economy opportunities that offer GHG mitigation potential, create or maintain jobs, reduce waste disposal, and support graduation from least developed country status by increasing GDP.¹⁵ The recommendations are based on an analysis of resource use, asset use and waste disposal in the country. The report is structured as follows:

PART 1: Current situation, developments and ambitions: This part describes the current situation in Lao PDR, its development ambitions and important trends into the future. It provides an overview of planned investments in infrastructure, import and export, demographics, and land use in Lao PDR and describes where Lao PDR's policies and development ambitions align well with a transition to a more circular and low-carbon future.

The description of the environmental situation points out where material value is lost in the form of emissions into the air, water and soil. The socio-economic situation describes which sectors or

economic activities are most important to Lao PDR in terms of added value and jobs.

PART 2: Thinking in flows and stocks: Part 2 maps out the material resources used in Lao PDR, distinguishing domestic products from imports. Data visualizations help explain how the use of products, materials and semi-fabricated products relate to GHG emissions in Lao PDR and the international value chains of imported goods and services.

PART 3: Circular economy strategies: Part 3 looks at specific material flows and proposes 17 circular economy GHG mitigation interventions. Eleven of these interventions are based on an analysis of specific material flows and consultations with over 150 stakeholders. These interventions occur along the value chains of products that expire, those that last and those that flow. The business case for each of these interventions was analysed.

A policy analysis and stakeholder training and engagement programme provided the insights for policy recommendations for each intervention and generated six additional interventions that are more service-oriented. These interventions create the enabling conditions for a transition to a circular and low-carbon economy and relate to the public sector, commercial services such as tourism, and financial services.

The analysis prioritizes circular economy opportunities that offer GHG mitigation potential, create green jobs, reduce waste disposal, and increase GDP

No country starts from scratch in the transition to a circular economy. Therefore, Part 3 also describes selected existing circular economy initiatives. They provide the basis from which to expand or develop new initiatives that rely on similar principles and enabling conditions.

1.2. Key definitions

1.3. Lao PDR's development ambitions focus on green economic development and jobs

The 9th five-year NSEDP sets out Lao PDR's development priorities for the 2021-2025 period. This plan prioritizes the transition to a circular economy, particularly in its Outcome 4. The circular economy plays an even more prominent role in the plan for this latest period than it did in previous ones.²¹

The plan defines six outcomes that guide development in Lao PDR up to 2025:

OUTCOME 1: Steady economic growth with quality, stability and sustainability;

OUTCOME 2: Improved human resources with enhanced research capacity and ability to meet development needs and the use of science and technologies to improve efficiency and add value to production and services;

OUTCOME 3: Gradual enhancement of material and psychological well-being in keeping with improved food and income security;

OUTCOME 4: Environmental protection and natural disaster risk reduction;

OUTCOME 5: Robust infrastructure development, use of the country's potentials and strategic location, and active engagement in regional and international cooperation and integration; and,

OUTCOME 6: Efficient public administration and a society characterized by equality, justice and protection in line with the effective and strict rule of law.²²

Trade tensions between large economic powers, the COVID-19 pandemic and the resulting declines in international trade, tourism and foreign investment are expected to severely impact the country.

In response, the government seeks to secure sustainable and inclusive growth by investing in human capital and infrastructure. It is also preparing to support vulnerable households and affected migrant workers through direct cash transfers.²³

Lao PDR's population is young, with a median age of 24 years. Education is a priority under Outcome 2. Although Lao PDR achieved its goal of universal access to education, early school leaving among primary school age children has resulted in a childhood illiteracy rate of 10 percent.²⁴

Around 65 percent of Lao people live in rural areas and 70 percent of the population works in the agriculture sector. Women play an important role in agricultural production, managing almost 70 percent of farms in 2010-2011.²⁵ If the circular economy seeks to reduce natural resource exploitation, it should also safeguard the proper use of human resources, where gender plays an important role. Evidence indicates that improving gender equality and women's participation in the economy could drive economic growth.²⁶

1.4. Agriculture and forestry operations provide 65 percent of jobs and are responsible for 71 percent of GHG emissions

The Lao Statistics Bureau indicates that, retail and wholesale trade made the largest contribution to GDP in 2019, closely followed by commercial services such as financial and real estate services (Figure 7). Tourism, generally regarded as a very important economic sector in Lao PDR, contributed 3 percent.²⁷

The majority of 2019 employment was in the agriculture and forestry sectors (65 percent), followed by commercial and public services (including transport), retail and tourism (18 percent), and industry (5 percent).²⁸ These figures are based on the national estimate of 9.4 percent unemployment for 2019,²⁹ which differs from the 0.62 percent based on International Labour Organisation (ILO) models and the 19 percent reported on the World Bank country page.³⁰

The metabolic analysis of 2019 data shows that agriculture and forestry are responsible for 67 percent of production-based GHG emissions. Organic resource extraction and organic waste management are thus obvious areas of focus for mitigation action. Utilities account for 14 percent of emissions, which

Box 2 Key definitions

Circular Economy

"Looking beyond the current 'take, make and dispose' extractive industrial model, the circular economy is restorative and regenerative by design. Relying on system-wide innovation, it aims to redefine products and services to design waste out, while minimizing negative impacts. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital".¹⁴

Socio-economic metabolism

"The set of all anthropogenic flows, stocks, and transformations of physical resources and their respective dynamics assembled in a systems context".¹⁵ In the context of this analysis, Lao PDR's metabolism refers to the flows and stocks of material resources, energy and waste.

Systems approach

"A focus on the development of an integrated perspective that includes all levels, rather than on the isolated search for ready-made solutions to sub-problems".¹⁶

Secondary resources

Once 'waste' has been collected and prepared for recycling, it becomes a new resource. It is then a secondary resource, which differs from a primary resource that originates from extractive industries, such as mining.

Nationally Determined Contribution

Countries' submissions to the UNFCCC of their mitigation commitments for 2030, or beyond, under the Paris Agreement.¹⁷

Products that expire

These are food products that have a limited lifetime as they expire after a given period. Since food products are mostly of vegetable or animal origin, their end-of-life products are also organic materials.

Products that flow

Most materials entering the economy every year typically reach their end of life within a year. Examples are packaging and consumables like cosmetics, cleaning agents and healthcare products.¹⁸

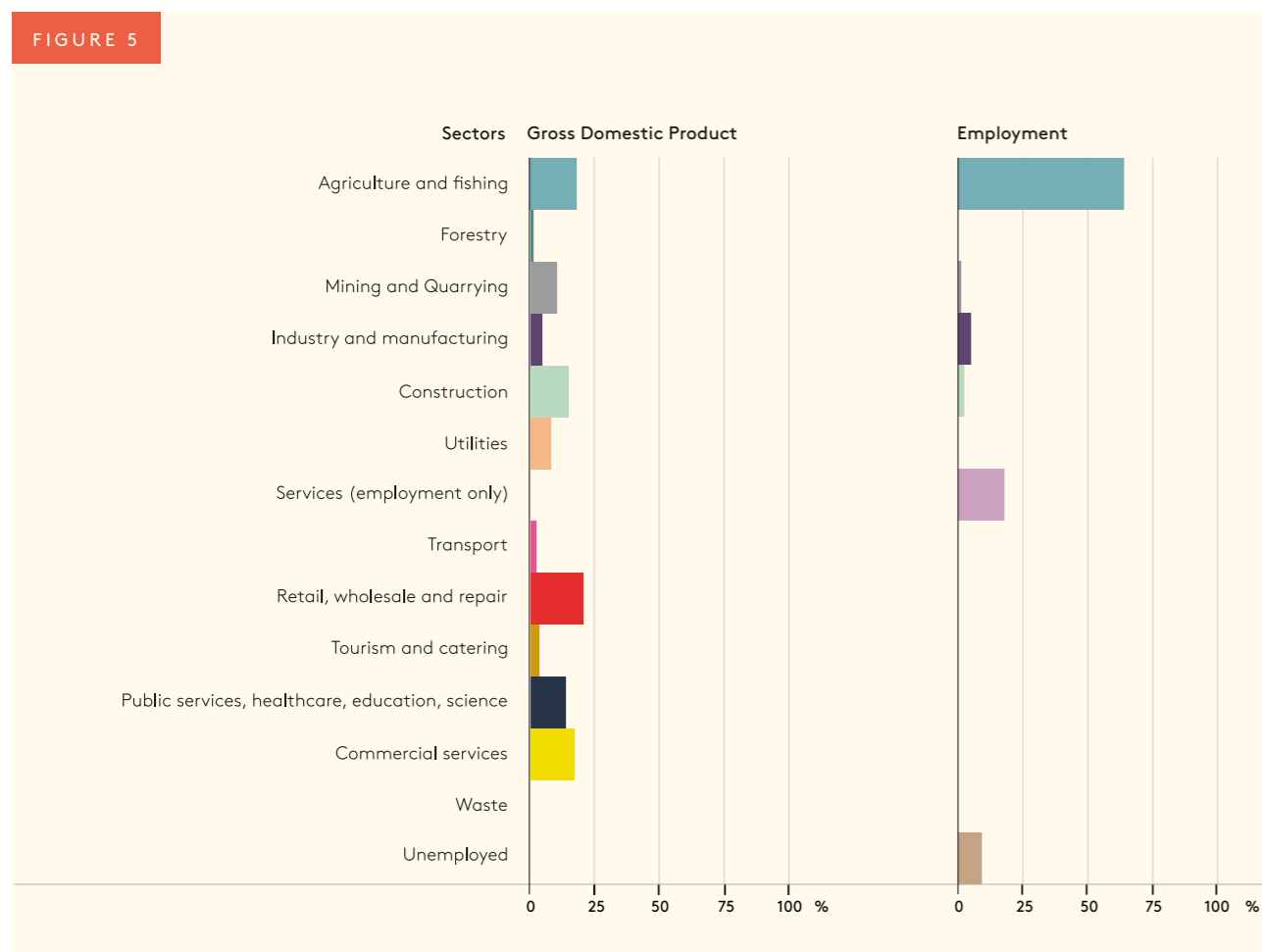
Products that last

The other materials become produced stock or long-term stock and are typically in use for longer than a year. Examples are capital equipment, buildings and infrastructure.¹⁹

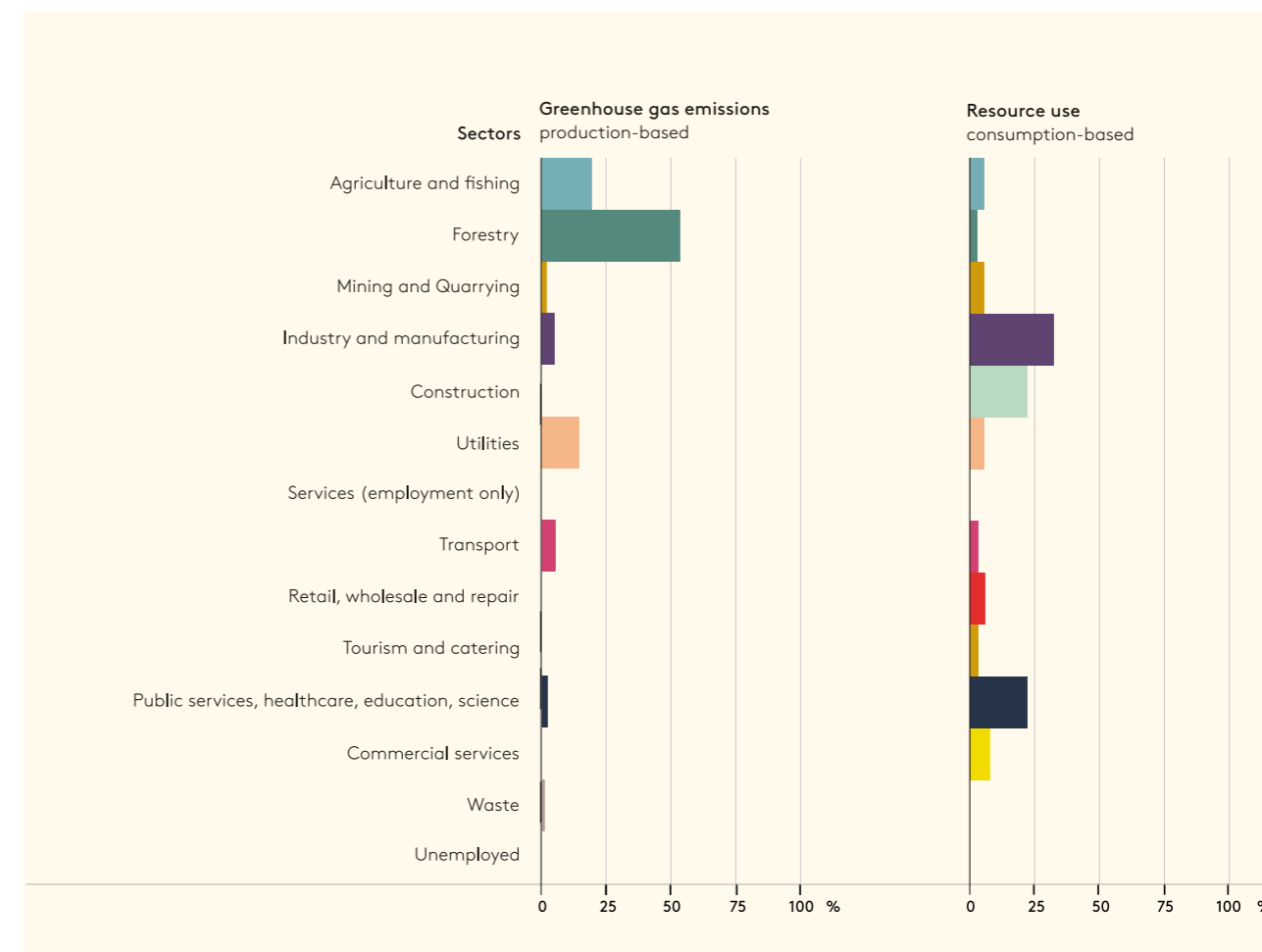
Natural assets

"Natural assets are assets of the natural environment. They consist of biological assets (produced or wild), land and water areas with their ecosystems, subsoil assets and air".²⁰

FIGURE 5



Breakdown of GDP, employment, production-based GHG emissions and consumption-based resource use by sector³²



are due primarily to the relatively new Hongsa coal-fired plant. Industry and manufacturing follow (6 percent) and transport is responsible for 5 percent.

According to the Sustainable Consumption and Production Hotspot Analysis Tool (SCP-HAT) from 2015 (the most recent year available), the country's largest end consumers of resources are industry and manufacturing (29 percent), construction (20 percent), and public services (20 percent).³¹ Secondary sectors, such as construction and industry, are generally countries' larger resource users. The tool does not explain why public services use so many resources. The detailed analysis of flows in Part 2 of this report does not confirm that finding. In general, services tend to have a small resource footprint.

1.5. New infrastructure developments affect resource and trade flows

In 2019, Lao PDR imported \$7.2 billion worth of products and exported products valued at \$6.6

billion.³³ With GDP of \$18.2 billion,³⁴ the Laotian economy relies more heavily on international trade than the global average.³⁵ Imported products include mineral fuels, vehicles, machinery and equipment, and construction materials. Thailand, China and Vietnam supply 79 percent of the import value.

Export value is composed of electricity (20 percent), ores, copper and precious metals (11 percent), electrical equipment (10 percent), and garments (8 percent). Most of the remainder are agricultural products.

Lao PDR participates in China's Belt and Road Initiative and is building a 414-km railroad that will connect Kunming, China with Vientiane through the Boten border crossing. The railway is a segment of the China-Indochina Peninsula Economic Corridor, connecting Kunming with Singapore via Lao PDR, Thailand and Malaysia.³⁶

The project is consistent with the national ambition to graduate from a landlocked country to a land-

linked one. The railway could link Lao PDR to major consumer markets in China and to countries that belong to the Association of Southeast Asian Nations (ASEAN) and will alter resource flows. The railway is expected to increase trade flows between Lao PDR and China from 1.2 million tonnes to 3.7 million tonnes annually. Compared to road transport, the railway could reduce transport costs between Kunming and Vientiane by 40 to 50 percent, or about \$30/tonne. In addition, it may generate an additional 3.9 million tonnes of transit trade between China and other ASEAN countries through Lao PDR. This includes 1.5 million tonnes currently transported by sea.³⁷ Assuming that Lao PDR's trade flows with China will increase in proportion to their current volumes, the result would be as follows:

- export of copper ore (30 percent of export value), rubber (9 percent), bananas (7 percent), potassium fertilizers (5 percent) and refined copper (4 percent); and,
- import of machinery and electric equipment (40 percent), metal articles (26 percent), vehicles and their parts (5 percent).³⁸

To benefit from improved railway connectivity, Lao PDR will have to invest both in its road network to link railway stations with its production and consumption centres and in cargo handling equipment. These infrastructure developments require significant volumes of construction materials; in recent years, Lao PDR increased its cement production capacity.³⁹

While the World Bank analysed the risks and opportunities of the Boten-Vientiane railway, it did not consider environmental risks. This despite the fact that the project would be considered a Category A project, deemed to be of highest risk in terms of environmental and social concerns. An environmental impact assessment (EIA) is not currently available.⁴⁰

In addition to transport infrastructure, Lao PDR plans to expand its hydropower capacity from 10 GW in 2019 to over 14 GW by 2025. By that time, the country will have developed more than half of its 26

GW hydropower potential. It also plans to expand the capacity of its single coal-fired plant from 1.9 GW⁴¹ to 2.5 GW and increase access to electricity by grid extensions and off-grid rural electrification. Generation is expected to total approximately 82,733 GWh by 2025.⁴² These investments will also require large volumes of construction materials soon.

Due to recent investments, the electrification rate is high – 98 percent in 2018. However, additional investments are urgently needed to improve access to clean water and sanitation. In 2017, 75 to 78 percent of the population had access to safe drinking water and sanitation, while only 48 percent of primary schools and 25 percent of health facilities did. This contributes to relatively high infant mortality (38 deaths per 1,000 live births) and mortality under 5 years of age (47 deaths per 1,000 live births).⁴³

1.6. The NDC targets forestry; investments are needed to improve climate resilience

According to the 2020 Global Climate Risk Index, Lao PDR ranks 22nd out of 180 in terms of exposure to

loss and damage due to climate change (the higher the ranking, the higher the exposure) Although the country fell to 45th place in the 2021 index, the region remains highly vulnerable.⁴⁴

In addition, with 65 percent of the workforce employed in the agriculture and forestry sectors, the Laotian population relies heavily on high-quality natural resources for its subsistence.⁴⁵ Since droughts and floods are expected to cause increasing damage to agricultural crop production, irrigation systems, roads and bridges, climate change threatens food security. In 2017, Lao PDR lost around 30,000 hectares (about 130,000 tonnes) of rice crops from flooding, drought and locust outbreaks. In 2018, storms caused the breach of the Xe Pien-Xe Nam Noy Dam, with severe losses of life and assets,⁴⁶ indicating that the country needs to invest in climate resilience.

To contribute to the GHG mitigation commitments under the Paris Agreement, Lao PDR submitted an updated NDC in May 2021. The focus of the updated submission is on reforestation and fossil fuel use reduction.⁴⁷ The latest NDC includes the following mitigation levers (Figure 6):

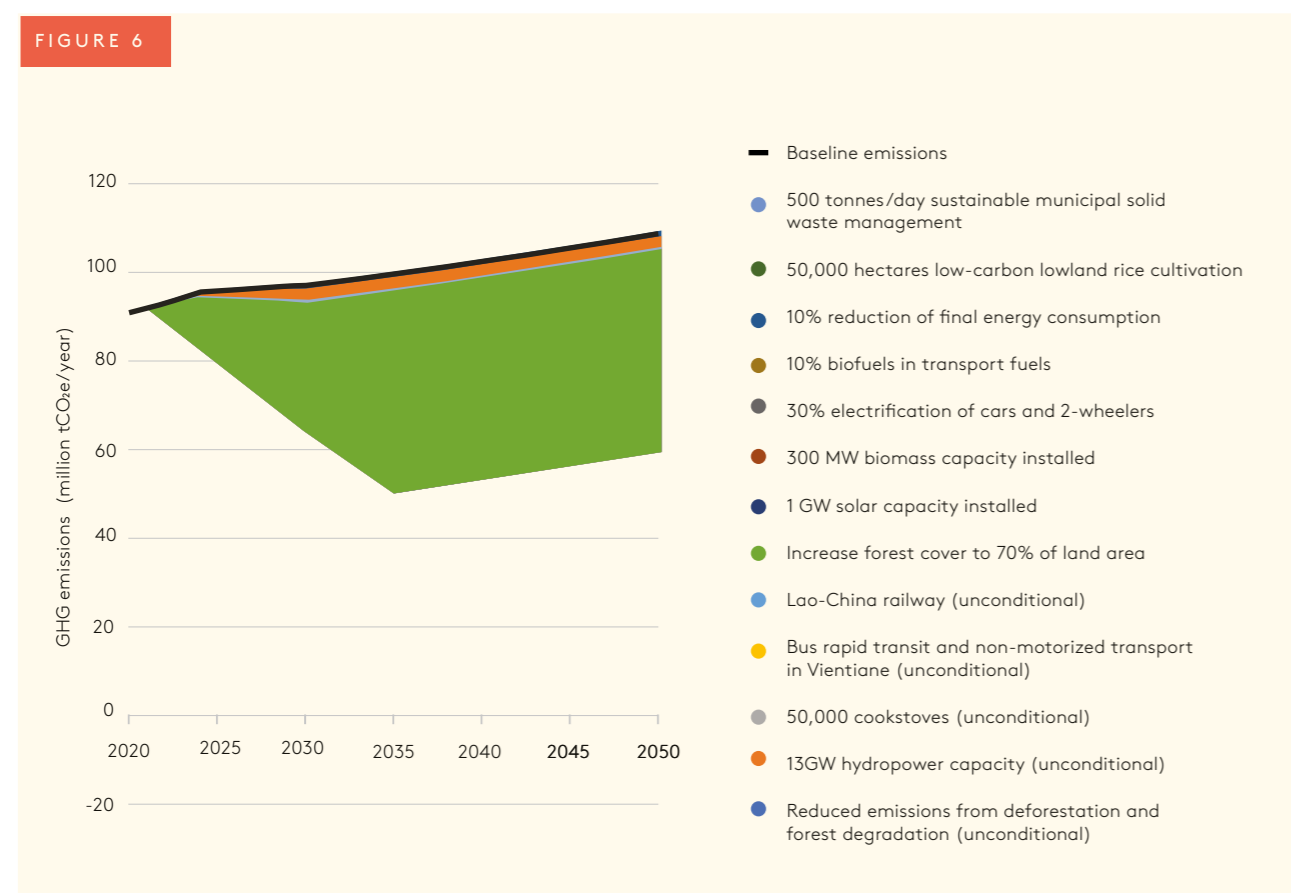


Figure 6: GHG emission reduction potential of interventions proposed in the updated NDC

The unconditional measures proposed in the NDC relate to reducing emissions from deforestation and forest degradation, adding 13GW in total hydropower capacity; introducing 50,000 energy efficient cookstoves; adopting three transport measures to support a new bus rapid transit (BRT) system in Vientiane; expanding non-motorized transport; and building the railway line between Vientiane and Boten. The other measures – including the most substantial, which seeks to increase forest cover to 70 percent of land area - are conditional upon international support.⁴⁸

The Global Green Growth Institute (GGGI) supported the Government of Lao PDR to update its first NDC. In the process, they also considered GHG mitigation opportunities, which, ultimately, were not included in the NDC. Those included:

- Energy: rice husk cogeneration plants, biomass power from biomass residues, bagasse power, micro-hydro, landfill gas use and waste incineration, biogas use, solar energy;
- Transport: blending biodiesel in diesel and bioethanol in gasoline, electric trucks and modal shift to rail;
- Industry: clinker replacement, waste heat recovery in cement and steel plants, fuel switching;
- Energy efficiency: households, street lighting and power distribution grids; and,
- Forestry: reforestation, reduced emissions from deforestation and forest degradation (REDD) and avoided deforestation, assisted forest regeneration, reforestation with agroforestry, reforestation with silvopasture, reduced emissions from charcoal production.⁴⁹

The goal of this metabolic analysis is to identify mitigation opportunities that extend beyond those listed in the updated NDC and those already considered by the Government of Lao PDR. To avoid double counting, the mitigation potential overviews will identify overlaps.

1.7. Conclusion – Part 1

Part 1 concludes that the circular economy strategies identified should aim to support four priorities:

1. Job creation, in particular for younger generations. In a circular economy, human – rather than natural – capital is the main source of national revenue. The informal economy and subsistence agriculture provide a living to many

Laotians. Both should be at the forefront when identifying circular economy opportunities. In the transition to a circular economy, women and marginalized groups should gain access to the benefits accruing from that transition;⁵⁰

2. Mitigation action, in agriculture and optimal use of the forestry sector as a potential carbon sink and its ability to contribute to building climate resilient infrastructure;
3. Private sector development, including improving Lao PDR's position as a regional supplier of valuable resources, while ensuring that economic activities – in particular, export-oriented – remain within the carrying capacity of the country's ecosystems; and,
4. Improving food security. A draft of the NSEDP justifies this as follows: "Maternal and child health and nutrition is vital for a child to realize his or her full potential, a foundation to enable a new generation to learn effectively and efficiently".⁵¹

Last, Lao PDR strives to achieve macro-economic stability under sound fiscal conditions. To ensure that the suggested interventions contribute to this outcome, fiscal reform, government procurement and sectoral policies will be reviewed in detail.

2 Material flows and their impact on natural assets and the climate

2.1 Reader's guide

Part 1 showed that mitigation efforts should focus on those sectors that contribute most to GHG emissions and provide the majority of jobs. These are agriculture, forestry and public services, including utilities. Other development priorities are to create green jobs, ensure food security and secure Lao PDR's position as a regional supplier of valuable resources.

Part 2 examines material flows and their impact on the quality of natural resources and the accumulation of material stocks in national vehicle fleets, transport infrastructure and buildings. This part describes Lao PDR's economic system through a metabolic analysis, which combines a material flow analysis and a stock dynamics analysis. It also looks at ways to measure development that are not limited to GDP and that also consider the extent to which value from extracted finite resources is invested to serve future generations. This section takes an economy-wide approach; Part 3 then focusses on specific material flows.


Parts 2 and 3 both rely on the results of a detailed metabolic analysis that analysed resource flows and their impact on natural assets at the point of extraction and disposal. The principles of a metabolic analysis are explained in more detail in Annex A, along with the definitions of the terminology used in the flows charts in this chapter.

2.2. Annual resource use increased from 17 million tonnes in 2005 to 214 million tonnes in 2019

The United Nations Environment Programme's (UNEP) SCP-HAT provides an overview of trends in domestic material use and extraction, emissions and land use up to 2015. Over the period 2005-2015, the domestic extraction of resources increased from 17 million to 49 million tonnes/year (Figure 10).⁵² The SCP-HAT figures exclude water and waste rock or overburden from mining operations.

However, extraction volumes have accelerated in recent years. In 2019, the production-based footprint, which excludes imports, was around 214 million tonnes/year. Unlike the SCP-HAT figures, this estimate includes waste rock and tailings from mining. If they are excluded, the figure drops to approximately 134 million tonnes/year. With much of the mined materials exported, consumption-based resource use (which excludes export-related extraction) is significantly lower, totalling 145 million tonnes/year.

Comparing the 1990-2015 SCP-HAT data to the 2019 metabolic analysis shows that material use in Lao PDR has increased significantly in recent years. This growth is mainly due to the expansion of mining activities and opening of new coal mines, coal-fired power plants and cement kilns.



The metabolic analysis shows the impact of resource flows and their impact on natural assets at the point of extraction and disposal

2.3. Mining and forestry operations dominate resource use in Lao PDR

Figure 8 provides an overview of material use in Lao PDR. It shows all materials used in tonnes/year, excluding water but including waste rock from mining. Reading the graph from left to right, starting with the 'Resource type' column, shows that the Laotian economy relies mostly on minerals, followed by biomass. The next column distinguishes the 'Origin' of these materials and indicates whether the materials are from finite resources (mining) or regenerative resources (sustainable forestry and agriculture) or are imported.

The next column, headed 'Product type', shows which kinds of products are used. When waste rock from mining is excluded, most products used are wood products, mineral construction materials and vegetables, closely followed by fuels. After use, most of these products contribute to territorial GHG emissions, are stored in new buildings or vehicles for long-term use, or are applied on land as soil enhancer.

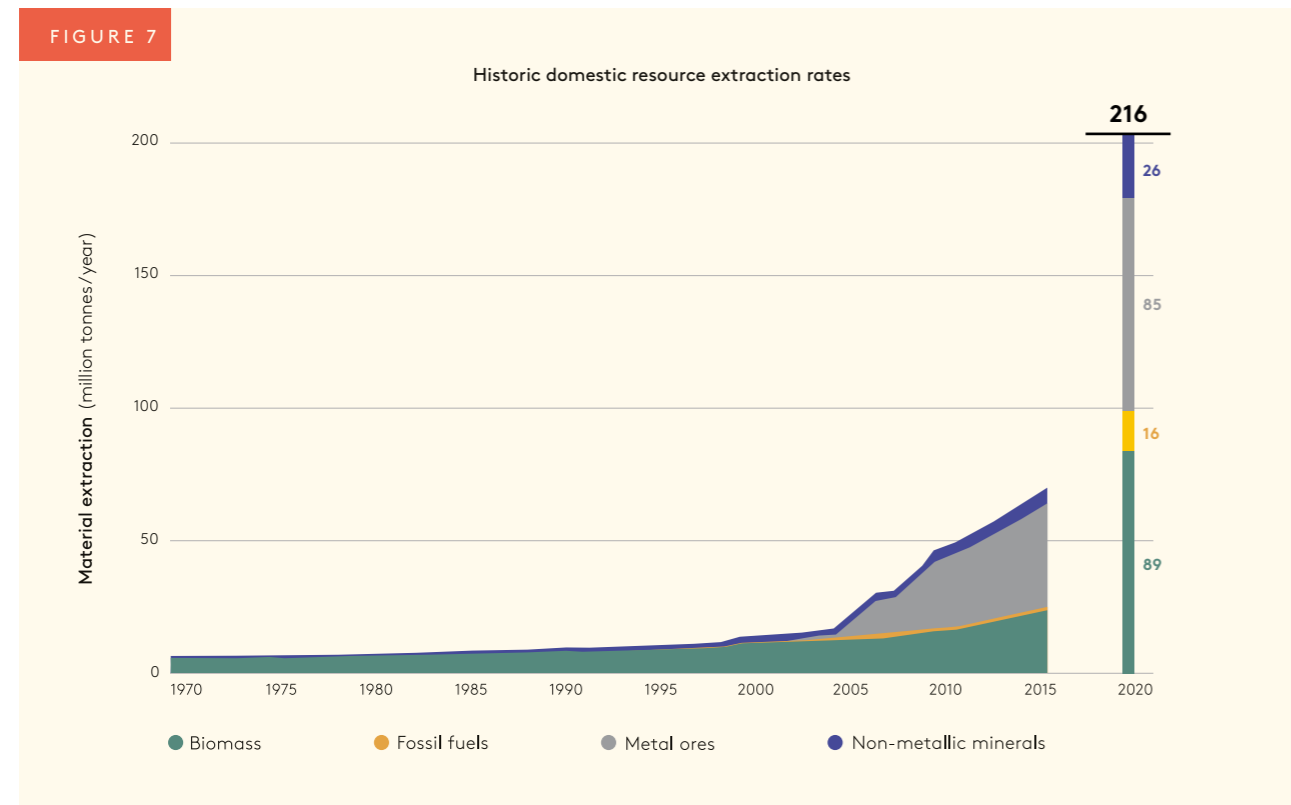
The total annual material flow is estimated at 230 million tonnes/year. This excludes the estimated 7 billion tonnes of water. Imports are not corrected for

their actual impact on global raw material extraction. When excluding waste rock and tailings from mining operations, annual material flow totals 135 million tonnes/year. In the visual, waste rock from mining is shown at the bottom right.

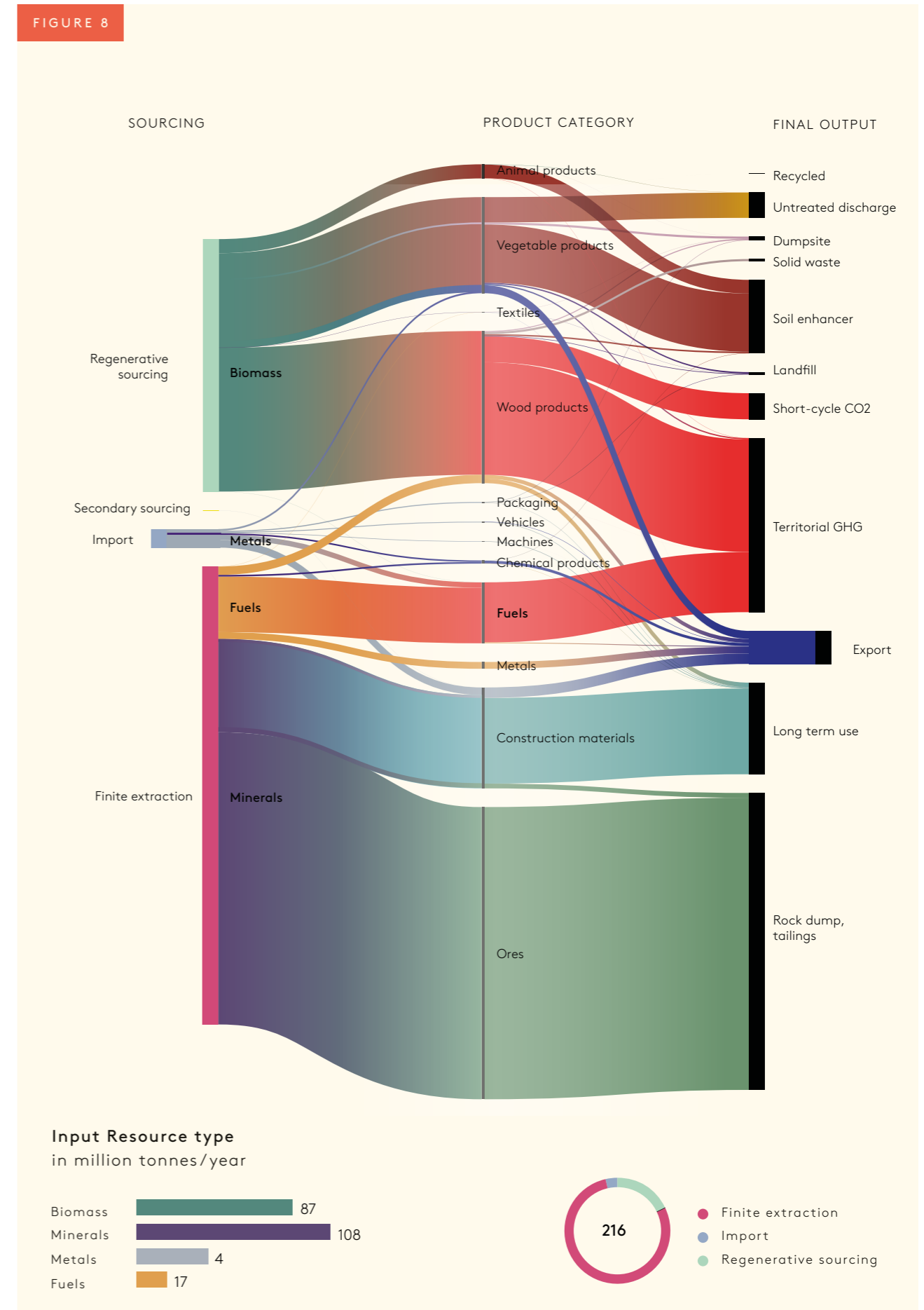
2.4. Although GDP is growing, per capita wealth is declining

This section reviews the impact of material extraction and disposal on the quality of natural assets. It explores whether Lao PDR is relying on natural resource rents from finite resources and, if it does, whether these rents are invested to serve future generations or used for current consumption.⁵⁵

Natural resource rents compose only a small part of Lao PDR's GDP (Figure 10). They totalled approximately 13 percent for the period 2006-2013, but fell to 4 percent in 2018. According to the World Bank, resource rents from the extraction of mineral resources and excessive wood extraction make up the lion's share of such rents.⁵⁶ Because the World Bank lacks data on coal rents from 2012 onwards, actual resource rents are likely higher. Between 2014 and 2019, coal extraction increased from 26,000

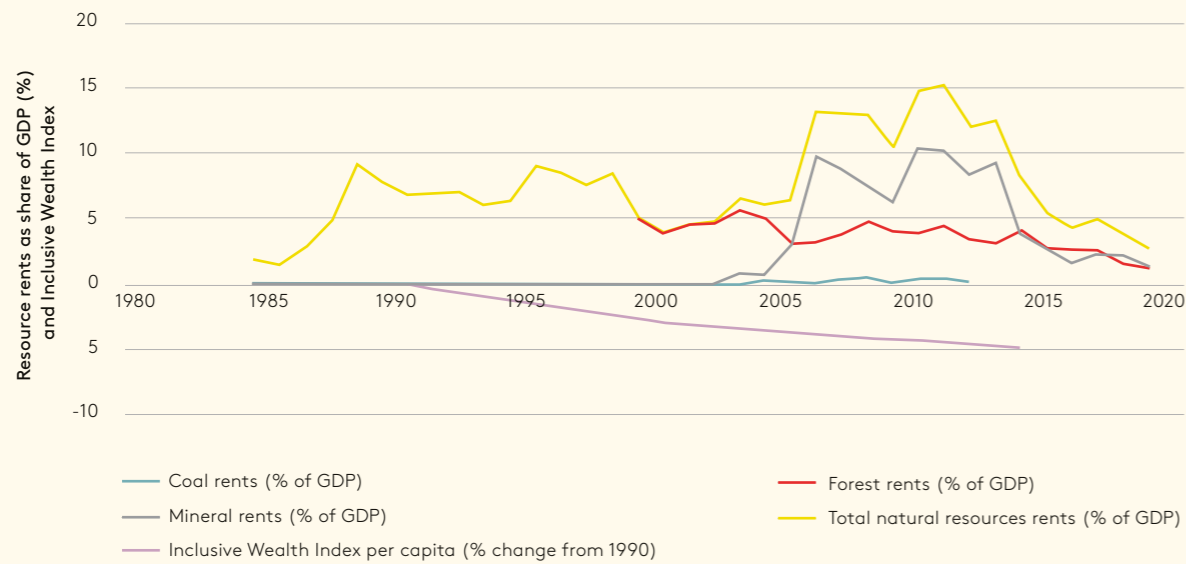


Historic trends in material use⁵⁵



All products and materials used in Lao PDR in 2019, excluding water but including waste rock from mining.⁵⁴

FIGURE 9



Resource rents and the Inclusive Wealth Index for Lao PDR

tonnes/year to 15 million. Prior to that, from 1985 to 2003, forest rents dominated. Minerals and coal extraction was added more recently.

Deforestation is a concern in Lao PDR, mainly driven by the expansion of agriculture and clearing for hydropower projects, mining sites and other infrastructure development. Forest degradation is attributed primarily to illegal logging and shifting cultivation.⁵⁷ This suggests that when determining the circularity of consumption and production in Lao PDR, the calculation should take into account that not all production from forests and agriculture can be considered regenerative or circular.

High resource extraction can contribute to the accelerated development of infrastructure. In that case, resource rents are invested also for the benefit of future generation. The Inclusive Wealth Index (IWI) seeks to measure this. Unlike GDP, the IWI focuses on whether countries “are developing in a way that allows future generations to meet their own needs... [E]ach generation must bequeath to the next as large a productive base as it inherited from its predecessor”.⁵⁸ It does that by assessing a country’s stock of assets, distinguishing among its manufactured, human and natural capital. Lao PDR’s per capita IWI is declining (Figure 10). This is because investments in produced capital to develop healthcare and education and produced

capital such as infrastructure are not keeping pace with population growth. A review of the World Bank’s adjusted (or genuine) net savings confirms this conclusion. This indicator is “a measure of gross national saving minus depreciation of produced capital, depletion of subsoil assets and timber resources, the cost of air pollution damage to human health, as well as a credit for education expenditures.”⁵⁹ It shows whether a country can sustain long-term growth and warns against consuming more wealth than a country is adding. For Lao PDR, the indicator is negative, which means that the country is running down its capital stocks at the expense of its future social welfare.

2.5. Consumption in Lao PDR is 27 percent circular

Lao PDR’s circularity was calculated from the metabolic analysis and its 332 material flows. The country’s consumption-based circularity gap specifies the share of domestic consumption from renewable or secondary resources that are cycled back into the economy after use. The 332 material flows total 216 million tonnes, which is the total amount of materials used in the country annually, regardless of origin or destination (excluding water). Domestic extraction of materials, which refers to the extraction of minerals, fish, forestry products and

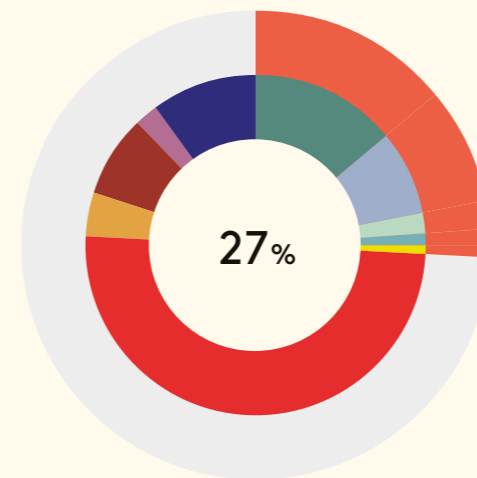
agricultural products and the volume that is recycled or reused, total 206 million tonnes, of which 81 million tonnes are mining waste rock and tailings.⁶⁰

The circularity of consumption in Lao PDR considers the circularity of the raw material footprint of all materials used in the country. This includes domestic extraction and the raw material equivalent of imports, provided that the products are used in Lao PDR. The circularity of consumption is estimated at 27 percent, mainly due to the land application of clean organic residue flows and use of regenerative firewood.

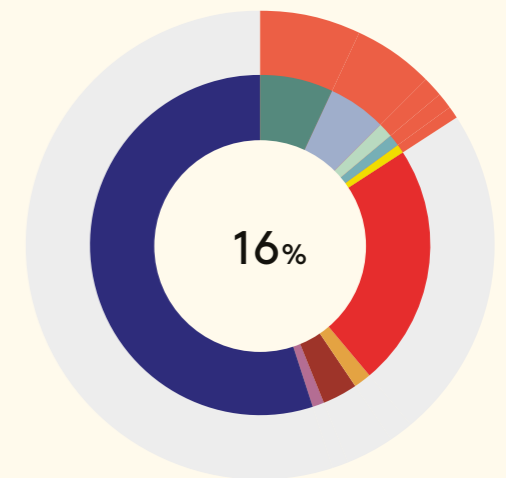
The circularity of production, on the other hand, considers only those products produced in Lao PDR, regardless of whether they are consumed domestically or exported. This estimate excludes raw materials use in imported products that are consumed in Lao PDR. The circularity of production is 16 percent. This is lower than the circularity of consumption due to the large volume of material extraction in Lao PDR that supports the export of products with a high raw material footprint, such as copper, gold, potassic fertilizers and electricity from a coal-fired power plant.

FIGURE 10

Circularity of consumption



Circularity of production

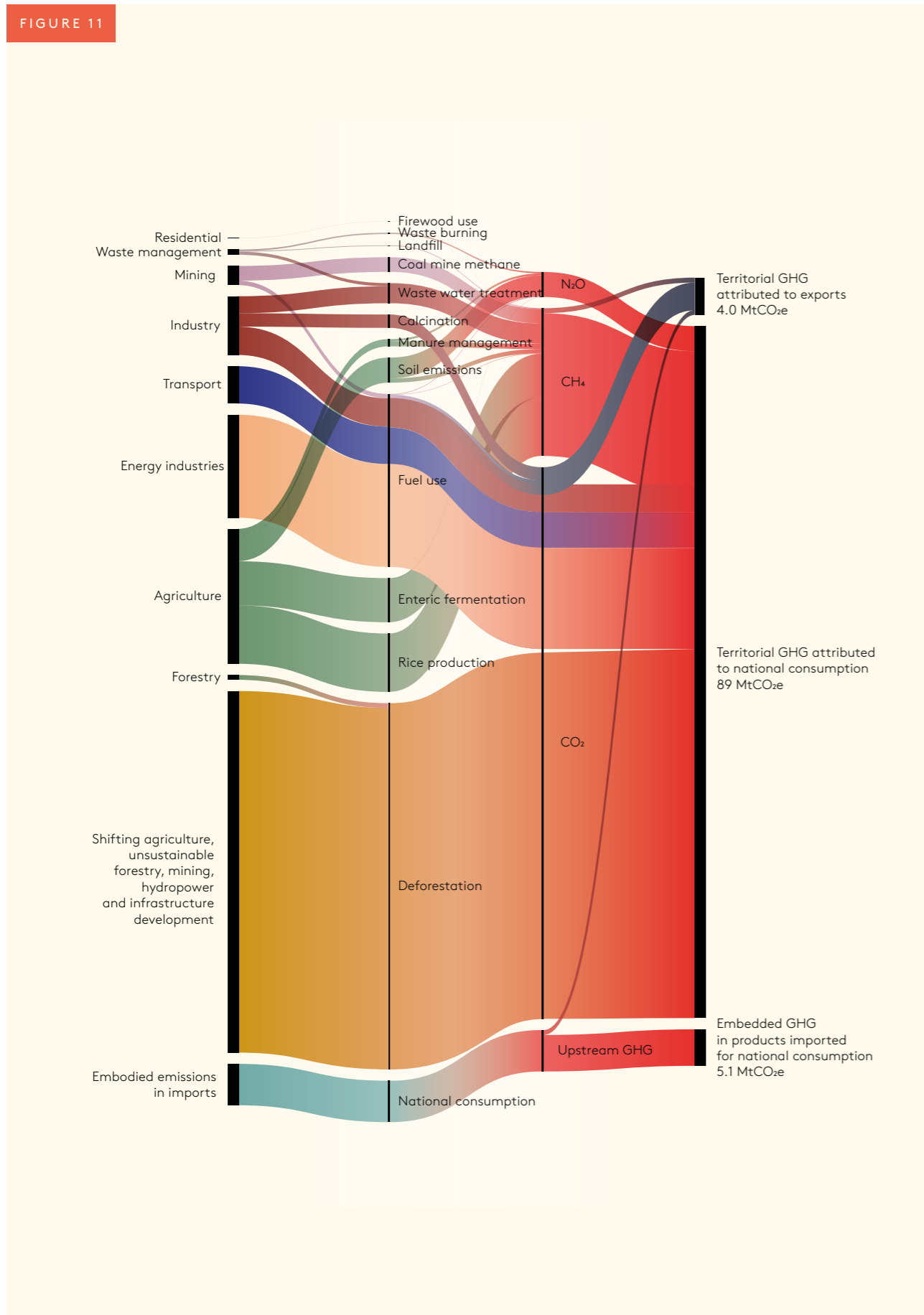


- Organic residues from regenerative origin applied on land
- Regenerative firewood
- Regenerative food with nutrient recovery after consumption
- Recycling (< 1%)
- Regenerative materials
- Circular imports
- GHG emissions
- Fossil fuel use
- Resources landfilled or untreated discharge
- Unsustainable food production and/or food without nutrient recovery
- Linear imports

circular
linear

Circular and linear material flows in Lao PDR ⁶¹

FIGURE 11



GHG emissions from Lao PDR and embedded in imported and exported goods and materials⁶⁶

2.6. Territorial GHG emissions for 2019 are estimated at around 89 MtCO₂e

Analysing the carbon footprint of consumption in Lao PDR helps to prioritize interventions that can reduce the country's GHG emissions and the carbon footprint of national consumption. Emissions may come from Lao PDR itself, but may also be embedded in products imported for Laotian consumers. Some emissions are associated with products produced in Lao PDR that serve foreign customers, while some emissions abroad are related to goods and services consumed by customers in Lao PDR. In addition, when carbon-intensive industries move from countries with strict regulations to countries with more lenient environmental regimes, this can hamper global efforts to meet the Paris targets.⁶²

Territorial GHG emissions for 2019 are estimated at around 89 million tCO₂e, or 44 million tCO₂e when excluding emissions from deforestation and forest degradation.⁶³ Forestry emissions are around 50 percent of the country's total. The remaining GHG emissions are primarily carbon dioxide (CO₂) from power production, cement production and the use of fossil transport fuels. Agricultural activities, such as rice production, and emissions from enteric fermentation by livestock generate most of the methane (CH₄) emissions.

The estimated 2019 emissions are higher than the 53 million tCO₂e mentioned in the NDC.⁶⁴ The main reasons are that transport fuel consumption has increased faster than anticipated in the NDC models, which offsets some of the reductions resulting from hydropower implementation. Lao PDR also increased coal-fired power production. The latest data on forestry emissions provide higher estimates than those in the NDC models. Finally, emissions from industrial wastewater treatment in the metabolic analysis are also estimated at above those in the NDC models.⁶⁵

Upstream emissions generated during the production of imported goods and services total 5.1 million tCO₂e. Around 7.7 million tCO₂e of territorial emissions are related to the production of goods and materials that are exported.

Finally, neither the approach to calculating long-term GHG emission scenarios for Lao PDR in this project nor the estimates from the NDC models followed the latest Guidelines on National Greenhouse Gas

Inventories from the Intergovernmental Panel on Climate Change (IPCC).⁶⁶ Both initiatives focussed on identifying mitigation opportunities, rather than updating the latest GHG emission inventory from Lao PDR. In the metabolic analysis, GHG emissions were estimated by analysing and quantifying material flows and their associated GHG footprints. Since that differs from the approach that the IPCC prescribes, the outline is also likely different.

2.7. Conclusion – Part 2

Consumption in Lao PDR is 27 percent circular, due primarily to the large share of regenerative materials used and management of organic waste. At 16 percent, the circularity of production is considerably lower than the circularity of consumption, as this indicator includes the large material footprint of the mining sector, which is mostly export-oriented.

Most of the materials used are minerals extracted during the mining of metals, followed by the biomass flows associated with the production of wood products and vegetables and, last, by fossil fuels. In 2018, an estimated 4 percent of GDP consisted of resource rents from the extraction of minerals and deforestation. However, this figure does not take into account recent increases in coal extraction and combustion.

The country's carbon footprint is the result primarily of deforestation, the use of fossil fuels for power generation and transport, and methane emissions from manure management and rice production. Some of these emission sources, such as fossil fuel use for power production and coal mine methane, are related to very recent investments in Lao PDR. Fuel use in the transport sector has grown rapidly in recent years, driven by the quadrupling of the vehicle fleet in only nine years.

A significant share of organic residues is applied on land as a soil enhancer, while a large share of minerals is used to build up infrastructure and expand the building stock. However, the IWI indicates that the development of infrastructure and public services lags population growth. As a result, per capita wealth is declining. The World Bank's adjusted net savings measure confirms that Lao PDR is not reinvesting all its resource revenues. This implies that the country is consuming more wealth than it is investing for the longer term.

3 Circular GHG mitigation opportunities

3.1. Readers' guide

Part 1 described the ambitions, trends and developments that will have a material impact on resource use in Lao PDR. Part 2 presented the outcome of an analysis of country-wide resource use, waste production, the quality of natural assets and GHG emissions. Following the findings from Parts 1 and 2, priority has been given to those circular mitigation opportunities that reduce GHG emissions, create jobs, and preserve or strengthen natural assets.

Part 3 examines the life cycle of specific products in detail and suggests 17 circular economy interventions. Eleven of these interventions occur along the value chains of products that expire, those that last and those that flow. The short- and long-run domestic and international GHG mitigation potential for these 'core' interventions is estimated, along with their potential to create green jobs, contribute to growth of the Laotian GDP and avoid waste. To determine the prospective business case for each intervention, we estimate the CAPEX, marginal abatement costs, net present value and payback time.

The remaining six interventions can be considered as 'enabling' as they support the transition to a circular economy in Lao PDR. They are in the service sectors, which have a relatively small material footprint. These interventions have not been identified through

an analysis of material flows and stocks but, rather, through the stakeholder engagement process. They target public services and policies, commercial services with a focus on tourism, and financial services. Given their enabling role, the potential impacts of some of these interventions do overlap with the impacts of other interventions and their business prospect could not be analysed.

Part 3 presents the existing circular economy initiatives in Lao PDR for each of the 17 core or enabling interventions. Existing initiatives provide a solid basis from which to expand or develop new initiatives that rely on similar strategies and enablers. The existing initiatives, as well as the 17 interventions, have all been classified among the main circular economy strategies and enablers with which they are linked (see Box 3).

Although the latter four are referred to as 'enablers' by Circle Economy, in some cases they are crucial elements to reduce the material impact of certain value chains. Transport provides an example. We lack the strategic minerals to electrify our global car fleet, in particular when looking at the limited time which remains to bring global transport emissions in line with a below 2.0 °C pathway.⁶⁸ In addition to increasing the modal share of active and public transport, we need to shift from a mobility system based on private car ownership to a service or vehicle sharing model.

Part 3 examines the life cycle of specific products in detail and suggests 17 circular economy interventions



Box 3 Circular economy strategies and enablers

To define a common language for the circular economy, the non-governmental organization (NGO) Circle Economy mapped the terms and definitions used by over 20 organizations, ranging from NGOs to government agencies, academia and consultancies. Three strategies and four enablers emerge from these terms and definitions:



1. Extend the lifetime

Maintain, repair and upgrade resources in use to maximize their lifetime and give them a second life through take-back strategies, where applicable.



2. Use waste as a resource

Use waste streams as a source of secondary resources and recover waste for reuse and recycling.



3. Prioritize regenerative resources

Ensure that renewable, reusable, non-toxic resources are used efficiently as materials and energy.



4. Rethink the business model:

Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services.



5. Design for the future

Adopt a systemic perspective during the design process to ensure that the proper materials are used for appropriate lifetime and extended future use.



6. Incorporate digital technology

Track and optimize resource use and strengthen connections among supply chain actors through digital, online platforms and technologies.



7. Team up to create joint value

Work together throughout the supply chain, internally within organizations and with the public sector to increase transparency and create shared value.

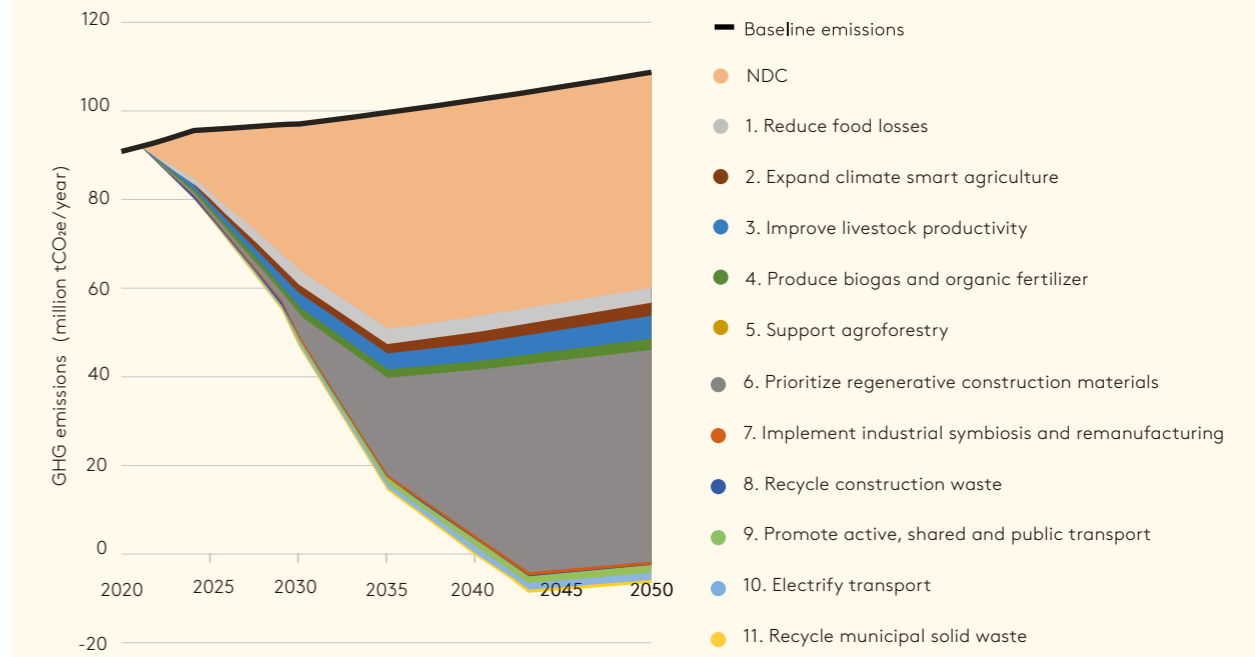


8. Strengthen and advance knowledge

Develop research, structure knowledge, encourage innovation networks and disseminate accurate, verified findings.⁶⁸

29

FIGURE 12



GHG emission reduction potential of the circular economy interventions, in addition to the NDC, 2020-2050

3.2. The 17 interventions and their environmental and socio-economic impact in Lao PDR

Of the eleven core interventions, those with the greatest global GHG mitigation impact include using wood-based construction materials to substitute for carbon-intensive construction materials within Lao PDR and abroad (Intervention 6), followed by reducing food losses (Intervention 1). The territorial GHG mitigation potential of the next five interventions all have a similar level of impact: expanding climate smart agriculture (2); improving livestock productivity (3); producing biogas from industrial organic waste (4); promoting shared, public and active mobility (9); and electrifying transport (10).

Seven of the eleven circular GHG mitigation opportunities identified are in the food or forestry value chains, representing 89 percent of domestic circular mitigation potential. When implemented, these interventions would reduce national solid waste volumes by 5.2 million tonnes.

The interventions that offer the greatest potential to reduce solid waste involve efforts to reduce food losses (1) and the recycling of municipal and solid waste (11). In terms of contributing to green or circular GDP, prioritizing wood-based construction materials (6) offers the greatest potential based on its combined domestic and export potential. Reducing food waste (1) and implementing industrial symbiosis and remanufacturing trail the others (Figure 13).

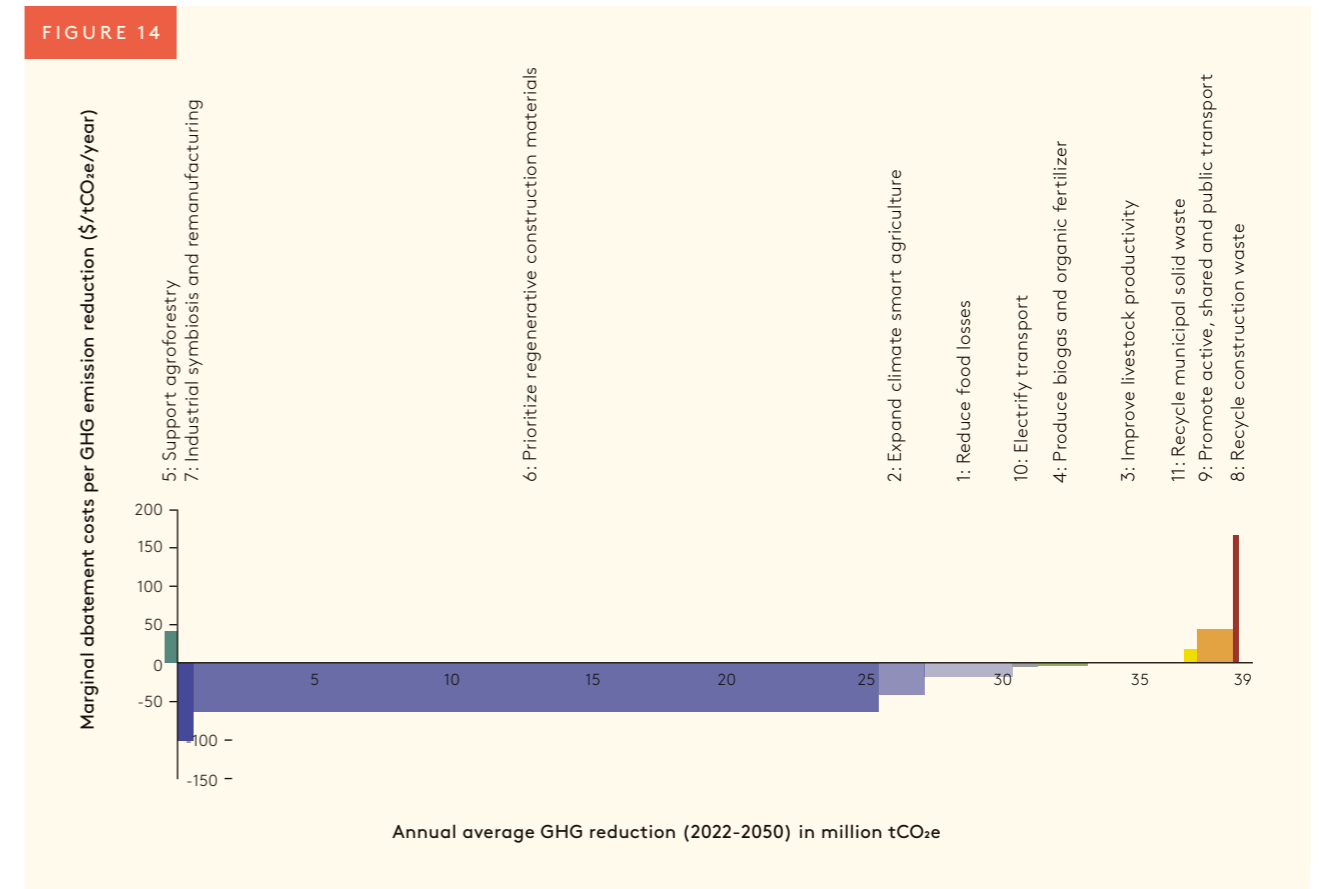
3.3. Reductions in foreign GHG emissions associated with carbon-intensive imported products

In addition to reducing territorial emissions, the interventions in Lao PDR also reduce emissions when the country imports fewer carbon-intensive materials. This foreign or upstream mitigation potential is projected to average around 2.2 million tCO₂e/year during the period 2030-2050. It is based on reduced fossil fuel imports due to interventions in transport; reduced imports when substituting LPG with domestic biogas and imported fertilizers with

FIGURE 13

Intervention	Domestic			International
	GHG mitigation (tCO ₂ e/year)			
	2030	2040	2050	
Products that expire				
1 Reduce food losses	3.5	3.7	3.9	
2 Expand climate smart agriculture	2.0	2.1	2.2	
3 Improve livestock productivity	3.0	4.0	5.4	
4 Produce biogas and organic fertilizer	1.8	2.1	2.6	0.51
5 Support agroforestry	-0.60	-0.63	-0.67	0.58
Products that last				
6 Prioritize regenerative construction materials	5.5	38	48	
7 Implement industrial symbiosis ...	0.62	0.67	0.72	0.18
8 Recycle construction waste	0.093	0.10	0.11	
Products that flow				
9 Promote active, shared and public transport	0.72	1.7	1.8	0.44
10 Electrify transport	0.66	1.5	1.6	0.35
11 Recycle municipal solid waste	0.46	0.50	0.54	0.14
Total/average	17.7	53.8	66.3	2.2
Public services: the policy framework				
12 Strengthen circular procurement	0.14	0.14	0.15	0
13 Align the tax regime	4.8	5.1	5.3	1.0
14 Develop a circular economy roadmap	n/a	n/a	n/a	0
15 Educate on the circular economy	0.055	0.058	0.061	0
Commercial services: tourism				
16 Promote ecotourism	0.75	0.79	0.83	0
Financial services				
17 Mobilise finance	75.9	79.8	83.9	0

FIGURE 14



Marginal abatement cost curve with the estimated economic and climate impacts of eleven circular interventions related to products that last, flow and expire

organic fertilizers from anaerobic digesters; and reduced import of recyclable materials and car parts due to remanufacturing and recycling activities in Lao PDR.

3.4. The business prospect of the eleven core interventions

The business potential of the eleven core interventions in products that expire, flow and last has been examined under current policy conditions in Lao PDR. This provides insight into whether the interventions represent a viable business case or whether further financial incentives or policies are required.

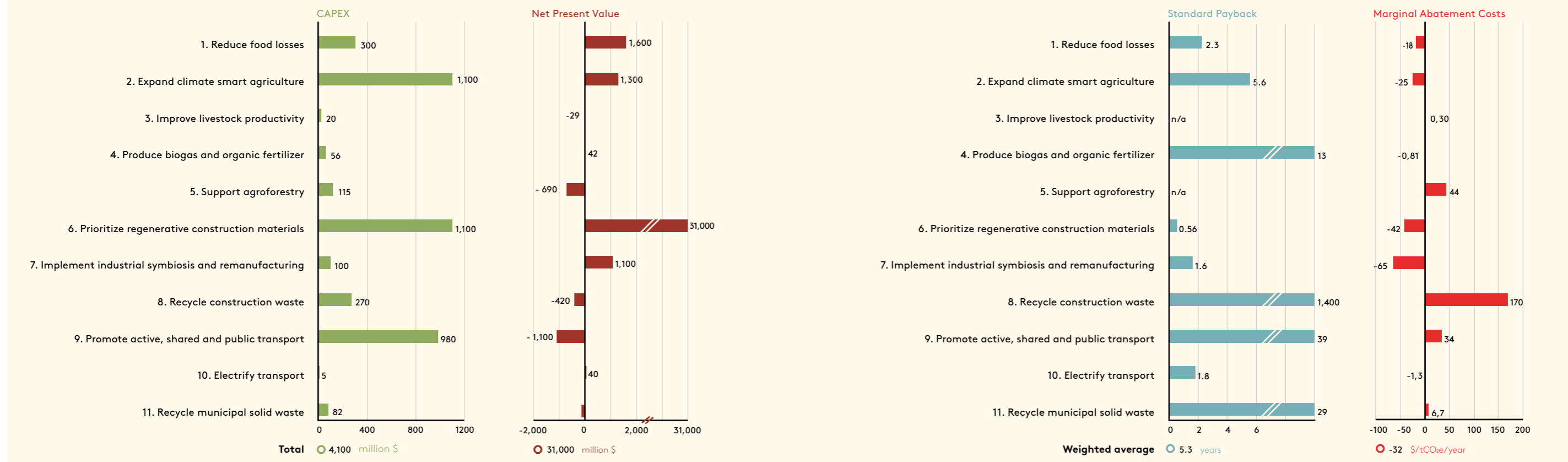
Combining the GHG reduction potential with the business case, each intervention can be plotted on a marginal abatement costs curve. The curve shows the economic value of an intervention compared to its GHG reduction potential. If the

curve is positive, a financial incentive is needed to achieve a net GHG reduction. If it is negative, an intervention has both a positive climate impact and a positive business case for every tonne of CO₂e reduced.

The marginal abatement costs curve combines the GHG mitigation potential with the marginal abatement costs (Figure 13). It shows that the cost of abating more than 59 million tCO₂e/year in 2050 from circular economy interventions is negative. In other words, these interventions create value for each tonne of GHG emissions avoided or sequestered. This is the case for six interventions.

The remainder require government support or other financial incentives. The remaining interventions can reduce GHG emissions but require financial incentives if they are to be economically viable. This can be done with policies that take into account negative externalities of linear value chains. Introducing a carbon price offers an example.

FIGURE 15



The business prospect of the eleven circular GHG mitigation interventions

In the marginal abatement costs curve, a carbon price would effectively move the x-axis upwards, increasing the number of interventions that are financially attractive and do not require additional financial support.

Intervention 5 – on agricultural commodities from agroforestry – presents an exception. This intervention has a negative net present value but the returns involve improving the livelihood of rural communities. It is proposed here because it creates non-monetary returns, although it increases, rather than avoids, GHG emissions. Other interventions also offer a weak business case but are still viable options. Take, for example, the promotion of active, shared and public transport. This investment could be compared to a baseline of investments in other transport modalities, such as roads for private vehicles, and could be funded by redirecting existing funds, rather than allocating new ones. Redirecting funds and implementing this intervention would create many co-benefits related to health, safety, the efficient use of infrastructure and space in urban centres, air quality, and the overall liveability of cities and villages. However,

these returns are not quantified monetarily and, therefore, are not factored into Figure 13.

Capital expenditure – which these eleven interventions require – is highest for climate smart agriculture (Intervention 2), followed by wood-based construction materials (6), the promotion of active, shared and public transport (9) and reducing food losses. The payback for the seven interventions with a positive net present value ranges from several months to 13 years. When considering a payback period of six years feasible, 85 percent of the mitigation potential is commercially viable.

In terms of business impact, Figure 15 also reflects the net present value and the expected payback time of each intervention. Six circular interventions have a positive net present value. This implies that the discounted present value of all future cash flows related to that intervention is positive and the investment is, thus, commercially attractive.

Finally, investors seeking to recover their investment within a short timeframe often use payback time. This focus on mitigating investment risk is often

applied to countries whose risk profile investors consider high. Four out of the eleven interventions have a payback of less than 2.5 years. Together, they represent 82 percent of the circular GHG mitigation potential.



Products that expire

1–5

3.5. Products that expire

Products that expire are those in the food value chains. These are typically products of vegetable or animal origin, with a limited lifetime, and that generate organic residues. Lao PDR's food value chains contribute 16 percent of GDP and provide around 65 percent of employment.⁷⁰

3.6. Material flows

The food value chains represent 30 percent of all material flows in Lao PDR (excluding water and waste rock from mining operations). The detailed overview of products that expire, or food products, shows that most food products consumed in Lao PDR are produced domestically.

The agriculture sector consumes 96 percent of all water, used for irrigation. Post-harvest food losses, shown in the 'Product' column as production and post-harvest waste and processing losses, are significant. However, Figure 15 does not include water flows.

Despite growing volumes of fossil fuel imports and domestic coal extraction, fuelwood remains an important energy source for Lao PDR. Expressed in tonnes, 7.0 million out of 23.6 million tonnes (or 30 percent) of the fuel consumed in Lao PDR is fuelwood. When attributing the GHG emissions from forest degradation and deforestation to agriculture – which is an important driver for deforestation⁷¹ – GHG emissions from food value chains represent 65 percent of territorial emissions (Figure 16).

3.7. Existing circular economy initiatives

Existing circular economy initiatives in Lao PDR's food value chains focus on community-based and organic agriculture. (See list on page 46).

3.8. Circular GHG mitigation opportunities

This section focusses on organic material flows, specifically food and forestry products. A circular agricultural, fishery and forestry sector in Lao PDR would operate within the regenerative capacity of the soils, fishing grounds and forests in keeping with this notion: "It is not the efficiency of subsystems (e.g., crops or livestock production) but the efficiency of the entire food system that matters".⁸²

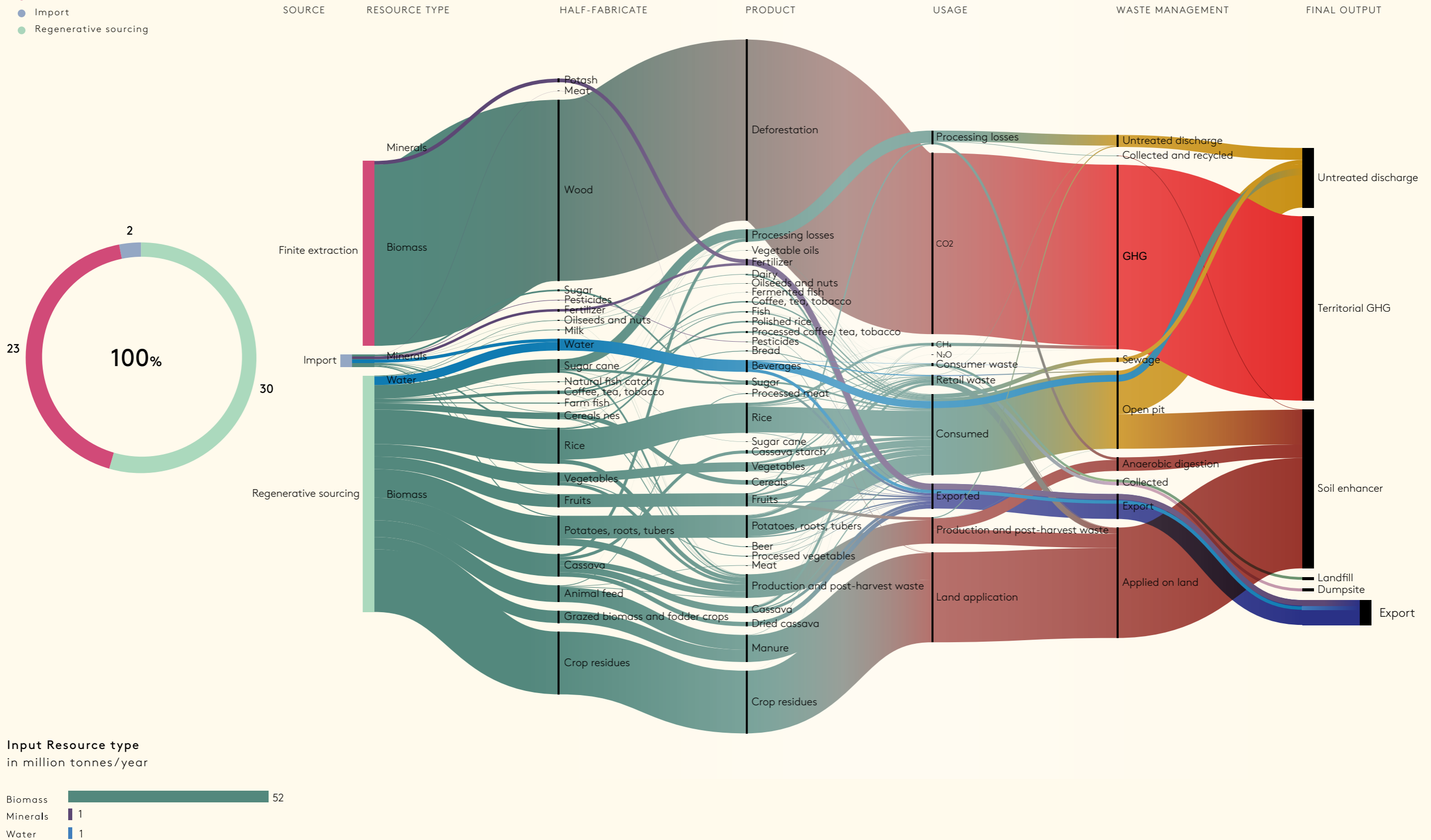
A circular food system is based on three principles:

- Plant biomass is the basic building block of food and should be used by humans first;
- Organic by-products should be cycled back into the food system; and,
- Animals should be used for what they can best provide.

These principles refer to optimizing yields without using synthetic inputs to reduce emissions per unit area. Such systems rely on nutrient inputs from the application of manure, crop residues, or food waste and food losses, which help maintain or, even, increase soil carbon levels. Legume species that fix atmospheric nitrogen through symbiosis with rhizobia bacteria in root nodules can be used to fix nitrogen. This recognizes soil quality as the basis of a productive agricultural system. In addition, animals have a role in recycling biomass that is unsuitable for direct human consumption into the food system.⁸³

FIGURE 16

- Finite extraction
- Import
- Regenerative sourcing



Material flows of products that expire.⁷¹



Laos Buffalo Dairy

Addressing malnutrition by farming buffalo

Laos Buffalo Dairy is a socially responsible, sustainable business. Through the production and sale of cheese and ice cream, it provides farmers with additional income and animal husbandry skills and improves children's nutrition.⁷³



Clinsect

Converting organic waste into fertilizer and animal feed using soldier flies

Clinsect processes close to 60,000 tonnes of organic waste from the beer, beverage and cassava industries. Soldier flies are used to convert the waste into fertilizers and protein-rich animal feed.⁷⁴



Dakdae

Producing organic food products

DakDae is a social enterprise led by women. It provides a market platform, branding and product development services for high quality, local food products from Lao PDR. Their principle of a Happy Earth prompted the organization to use organic production methods.⁷⁵ Along with other companies, such as Dam Dam and AgroAsie Lao, Dakdae⁷⁶ has set up refill stations in Vientiane for sustainably produced cleaning products.⁷⁷



World Vision International

Implementing a community programme on agriculture, nutrition and sanitation

Improved production of home-grown crops, combined with the sale of excess vegetables and investments in sanitation and hygiene, helps reduce malnutrition and improve community health.⁷⁸



World Food Programme

Establishing climate smart villages

Drawing on a CGIAR guidebook (formerly the Consultative Group for International Agricultural Research), the World Food Programme is supporting the establishment of five climate smart villages in Phongsali province, Lao PDR.⁷⁹

Organic Home Delivery

Pre-ordering food to reduce food waste and losses

The business initiative, Organic Home Delivery, allows customers to pre-order organic products through an app or website. Food waste can be reduced by producing only what has been ordered and using a grow-to-order model. Organic Home Delivery was created with support from the Ministry of Agriculture and Forestry and the Japan International Cooperation Agency (JICA). Other producers have adopted the concept.⁸⁰ In addition, an IT company in Lao PDR recently developed a grow-to-order app for a large-scale vegetable producer to reduce the need for cold storage and reduce food losses.



Green Earth Centre

Developing community-based organic agriculture initiatives

The Green Earth Centre is in Lao Ngam District, Salavan Province. It operates a demonstration farm and offers training in organic agriculture. To raise revenue, the Centre organizes tours for tourists.⁸¹

The Lao Planted Forest Products Group

Carrying out an industry initiative on sustainable forestry operations

The Lao Planted Forest Products Group (LPPF) is an industry working group that includes tree plantation companies, wood fibre processors, development partners and research institutions. Its stated aim is to develop an environmentally sustainable and commercially viable tree plantation and wood industry sector that will contribute to Lao PDR's socio-economic development.

3.9. Intervention 1: Reduce losses and waste in food value chains



Strategy description

Estimates suggest that uneaten food contributes 8 percent to global GHG emissions.⁸⁴ Avoiding food waste and loss⁸⁵ is thus the mitigation opportunity with the greatest potential impact.⁸⁶ In Southeast Asia, roughly 26 percent of all food produced is lost or wasted. Food losses during handling and storage are among the highest in the world.⁸⁷

Reducing food losses can avoid GHG emissions associated with the production of food products that are not consumed, but are lost in the food value chain. In addition, reducing these losses can help improve food security, for example, by reducing transport distances and supplying food residues to nearby communities. Despite Lao PDR's economic growth, an estimated 23 percent of the population suffers from undernourishment.⁸⁸ Food security is an issue mainly for the rural population, causing underweight and child development issues such as stunting. Climate change-induced natural disasters are expected to aggravate food security issues.⁸⁹

International examples

Cassava represents approximately 13 percent of crop production in Lao PDR, making it the single largest crop produced per year,⁹⁰ valued at \$225 million.⁹¹ Cassava value chains tend to incur relatively high transport losses and the crop can perish within 48 hours after harvesting.⁹² Research on cassava value chains in Guyana indicates that investments that reduce losses and waste throughout the value chains offer attractive returns.⁹³

Bangladesh's fruit value chain for mangoes presents another successful example of efforts to reduce food waste and losses. Farmers there adopted a modified harvesting tool to reduce mechanical damage and latex staining, removing latex from the fruit with a hot water bath. This reduced losses from 38 percent to 18 percent along the full value chain, reducing losses by close to 50 percent.

Other case studies in South Asian countries show that some have reduced food loss by discarding damaged harvest that is prone to rot and can contaminate other harvest. Other successful strategies have included using optimal closed, yet breathable, transport and storage containment to

minimize external contamination and keep pests out.⁹⁴ Low-cost investments in crates, storage and handling have reduced losses by 60 percent in papaya value chains in Lao PDR, 85 percent in Cambodian tomato value chains, and 48 percent in banana value chains in Vietnam.⁹⁵

Several start-ups within the ASEAN region are providing solutions to food waste management. For example, Lumitics is a Singapore-based start-up that developed AI food waste tracking technologies to help kitchens and restaurants track their food waste and increase sustainability.⁹⁶ Garda Pangan is an Indonesia-based start-up that helps redistribute excess food from restaurants and events to the needy.⁹⁷

Policy framework

The Lao PDR Agriculture Development Strategy⁹⁸ aims to achieve clean, safe, environmentally friendly agriculture production that follows sanitary guidelines. However, the strategy only focuses on food production and does not specify any strategies to reduce food loss, such as minimizing food loss through supply chain management. Although reducing food losses can contribute to reducing GHG emissions and food security and offers an attractive business prospect, it is not part of the national green growth strategy.⁹⁹

Business case

According to Project Drawdown, food waste reductions of around 50 percent are realistic.¹⁰⁰ For the business case and impact estimates, it is assumed that 40 percent of food currently lost or wasted can be saved and sold to consumers in Lao PDR. When applying local market prices¹⁰¹ to this volume, the additional private sector revenues total \$1.5 billion/year.

The initial investment required for adequate storage, harvesting crates, dryers and pressing units and improved transport, for example, totals an estimated CAPEX of \$300 million. Investing in these types of equipment to save additional food products that can be sold is profitable: with operating costs of \$1.4 billion/year, operating profits of \$130 million/year can be earned. Thus, the initial investment can be earned back within a little over two years.

These figures may seem 'too good to be true', but are confirmed by research on the business case for food waste reduction. A World Resources Institute study estimated for 17 countries that every dollar invested in reducing food waste and losses yielded \$14 in savings.¹⁰² Research on cassava in Guyana which is



\$1.5 billion

The value of food waste and losses which can be avoided is \$1.5 billion per year

also a common crop in Lao PDR – also confirms that relatively basic investments can yield significant results. Investment in harvesting tools yielded \$194 in additional revenue for a 10-acre plot and investments in crates during harvesting yielded \$233 in additional revenue for a 5-acre plot.¹⁰³

Next steps

The government should consider developing and implementing a food waste reduction strategy based on the Singapore model. In addition, it could consider ways to further promote recent private sector innovations, such as the recent development of apps in Lao PDR, to help minimize waste from agricultural production. Lao PDR can also learn from recent innovations that address food waste in Singapore and Indonesia.

Other interventions that can help reduce food losses include:

- minimizing distances from harvest to processing or sale sites;¹⁰⁴
- investing in initiatives to improve the crop's pest and disease resistance, such as the cassava clean stem multiplication facility;¹⁰⁵
- adopting improved harvesting techniques;
- providing adequate storage to limit exposure to moisture, heat and pest infestation with hermetic

bags or metal silos or use stackable crates to reduce pressure;

- using mobile processing units, solar dryers, graters and pressers, where applicable;
- setting up contractual and aggregation points to help bring products to market and warehouse receipts systems to reduce losses during storage; and,
- improving transport conditions and cold storage capacity.¹⁰⁶

Impact

Organic waste makes up 64 percent of municipal solid waste in Lao PDR.¹⁰⁷ Estimates indicate that around half of this volume – or 670,000 tonnes/year – is food waste.¹⁰⁸ However, when applying the 26 percent estimated food waste and losses (or indicators drawn from literature on material losses during food processing), post-harvest losses are then added to the total volume of organic waste. This increases food losses and waste volumes to around 6.4 million tonnes/year. The GHG emissions generated by food production in Lao PDR thus total 8.3 million tCO₂e per year.¹⁰⁹

The Sustainable Development Goals aim to reduce global food waste by 50 percent by 2030.¹¹⁰ Project Drawdown confirms that this is a realistic goal.¹¹¹

This analysis uses a more conservative goal of 40 percent in estimating the GHG mitigation potential of reducing food waste in Lao PDR. In the long-term strategy model, the intervention is assumed to be implemented gradually starting in 2022, with full implementation by 2030. By 2030, it would reduce GHG emissions by 3.5 million tCO₂e/year.

The GDP potential of this interventions is the value of all food saved, estimated at \$1.5 billion, which could support the creation of 260,000 jobs.¹¹²

Reducing food waste in Lao PDR also reduces landfill methane gas from disposal sites in territorial GHG emissions. These reductions are not considered in the estimated mitigation potential of reducing food waste and losses. Still, it could be substantial. For the updated NDC, 2020 emissions from landfills were estimated at 81,000 tCO₂e/year.¹¹³ This estimate seems conservative as other sources refer to 110,182 tCO₂e/year in emissions for Vientiane alone. The city is home to approximately 13 percent of the Laotian population.

Sectors where the interventions occur

Domestic	Agriculture, transport, food processing industries, retail, consumers
International	n/a

IPCC sectors where the mitigation impact occurs

Domestic	3A Livestock, 3B2 Cropland, 3C Aggregate Sources and Non-CO ₂ Emissions Sources on Land, 4A Solid Waste Disposal
International	n/a

Socio-economic and environmental indicators

GDP potential (million \$)	1,500
Job creation potential (jobs)	260,000
Solid waste avoided (t/year)	2,580,000

Business case

CAPEX (million \$)	300
Net present value (million \$ over 2022-2050)	1,600
Standard payback (years)	2.3
Marginal abatement costs (\$/tonne CO ₂ e per year)	-18

GHG mitigation potential (MtCO₂e/year)

2030	3.5
2040	3.7
2050	3.9

3.10. Intervention 2: Combine climate smart agriculture with organic certification



Strategy description

The agriculture sector in Lao PDR is responsible for 22 percent of national emissions. Rice cultivation is the main source, followed by enteric fermentation.¹¹⁴ The updated NDC lists the implementation of adjusted water management as one of the conditional mitigation activities in lowland rice fields,¹¹⁵ but more can be done to reduce emissions from food production.

The sector is vulnerable to extreme weather events, notably flooding and drought. The immediate impacts on vulnerable households require immediate food security interventions and these extreme events are likely aggravated by continuing climate change.¹¹⁶ In addition, changing agricultural practices – which focus on cash crops, monocropping and reduced fallow periods – aggravate soil degradation and erosion, reduce soil nutrients, and decrease soil organic matter.¹¹⁷

Climate smart agriculture¹¹⁸ offers a combination of measures that reduce GHG emissions, while also increasing the resilience of agricultural production to the impacts of climate change. This is achieved, typically, through a combination of measures involving soil and nutrient management, water harvesting and use, biodiversity management, pest and disease control, and the use of quality seeds and planting materials of well-adapted crops and varieties. Agronomic research can help identify which crops and varieties are most suitable in a specific location.

Lao PDR uses relatively little fertilizer and pesticide. For some crop types, average fertilizer application is 100 times less than that in countries such as Taiwan or Japan.¹¹⁹ This provides a good basis for certifying products that meet the organic production requirement, creating added value. However, the fertilizer use figures need to be put in the proper context. Experts consulted on fertilizer use at the provincial level report fertilizer volumes of 0.8 tonne per hectare (ha). They also state that government statistics do not account for all fertilizer trade. In addition, the use of pesticides and chemicals that are hazardous to human and animal health and to the environment are a national concern.¹²⁰

Climate smart agriculture can include breeding new crop varieties. Lao PDR has experience with breeding rice crop species suited to the Laotian context, both in terms of agricultural conditions and consumer demand for certain commodity characteristics. Similar programmes in other countries were less successful because they prioritized yield over quality.¹²¹

International examples

Climate smart agriculture can increase yields. Rice intensification trials involving some 15,000 farmers in the Lower Mekong Basin showed a 52 percent increase in rice yields. Financial returns for the farmers increased 70 percent, while GHG emissions fell by 14 to 17 percent.¹²²

Uganda was an early adopter of certification schemes and labels for organic production systems. As a result, its revenues from certified organic exports increased from \$3.7 million in 2003/4 to \$22.8 million in 2007/8. The scheme also reduced GHG emissions and chemical runoff into surface water.^{123 124}

Policy framework

Developing agriculture in Lao PDR is part of an effort to create jobs and income-generating activities in rural areas, decrease social inequality, and minimize the risks and vulnerability of rural communities to natural disasters and global economic uncertainties. Reducing monocropping and promoting integrated production, crop rotation and other ways to preserve soil quality are a national priority. The adverse social and environmental impacts of granting large concessions for agricultural development has prompted the government to suspend this programme in the past and put legal sufficient safeguards in place.¹²⁵

Currently, the 2016 Law on Investment Promotion provides tax and access-to-finance incentives that involve clean agricultural production and environmentally friendly agricultural processing.¹²⁶ Article 35 of the 2019 Decree on Climate Change covers the rights and responsibilities of the Ministry of Agriculture and Forestry related to climate smart agriculture, including R&D on resilient plant and animal breeds, promotion of technology and best practice production techniques and agrometeorology stations.¹²⁷

The Decision on Proposal on Voluntary Land Degradation Neutrality (LDN) Target Setting in Lao PDR for the 2020 to 2030 period is a voluntary effort



52%

Rice intensification trials showed a 52 percent increase in rice yields

that received international assistance. It aims to improve regeneration in terms of food and nutrients, forest, and land.¹²⁸ Finally, the objectives of the Agriculture Land Management and Development Strategy (ALMDS) to 2020-2025 and Vision to the year 2030 (2020) are to use technologies to protect land production capacity, prevent land erosion, develop agricultural ecosystems, and conserve biodiversity and green agriculture projects.¹²⁹

Business case

Climate smart agriculture can increase yields. A 45 percent yield increase for rice was assumed for the business case. This is still less than what other sources quote as realistic.¹³⁰ Half of the additional yields are assumed to be sold in Lao PDR and the other half to be exported. This ratio defined how to apply local market prices¹³¹ and export prices¹³² to calculate additional private sector revenues. The result is a \$1.0 billion annual revenue increase from the sale of agricultural commodities.

The initial investment required in certification programmes, quality planting materials and farmer education totals \$1.1 billion. Combined with annual

operational costs of \$800 million, this generates an estimated annual operating profit of \$200 million with a payback period of close to six years.

This estimate does not quantify the value of improving the climate resilience of agricultural production. Even without that, the literature confirms that climate smart agriculture is commercially viable. Research in Malawi shows that soil management increased gross margins by 47 percent and nutrient management by 61 percent.¹³³ The FAO also confirms profitability across a series of case studies.¹³⁴

Next steps

Lao PDR has already developed comprehensive legislation and strategies to promote clean, safe, environmentally friendly agricultural production. Products that have obtained the Good Agricultural Practices (GAP) Standards for Food Safety will receive a label from the Ministry of Agriculture and Forestry. Next steps could include the following:

- Improve efforts to promote the GAP label to encourage more producers to adopt the GAP Standards;
- Refer to the ASEAN Guidelines on Soil and

Nutrient Management¹³⁵ to develop soil nutrient management plans;

- Reactivate the Lao PDR agriculture and forestry working groups so that they can do more to promote best practice agriculture and forestry;
- Continue to raise awareness among Lao farmers about the Lao Climate Service for Agriculture (LaCSA) and use it to develop a 'real time' publicly available cropping calendar;
- Develop pilot projects and provide extension services that support low-carbon agricultural practices such as zero tillage and the use of cover crops;
- Make climate smart agriculture a key theme for ongoing discussion within the existing agriculture and forestry working groups;
- Consider aligning relevant legislation or standards (e.g., GAP Standards) with guidance in the ASEAN Regional Guidelines for Promoting Climate Smart Agriculture;¹³⁶
- Continue to promote uptake of the GAP Standards among producers and consumers;
- Continue research and development on climate-resilient crop varieties and agricultural practices in the Lao context; and,
- Support regional cooperation within ASEAN on research and development, capacity building, and training in climate smart agriculture.

The specific climate smart agriculture measures taken should be part of a strategy to improve climate resilience, reduce GHG emissions and increase yields. The following recommendations focus on the main crops only: rice, cassava, sugar cane and vegetables. Together, they make up 70 percent of agricultural production in Lao PDR. Although they have been implemented at limited scale, current good practices in Lao PDR include systems of rice intensification, integrated crop management and diversification, the adoption of stress-tolerant varieties, intercropping, and improved post-harvest handling and seed production.¹³⁷

The priority measures include:

- Accelerating the implementation of adjusted water management in rice cultivation, which reduces methane emissions;¹³⁸
- Breeding and disseminating rice and maize varieties with a higher tolerance for drought and submersion that are suitable for three ecosystems (upland, irrigated lowland and rainfed lowland); and,¹³⁹
- Provide extension services that support low-carbon agricultural practices such as zero

tillage and the use of cover crops.¹⁴⁰

The successful adoption of climate smart agriculture requires participatory on-farm and off-farm actions. Simply proposing technical solutions is not sufficient.¹⁴¹ Interventions typically start with extension services, including training farmers in climate smart agriculture. When this is adopted, Lao PDR will be able to rely less on imported chemicals to fertilize its soils and control pests. That could create an opportunity for broader organic certification, which could increase the added value of agricultural commodities. Clean and organic agricultural production is one of the objectives of the national green growth strategy.¹⁴²

Impact

Climate smart agriculture can increase rice yields by up to 45 percent (some sources even cite increases of up to 60 percent¹⁴³), while reducing GHG emission by at least 14 percent.¹⁴⁴ Applied to the 780,000 hectares of paddy rice in Lao PDR, rice production could increase by around 1.8 million tonnes and GHG emissions could fall by 1.0 million tCO₂e. With a farm gate value of around \$1.0 billion,¹⁴⁵ the increased yield could support 170,000 new agriculture jobs.

The GHG mitigation estimates assume that the additional rice production will add production, rather than replace rice production elsewhere. Since rice is less responsive to organic fertilizer,¹⁴⁶ this assessment assumes that the use of mineral fertilizers will continue.

Climate smart agriculture can also increase soil carbon content. The soil organic carbon sequestration estimate across Lao PDR is based, conservatively, on 0.8 tonne CO₂e per hectare. This assumes the adoption of reduced tillage practices only.¹⁴⁷ They have been applied to 1.2 million hectares that are monocropped annually with maize, vegetables, rice, sugar cane and cassava. This adds another 900,000 tonnes of CO₂e/year of sequestration potential. The combined mitigation potential of climate smart agriculture totals 2.0 million tCO₂e in 2030. Assuming the intervention is implemented in 2022 and develops in line with the trend in rice and other crops, the mitigation impact begins in 2022, is fully implemented in 2030 and will avoid 2.2 million tCO₂e in 2050.

Sectors where the interventions occur

Domestic	Agriculture
International	n/a

IPCC sectors where the mitigation impact occurs

Domestic	3B2 Cropland, 3C7 Rice Cultivations
International	n/a

Socio-economic and environmental indicators

GDP potential (million \$)	1,000
Job creation potential (jobs)	170,000
Solid waste avoided (t/year)	0

Business case

CAPEX (million \$)	1,100
Net present value (million \$ over 2022-2050)	1,300
Standard payback (years)	5.6
Marginal abatement costs (\$/tonne CO ₂ e per year)	-25

GHG mitigation potential (MtCO₂e/year)

2030	2.0
2040	2.1
2050	2.2

3.11. Intervention 3: Improve livestock productivity



Strategy description

Methane emissions from enteric fermentation and manure management make up 9 percent of Lao PDR's territorial GHG emissions. The sources of these emissions include buffalo and cattle (around 55 percent), pigs (30 percent) and chicken (11 percent).¹⁴⁸ The number of pigs, cattle and goats in the Laotian livestock sector is growing rapidly.¹⁴⁹

Beef is the most resource-intensive of all protein sources¹⁵⁰ and has a relatively high GHG footprint, due to its associated methane emissions. Globally, adopting a plant-rich diet is third most effective way to reduce GHG emissions, after the renewable electricity solutions of onshore wind turbines and utility-scale solar photovoltaics.¹⁵¹

However, livestock are particularly important in the northern provinces, which have higher poverty rates and where the mountainous terrain makes the land less suitable for crops.¹⁵² Livestock also play an important role in a circular food system,¹⁵³ for example, by converting residual flows or crops unsuitable for human consumption, consuming grass and herbs from pastures in areas unsuitable for growing food, and providing manure to enhance soil quality. The latter is particularly important in Laotian rice fields.¹⁵⁴

Livestock are also an important source of income for smallholder farmers. According to the World Bank, livestock supports the livelihoods and food and nutrition security of almost 1.3 billion people globally, while helping to preserve biodiversity and sequester carbon in soils.¹⁵⁵

The updated NDC¹⁵⁶ does not address measures to reduce methane emissions from livestock, but according to the World Bank¹⁵⁷ and FAO,¹⁵⁸ additional productivity improvements through improved forage quality, grazing management and improved animal health offer significant mitigation potential.

International examples

The World Bank supported the adoption of climate smart livestock practices among more than 23,000 household-based Vietnamese livestock farmers. This helped them reduce their environmental impact through livestock waste management, disease

control and the provision of veterinary services.¹⁵⁹ A similar programme in Uruguay focussed on improving grazing areas, animal waste management in watersheds and carbon sequestration in grasslands.¹⁶⁰

The Livestock Development and Animal Health Project in western Zambia, where the livestock sector contributes around 39 percent of rural income, offers another example. Diseases such as foot and mouth disease pose an immediate threat to income from cattle breeding. After strengthening veterinary services and setting up vaccination centres, an estimated 253,000 farmers benefited from reduced occurrence of diseases.¹⁶¹ In Kenya, introducing more resilient livestock varieties, improved manure management and agroforestry under the climate smart villages initiative improved food security and resilience of the livestock sector.¹⁶²

Policy framework

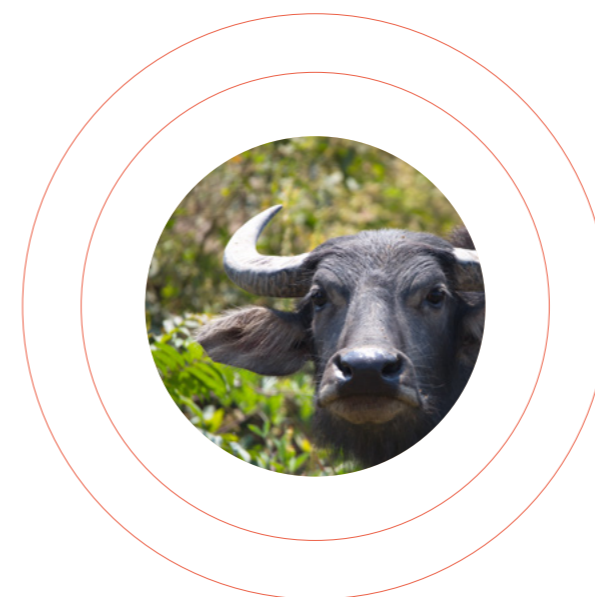
The 9th NSEDP sets targets for expansion of livestock herds of 3 percent to 4 percent/year.¹⁶³ The Law on Agriculture also promotes livestock production, prescribing guidance measures and activities to support agricultural investment, the availability of land and animal feed, vaccines, farmer training and collection of agricultural data.¹⁶⁴ The Law on Livestock Production and Veterinary Matters sets out measures to promote improved livestock production and animal health to ensure quality and productivity in the commercialization of animal products.¹⁶⁵

In addition, the Lao PDR Agriculture Development Strategy promotes the development and improvement of livestock productivity through activities such as surveying areas suitable for large scale livestock production, establishing a buffalo development centre and improving the existing cattle development centre, and providing free animal vaccinations and treatment in areas with high risks of disease outbreak, mountainous areas, poor and vulnerable areas, and remote areas.¹⁶⁶

The National Growth and Poverty Eradication Strategy recognizes the importance of livestock to poverty reduction, particularly in upland and sloping land areas,¹⁶⁷ while the NDC describes livestock vaccinations as a key climate change adaptation measure in the agriculture sector.¹⁶⁸

Business case

This intervention aims at increasing efficiency in meat and dairy production, rather than increasing



9%

Methane emissions from enteric fermentation and manure management make up 9 percent of Lao PDR's territorial GHG emissions

volumes produced. As a result, it reduces costs, rather than increasing sales volumes or raising additional revenues for the private sector. Costs savings could result from, for example, the amount of fodder used due to smaller herd sizes; this would be possible when losses to diseases are reduced. This could lead to cost savings of around \$81 million/year.

Total CAPEX of \$20 million in investments in vaccination centres and training for livestock farmers is anticipated, while additional operational costs could reach \$640 million to support veterinary services. Although accurate data is lacking to estimate the operational costs and cost savings from this intervention, the economics do not appear to be attractive and would require subsidies or other incentives. With a negative net present value, the business case is weak. However, on the other hand, the mitigation potential of this intervention can be realized at a cost of only \$30/tCO_{2e}. Recent studies from Costa Rica¹⁶⁹ and Italy¹⁷⁰ confirm the conclusion that improving livestock productivity requires policy support to offset financial and technical challenges.

Next steps

Steps towards achieving a more circular meat value chain could include:

- Improving forage quality: processing crop residues and providing good quality green fodder from multipurpose leguminous plants improves digestibility. Urea treatment can further improve the digestibility and nutritional value of crop residues, such as straws;
- Improving animal health, husbandry and breeding improvements: preventive health measures such as vaccination, improved veterinary services, the provision of shade and water (perhaps through agroforestry, circular mitigation intervention 1), and breeding strategies help to reduce mortality and increase fertility; and,
- Improving grazing management to optimize soil carbon sequestration: the impact of increased mobility and a better balance between grazing and resting can have a positive impact on productivity and the accumulation of soil carbon.¹⁷¹

Achieving this will require training smallholder farmers to support productivity increases¹⁷² through, for example, enhanced feeding,¹⁷³ improved animal health and welfare through disease prevention and veterinary services,¹⁷⁴ and improved pasture management and rotational grazing.

The government could consider establishing a formal collaboration with ASEAN partners in line with the Strategic Plan of Action for Cooperation on Livestock.¹⁷⁵ Furthermore, the Good Agricultural Practices Standards should be expanded to include livestock production and consider the GHG impacts of meat and dairy production compared to the nutritional and health guidance on minimum animal product intake.

Impact

GHG mitigation potentials exist in South Asian dairy (38 percent) and Southeast Asian pig farming (32 percent).¹⁷⁶ Applying these potentials to the Laotian livestock sector generates a GHG mitigation potential of 3.0 million tCO_{2e}/year for 2030. This assumes that this intervention will have been implemented in the period 2022-2030. Since meat and dairy-related products are expected to grow relatively quickly, the GHG mitigation impact of this intervention would likely increase significantly, too, reaching 5.4 million tCO_{2e} in 2050.

Increased GDP and job potential are small because this intervention focuses primarily on reducing losses, allowing production levels to be maintained with smaller herds.

Sectors where the interventions occur	
Domestic	Agriculture
International	n/a
IPCC sectors where the mitigation impact occurs	
Domestic	3A1 Enteric Fermentation, 3A2 Manure Management
International	n/a
Socio-economic and environmental indicators	
GDP potential (million \$)	0.78
Job creation potential (jobs)	150
Solid waste avoided (t/year)	0
Business case	
CAPEX (million \$)	20
Net present value (million \$ over 2022-2050)	-29
Standard payback (years)	n/a
Marginal abatement costs (\$/tonne CO _{2e} per year)	0.3
GHG mitigation potential (MtCO _{2e} /year)	
2030	3.0
2040	4.0
2050	5.4

3.12. Intervention 4: Small-scale and industrial scale biogas and organic fertilizer production



Strategy description

Wastewater treatment in open ponds at food processing industries in Lao PDR emits an estimated 79,000 tonnes of methane/year, with a total calorific value of around 4,000 gigajoules (GJ). Around 60 percent of these emissions are from cassava starch production. When cassava wastewater and pulp are treated in an anaerobic digester, for example, with an anaerobic sludge blanket (UASB) reactor,¹⁷⁷ the methane can be captured and used to substitute for fossil fuel. Anaerobic digestion yields the highest bio-energy production of wastewater treatment options.¹⁷⁸ Biogas is an attractive energy source in the remote locations where the cassava is processed and the reactors require much less space than open lagoons. The digestate can be used as fertilizer¹⁷⁹ or, even, as higher value-added products such as biofuels and organic acids.¹⁸⁰

Another source of feedstock for an anaerobic digester could be the organic fraction of municipal waste.¹⁸¹ An estimated 64 percent of municipal solid waste in Lao PDR is organic waste. Most of the country's solid waste is dumped in informal dumpsites or burned.¹⁸² The solution could be decentralized, based on biogas home systems,¹⁸³ or centralized, whereby the feedstock is collected and digested in a larger industrial installation. Home-based systems can provide cooking fuel and garden fertilizer. Industrial systems can provide fertilizer for agriculture and clean biogas in tanks for use by households, SMEs, industries and, even, vehicles.

When organic waste is separated from other municipal solid waste, landfill volumes will decrease, along with the production of landfill gas, a potent GHG. Furthermore, the anaerobic digester will produce biogas close to a city, providing an attractive alternative for bottled liquefied petroleum gas (LPG). LPG use is increasing in Laotian cities¹⁸⁴ as a cleaner alternative to charcoal. However, LPG is expensive because it is imported. When purified and compressed in tanks, biogas can provide a domestic alternative to LPG for use by households, SMEs and vehicles.

In 2010, Lao PDR used around 14,400 tonnes/year of chemical fertilizer, based on average use of

9.1 kg per hectare/year. Thailand uses an average of 158 kg/hectare/year and Vietnam uses 293 kg; fertilizer application in Lao PDR was far below that of neighbouring countries¹⁸⁵ and below the recommended volume.¹⁸⁶ Even if actual fertilizer application has increased significantly since 2010, or if all imports are not registered, yields could be increased using locally produced biofertilizer.

The government of Lao PDR supports building bio-fertilizer factories in the country.¹⁸⁷ Application of these products has yielded good results in field studies.¹⁸⁸ However, anaerobic digesters can produce both biogas and fertilizers, which makes the business case more attractive.¹⁸⁹

Lao PDR already has over 7,600 hectares of agricultural land under organic production.¹⁹⁰ The supply of organic fertilizer from decentralized anaerobic digesters could reduce the use of imported chemical fertilizers and allow the area under organic cultivation to be expanded. For some crops, such as rice, nutrient availability and the diversity of crop types used are favourable for maintaining and certifying the organic production conditions.¹⁹¹ To improve fertilizer quality, manure can be co-digested with the cassava pulp¹⁹² or other plant-based feedstocks.

International examples

There are many examples of successful biogas projects and programmes in Southeast Asia and, specifically, Lao PDR. The development organization SNV has run a biogas programme on small-scale digesters¹⁹³ and the Lao brewery has installed an anaerobic digester.¹⁹⁴ In nearby Thailand, the Thai San Miguel Liquor distillery uses biogas from industrial scale digesters to produce electricity.¹⁹⁵ Thailand has also covered lagoons as a low-cost solution to methane emissions from wastewater treatment by palm oil industries. There, too, the biogas can be used for power production.¹⁹⁶

Vietnam offers a very relevant example: a facility there that produces around 50 tonnes of cassava starch/day installed a digester to treat its 71,000 m³/year of wastewater. The project avoids approximately 30,000 tCO_{2e} of emissions/year, while the biogas is used for drying and to heat the anaerobic reactor.¹⁹⁷

Policy framework

The Decree on Energy Promotion and Development Fund facilitates mobilization of funding from both domestic and international sources by providing low-interest loans for projects incorporating new

technologies, innovative business models, and research and development in the energy sector.^{198 199}

Lao PDR's 2011 Renewable Energy Development Strategy aims to scale up biogas production and increase the number of households using biogas to 50,000 by 2025.²⁰⁰ More generally, certain categories of businesses, including renewable energy, are entitled to financial incentives²⁰¹ and companies using green technology benefit from a lower tax rate on profits (7 percent).²⁰²

Business case

The business case for biogas production has been analysed for industrial wastewater treatment. Using municipal or industrial solid organic waste to produce biogas is financially less attractive. Biogas can be produced from wastewater treatment in two ways: from covered lagoons and in tank digesters. In the business case analysis, both technologies are applied on a 50/50 basis.

Private sector revenues from biogas production are estimated at \$38 million/year, based on information from a methane recovery project in Lao PDR, with the biogas sold at the same price as LPG,²⁰³ while correcting for difference in the calorific value.

Private sector capital expenditure is estimated at \$56 million/year²⁰⁴ and operational expenditures at \$29 million/year,²⁰⁵ producing an operational loss of \$8.3 million/year, for a net present value of \$42 million. The payback period is 13 years, which is relatively long.

International examples show that positive business cases do, indeed, exist. In Thailand, cassava industries are estimated to produce 21 million m³ of wastewater, while cassava pulp production is estimated to produce 9.5 million. The business case for an anaerobic tank digester for both pulp and wastewater, using the gas for heat and power generation, is attractive. At a discount rate of 10 percent, and an investment of \$8.7 million, the net present value is \$6 million with a payback period of just over 4 years.²⁰⁶

Furthermore, with this investment, the starch factory would use 68 percent less land than would otherwise be required for lagoons. On-site production of biogas and power saves on electricity purchases.²⁰⁷ A detailed case study of small- and larger- scale biogas in Vietnam found that the technology was already viable in 2010, with internal rates of return (IRRs) reaching 50 percent.²⁰⁸ It is

also a more efficient source of energy than the production of energy crops.²⁰⁹

Finally, composting sites near or at markets in Vientiane are financially viable when transport distances are minimized. This is possible when composting yards are located at or near markets.²¹⁰

Next steps

The use of anaerobic digesters at an industrial scale can be encouraged if:

- The government collaborates with banks and development partners to develop low-cost finance options for biogas technologies to increase the viability of project development;
- The Ministry of Agriculture and Forestry develops guidelines on the production of compost from municipal solid waste to facilitate removal of the current restriction on use for agriculture and other applications, such as biogas production; and,
- The enforcement of water treatment and wastewater discharge requirements can strengthen the business case for proper wastewater treatment facilities.

At the household and small enterprise scale, the anaerobic processing of organic waste and use of biogas can be encouraged by:

- Discouraging the use of charcoal as a cooking fuel when biogas is a cleaner alternative; this also eliminates a driver of forest degradation;
- Lowering the investment barrier for biogas systems;
- Increasing the costs of landfilling to encourage the use of organic waste as a feedstock for anaerobic digestion;
- Levying a carbon tax on fuels to discourage the use of LPG for cooking;
- Encouraging source separation at hotels, restaurants and markets;
- Where anaerobic digestion is not possible, disseminating home compost bins or introduce composting yards near markets, as in Sao Paulo²¹¹; and,
- Promoting organic brands and products from Lao PDR and developing a widely-accepted organic standard.²¹²

Impact

The GHG mitigation potential under this impact estimate is based on avoiding methane emissions from wastewater treatment, avoiding landfill gas emissions and reducing LPG use. Eighty-four percent of the mitigation potential stems from reducing



79,000 tonnes/year

Wastewater treatment in open ponds at food processing industries in Lao PDR emits an estimated 79,000 tonnes of methane per year

methane emissions from wastewater treatment. Biogas production from industrial food processing is estimated at around 3,300 GJ/year, representing 1.6 million tCO₂e when the biogas is emitted. This is only a fraction of the theoretical biogas potential in Lao PDR. For example, processing all 2019 agricultural residues in an anaerobic digester would generate energy potential of 198,000 GJ/year.²¹³

To estimate the climate impact, only methane emissions from wastewater treatment at food processing industries are considered. Estimates indicate that anaerobic treatment of wastewater can reduce GHG emissions by 77 percent.²¹⁴ Avoiding the emission of 77 percent of biogas would reduce GHG emissions from Lao DPR by 2.6 million tonnes of CO₂e/year in 2050. This estimate considers economic growth, but not the mitigation potential of crowding out fossil fuel use when biogas is used as an alternative energy source or when additional feedstock is sourced for the digesters to increase their ability to produce biogas and fertilizer.

Urban organic waste can also be used as feedstock for anaerobic digesters, thus avoiding gas emissions from landfilling organic residues. For 2020, total landfill gas emissions from Lao PDR were estimated at 81,000 tonne CO₂e.²¹⁵ The impact of urban organic

waste composting could not be accurately quantified because the first-order decay model that provided the basis for the estimate of 81,000 tCO₂e of landfill gas could not be retrieved. The impact estimate below was based on the assumption that diverting organic waste from landfills could reduce landfill gas emissions by 50 percent, or 41,000 tonnes of CO₂e.

Finally, biogas from digesters can be used as an energy source, reducing the need for charcoal, which creates health issues due to indoor air pollution, and LPG. Taking household fossil fuel use as a proxy, households use an estimated 4,600 tonnes of LPG/year.²¹⁶ Assuming that biogas can replace 50 percent of that amount brings the GHG mitigation potential to 7,500 tonnes of CO₂e.

The international GHG mitigation potential considers reduced reliance on imported synthetic fertilizers and LPG, which reduces foreign GHG emissions by 0.51 million tonnes CO₂e. The \$40 million of potential GDP from this intervention is based on investment and the value of the biogas produced. It does not consider changes in added value from replacing imported synthetic fertilizers with an organic alternative.. The job potential is 6,900.

Sectors where the interventions occur

Domestic Waste management
International n/a

IPCC sectors where the mitigation impact occurs

Domestic 1A Fuel Combustion Activities, 2B Chemical Industry, 4A Solid Waste Disposal
 4D Wastewater Treatment and Discharge
International 1B2 Oil and Natural Gas

Socio-economic and environmental indicators

GDP potential (million \$) 40
 Job creation potential (jobs) 6,900
 Solid waste avoided (t/year) 610,000

Business case

CAPEX (million \$) 56
 Net present value (million \$ over 2022-2050) 42
 Standard payback (years) 13
 Marginal abatement costs (\$/tonne CO_{2e} per year) -0.8

GHG mitigation potential (MtCO_{2e}/year)

2030 1.8
 2040 2.1
 2050 2.6

International GHG mitigation potential (MtCO_{2e}/year)

2030 0.51
 2040 0.62
 2050 0.75

3.13. Intervention 5: Promote agroforestry to support rural livelihoods



Strategy description

The combined production of crops and timber production can support the supply of sustainable construction materials and offer a more profitable alternative to swidden agriculture. Combinations of forestry and livestock can also be considered, but since the livestock sector in Lao PDR is relatively small, the focus here is on combined production of crops and timber, which could include the use of perennials, such as fruit trees.

Forest cover in Lao PDR was around 41.5 percent in 2020.²¹⁷ The government aims to increase this to 70 percent,²¹⁸ or 16.58 million hectares, by 2030.²¹⁹ The policies underpinning that target include preventing deforestation, land conversions and illegal logging, on the one hand and on the other, investing in protected areas by community, preserving biodiversity,²²⁰ undertaking afforestation and reforestation, pursuing agroforestry, and promoting forest products and their efficient application.²²¹ Optimizing biodiversity is important in both reforestation and silvopasture.²²² Lao PDR is of global interest in terms of biodiversity because the country is one of the most biodiverse regions in the world.²²³

Soil erosion rates in parts of Lao PDR reach 40 tonne per hectare/year.²²⁴ Silvopasture can reduce this to one tonne/hectare/year,²²⁵ thus preserving soil quality for future generations and reducing the need to fertilize the soil.

Forest clearance in Lao PDR is associated strongly with elevation, distance to main roads and shifting cultivation practices. Increase in forest cover correlates with the establishment of rubber plantations, although at the expense of native forest, and shifting cultivation lands.

Agroforestry provides a more diverse set of food products than the monocropping that dominates large plantation and shifting cultivation. It also supports higher revenues for farms and reduces the vulnerability of agricultural production to climate change.²²⁶ Around 67 percent of Lao PDR's population currently depends on forests for its livelihood and more than 39 percent of rural family income is derived from non-timber forest products.²²⁷

International examples

Nearby Vietnam offers interesting examples of agroforestry applications. There, the Australian Centre for International Agricultural Research is promoting market-based silvopasture options, which have increased farmers' income while reducing soil erosion.²²⁸

Farmers in Cam My, in central Vietnam, use 'forest gardens' to sustain livelihoods and protect crops against variable weather conditions. Since some of the gardens were established on land designated as state-owned forest, policies had to be adjusted to support these silvopasture activities, while ensuring that services provided by the forests were not affected.

Large-scale monocultural maize farming on steep slopes aggravated soil erosion in northwest Vietnam. Together with landslides, this led to a loss of soil fertility and declining yields. Trials with silvopasture systems showed that these production systems provided both environmental and socio-economic benefits. Recognizing that success, local governments replicated the trials on 50 hectares at three locations.²²⁹ Studies in the same region showed that agroforestry increased revenues/hectare 2.4- to 3.5-fold, controlled surface runoff and erosion, increased soil fertility, and improved resilience to extreme weather.²³⁰

Policy framework

Rural development and poverty reduction is one of the pillars of the National Green Growth Strategy. Rural populations have barely benefitted from the economic growth of recent years. The government aims to improve rural education, promote the production of traditional goods and provide microfinance to facilitate rural development.²³¹ This intervention supports that objective.

Government forestry revenues declined in 2018 due to illegal logging and a failure to properly levy or collect forestry royalties and fees. As a result, logging and timber export bans were tightened.²³²

The Law on Forestry specifies that local communities shall participate in forest management, officially recognizes village forests in state-managed forests, and creates a village forest management planning system that includes commercial logging in village forests.²³³

Tree plantation developers historically struggled to find enough land to support their investment



40 tonne/ha/year

Soil erosion rates in parts of Lao PDR reach 40 tonne per hectare per year

objectives of establishing a processing industry. A 2019 decree addresses this, promoting concessions for investors who turn degraded land into 'Production Forest Areas'.²³⁴

Business case

Agroforestry generates both forestry and agricultural products, including crops, fodder and room for grazing. The presence of trees can increase crop yields by improving the physical environment, reducing wind speed and soil evaporation, and increasing humidity. The returns for farming households can thus be greater when adopting agroforestry systems rather than swidden cultivation with monocropping.²³⁵ This supports the argument that agroforestry systems can support farmers, while eliminating a key driver of deforestation. In addition, agroforestry systems are more resilient to climate change than monocropping²³⁶ and can help counter declines in agricultural production in the uplands of Lao PDR.²³⁷

To prevent double counting of forestry revenues under this intervention and those from Intervention 6 (prioritize and produce industrial wood-based construction materials), this intervention does not take account of revenues from wood-based

construction materials; only those from increased crop yields are considered. It is assumed that this additional crop production is consumed in Lao PDR and addresses undernourishment. To estimate the value of the additional agricultural commodities, local market prices²³⁸ are applied. This yields total private sector revenues of almost \$260 million/year.

Agroforestry requires an initial investment in educating farmers and preparing the land and it does not yield returns in the first few years.²³⁹ In Lao PDR, the initial investments in an agroforestry system are, at \$575/hectare, lower than the trees with livestock combination (at \$795/hectare).²⁴⁰ This investment value is divided over both Interventions 1 and 6, based on their respective revenues. Since the majority of revenues come from timber products, 1.3 percent of the initial investment of \$575 – or \$7/hectare – are attributed to this intervention, for a total CAPEX for this intervention of \$115 million, including investments in educating workers and machinery.

Crop production within an agroforestry system is not a profitable option. Operational costs are estimated at \$290 million/year, for an operational loss of approximately \$34 million/year. This generates

a net present value of -\$690 million. Since the intervention increases, rather than decreases, emissions, marginal abatement costs do not apply.

Next steps

Next steps should build on existing efforts of the Government of Lao PDR to develop a green forest economy that provides forest-dependent communities with wood and other forest products, while protecting watersheds and soils and protecting against climate risks.²⁴¹

1. Make promotion of 'best practice' agriculture and forestry processes and procedures the key objective of the existing agriculture and forestry working groups, with the support of leading companies that are already complying with international standards to facilitate export market access.
2. Consider making agroforestry models that use partnerships between tree plantation companies and local villagers a permanent agenda item in the existing forestry and agricultural development working groups.
3. Consider incentives such as access to land or tax incentives for companies that employ agroforestry models with ample community engagement as part of their forestry operations.
4. Implement the NDC.

The FAO already provides agroforestry extension services to communities and promotes the development and marketing of agroforestry products. To finance agroforestry incentives, carbon incentives can be coupled with agroforestry products to create additional value. Food forests can help optimize and diversify food production on small plots of land and could be implemented on smallholder farms and, perhaps, even in peri-urban settings.²⁴²

Impact

The 70 percent forest cover target would require reforesting around 2.85 million hectares.²⁴³ To put this figure into perspective, the total area of degraded or understocked forest land in Lao PDR is around 11.2 million hectares.²⁴⁴

Some sources calculate that agroforestry systems in Lao PDR can produce 1.76 tonnes of crops and fruit/hectare,²⁴⁵ but according to industry stakeholders, wood yields would be too low to be commercially viable. They clarify that intercropping at annual crop yields of 1.0 to 1.5 tonne/hectare

are realistic only in the first year of a seven-year rotation. In the second year, canopy cover and shade already shift the combined use of the plantations from crop production to grazing.

When the full area targeted for reforestation is placed under an agroforestry system, added crop production would total approximately 445,000 tonnes/year. With an estimated value of \$260 million, this additional agricultural production could support 44,000 agriculture jobs at an average annual salary \$4,253²⁴⁶ and sectoral employment elasticity of 0.2.²⁴⁷ This estimate is conservative since elasticity is relatively low and annual income high, but agroforestry operations can provide a living to many subsistence farmers. In addition, when using the estimated agroforestry revenues from Project Drawdown, the added value would be twice as high.²⁴⁸

The expanded agricultural activity under agroforestry would create additional territorial GHG emissions, estimated to reach 0.6 million tCO₂e/year by 2030. This estimate considers the growth of agricultural production, a theoretical potential of 445,000 tonnes in the reference year 2019, and related agricultural emissions of 1.3 tCO₂e/tonne product.²⁴⁹ In the long-term strategy model, the intervention is assumed to be fully implemented by the year 2030, with gradual implementation starting in 2022.

Sectors where the interventions occur

Domestic Forestry, agriculture
International n/a

IPCC sectors where the mitigation impact occurs

Domestic 3B1 Forest Land, 3A Livestock, 3B2 Cropland, 3C Aggregate Sources and Non-CO₂ Emissions Sources on Land
International 3A Livestock, 3B2 Cropland, 3C Aggregate Sources and Non-CO₂ Emissions Sources on Land

Socio-economic and environmental indicators

GDP potential (million \$)	260
Job creation potential (jobs)	44,000
Solid waste avoided (t/year)	0

Business case

CAPEX (million \$)	115
Net present value (million \$ over 2022-2050)	-690
Standard payback (years)	n/a
Marginal abatement costs (\$/tonne CO ₂ e per year)	n/a

GHG mitigation potential (MtCO₂e/year)

2030	-0.60
2040	-0.63
2050	-0.67

International GHG mitigation potential (MtCO₂e/year)

2030	0.58
2040	0.58
2050	0.58

Products that last

6-8



3.14. Products that last

'Products that last' refer mainly to the materials used in the construction sector, where houses and infrastructure are built to last for decades. The term includes material use for expanding the vehicle fleet and installing capital equipment. Vehicles and technical means of production tend to last more than a year. As such, they can be counted towards Lao PDR's long-term produced stock, serving current and future generations alike. The construction sector contributes 13 percent of GDP and provides 2 percent of jobs.

The Government of Lao PDR is investing in rails, roads, power generation and transmission infrastructure, and water purification and distribution networks. This is part of an effort to expand transport infrastructure while expanding hydropower capacity and improving access to clean water and sanitation. These investments will continue to demand large volumes of construction materials in the years to come.

3.15. Material flows

The total materials used in construction is estimated to be 29 million tonnes/year. Around 8 percent of these materials used in Lao PDR – primarily metal construction elements – are imported. Twelve percent of construction materials produced in Lao PDR are exported to foreign markets.²⁵⁰ By using 7 percent of wood-based construction materials in the construction sector, it contributes to the country's circularity, but only for material flows where the extraction of timber does not contribute to forest loss or degradation. The annual use of 124,000 tonnes of fly ash as a clinker substitute in the cement industry also contributes to reducing the construction sector's carbon and material footprint.

3.16. Current circular economy initiatives

The construction sector supports several inspiring initiatives that promote sustainable construction, relying on a combination of technical solutions at scale in industries and traditional knowledge of building design and tapping into locally available materials. (See list page 67).

3.17. Circular GHG mitigation opportunities

In a circular construction sector, regenerative and secondary resources receive priority over construction materials with a high carbon footprint. Lao PDR could prioritize wood-based construction, remanufacture vehicle parts and use clinker substitutes in cement production, while adjusting building design to minimize embodied emissions and energy use during the use phase. Circular public procurement by the Laotian government, development partners and investment banks can help drive the transition to a circular construction sector by creating demand for regenerative construction materials, efficient design and design for disassembly with wider re-use and recycling of construction materials.



Burapha Agro-Forestry Co., L

Agroforestry to provide farmers with food and cash income

Burapha uses agroforestry, combining crops or pasture with trees. This provides a landscape with diverse vegetation and allows farmers to increase their income by 3 to 3.5 times, while also investing in village infrastructure through the company's Village Development Fund. Burapha is able to sequester 84 tonnes of CO₂/hectare.²⁵²



Stora Enso

Free, prior and informed consent as basis for agroforestry development

Stora Enso adopted an agroforestry model that mixes eucalyptus plantations with rice production. Yields are only slightly lower than those from conventional plantations, but they allow communities to retain food production. In addition, placing land under permanent cultivation also helps reduce slash-and-burn or shifting cultivation.²⁵³



PML Easbeam

Wood-based construction materials

PML Easbeam runs a sawmill near Vientiane where it produces wood-based construction materials. The company cascades products from laminated structural materials to panels and particle boards. The sawdust is combusted in a boiler to supply heat to the sawmill.²⁵⁴



VALTIP 3

Developing a modern and sustainable wood processing industry

VALTIP3 is the third project in a long-running joint research programme to develop a modern sustainable wood processing industry in Lao PDR to support commercial tree plantation development. VALTIP3 has already supported the establishment of a veneer processing and products research centre at the National University of Laos. It has also helped to

create a local company, PML Easbeam, that aims to develop a manufacturing facility for engineered wood products that meet the requirements of the Engineered Wood Products Association of Australasia.



Hongsa coal-fired power plant

Fly ash to reduce the carbon footprint of cement

Fly ash from coal-fired power plants can substitute for clinker in cement production. Although coal-fired power production increases the grid emission factor, the use of fly ash reduces GHG emissions from cement production. Cement kilns in Lao PDR used an estimated 124,000 tonnes of fly ash²⁵⁵ from the Hongsa coal-fired power plant in 2019.²⁵⁶

Other companies

The use of UXO for reinforcement bars

An estimated 16,000 tonnes per year of scrap metal are extracted from remnants of war in Lao PDR, including unexploded ordnance. This activity is supported by the disclosure of remote areas with infrastructure development. However, extraction is very risky and if proper safety measures are not taken, it should not be encouraged as a recycling activity.²⁵⁷



Tom Atelier Architect and Design

Ecodesign

Tom Atelier Architect and Design is a local firm that provides modern architecture/interior and exterior design services. The company has been using renewable materials, including rattan and bamboo, for building design. Café Buratino and Dough & Co. are examples of its buildings.²⁵⁸



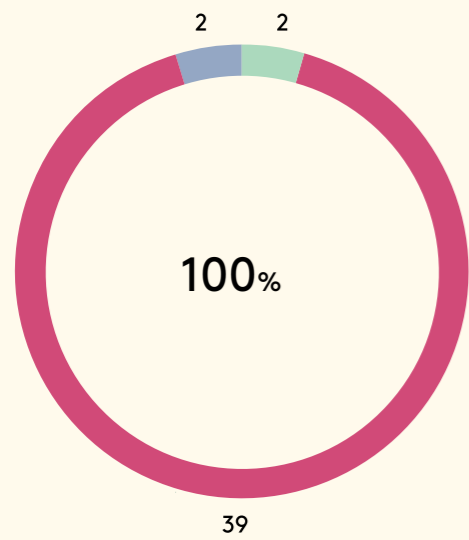
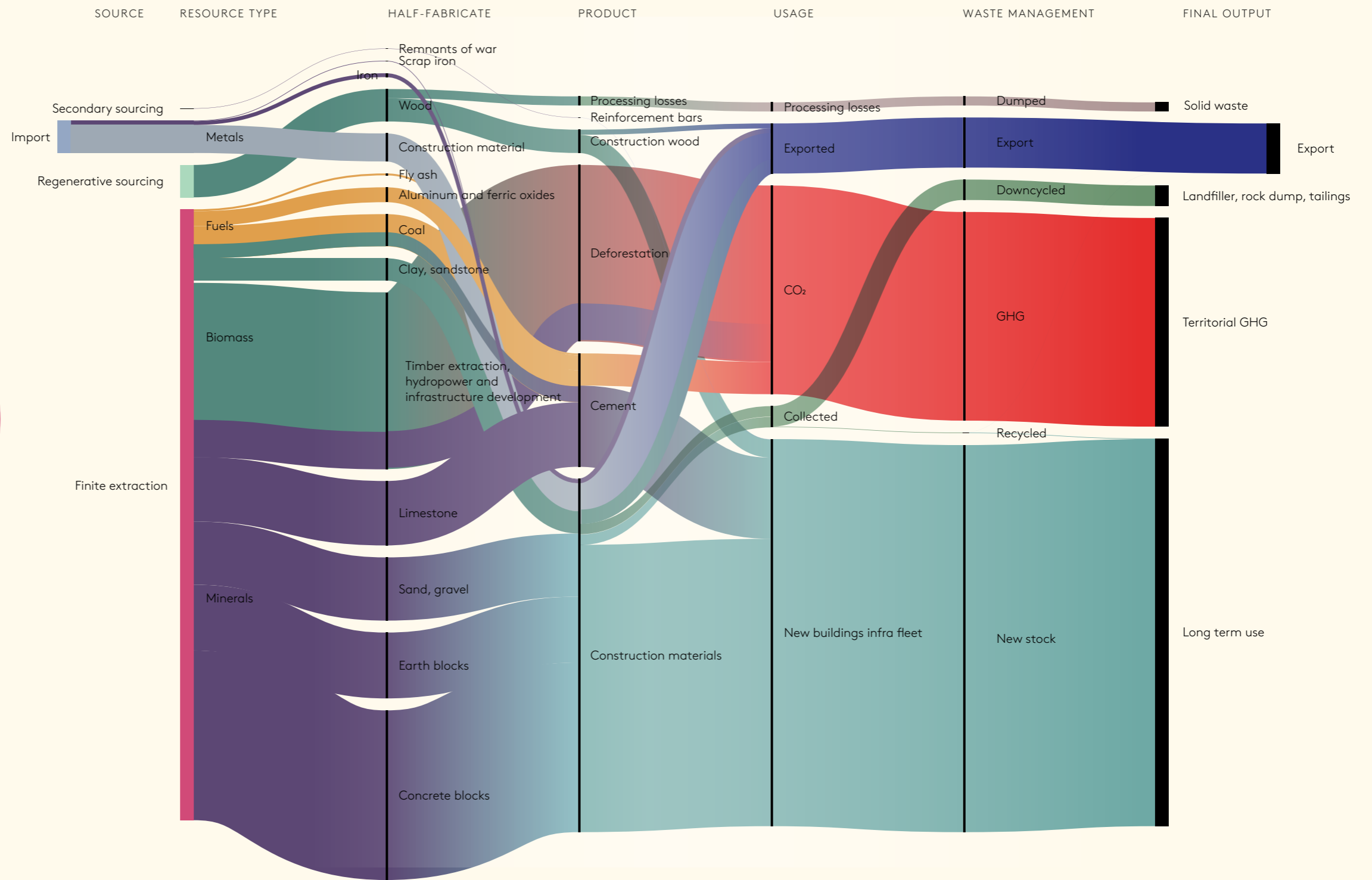
Envirotexture

Passive building design

Envirotexture is rebuilding village schools in Salavan Province in southern Laos. The schools are designed to be autonomous, so they incorporate passive design principles such as daylighting and cross ventilation. Villagers and volunteers source local and traditional construction materials.²⁵⁹

FIGURE 17

- Finite extraction
- Import
- Regenerative sourcing



Material flows of products that last²⁵⁰

3.18. Intervention 6: Produce industrial wood-based construction materials



Strategy description

Buildings can become a net carbon sink rather than a net source when using wood (instead of cement) and steel as the main construction materials. Wooden buildings can provide long-term durable storage of the CO₂ absorbed from the air during the initial growth and post-harvest replanting of the rotation forest. In addition, they avoid the GHG emissions associated with the production of conventional construction materials like steel and cement.²⁶⁰ Wood construction can also improve building liveability, contribute to people's well-being²⁶¹ while supporting national identity through modern architecture and preserving those elements of traditional construction methods that are better adapted to the specific circumstances in Lao PDR.²⁶²

Lao PDR produces 8.5 million tonnes of wood per year. Of that, 1.2 million tonnes are used in the construction and furniture sector. The remainder is used as firewood and in the pulp and paper industry.

Several large plantation owners, which include international corporations, produce wood that is certified by the Forest Stewardship Council (FSC). They do not use pristine, natural forests but some operators do contribute to deforestation. Sustainably produced wood and proper enforcement of standards on sustainable forest management are an absolute prerequisite for large-scale wood production under this intervention.

To achieve the 70 percent forest cover target, an additional 2.85 million hectares will be reforested in Lao PDR,²⁶³ although the definition of forest cover under this national target is not clear.²⁶⁴ With this acreage under an agroforestry scheme, it could support communities with food products, while providing cash revenue from the sale of wood products. The wood products could support a gradual displacement of carbon-intensive construction materials, such as concrete and steel, with industrial wood-based construction materials. Since the timber production potential exceeds national demand, Laotian wood-based construction materials could also serve foreign construction sectors.

International examples

In Peru, smallholder farmers produce timber through their agroforestry farm systems, supplying local and national markets with construction materials for low-cost housing. These systems encourage sustainable production over simply extracting construction wood from forests.²⁶⁵

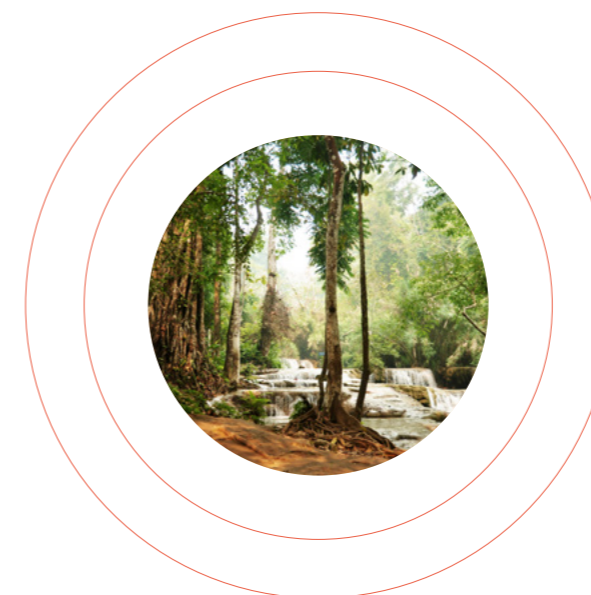
By the end of 2021, the largest wood-based building in Asia will be completed: a 40,000-m² university building in Singapore. The project required 7,000 m³ of cross-laminated timber and the building will have six storeys with 25 classrooms.²⁶⁶ Singapore lifted height limitations for wood-based construction in 2016 and adopted European standards for wooden construction materials.²⁶⁷ Research indicates that regional species, including some fast-growing species, are also suitable for the production of industrial wood-based construction materials such as cross-laminated timber.²⁶⁸ Growing interest from nearby China in wood-based construction has prompted European timber companies to open cross-laminated timber factories in China.²⁶⁹

Policy framework

Seeking to restore forest cover to 70 percent, the government adopted laws that regulate sustainable forest management and the trade of timber and policies to decrease slash-and-burn agriculture and that anticipate enhanced monitoring of existing forest. Investments are encouraged in forestry plantations using rotation methods on degraded and deforested lands to protect watersheds, restore soil quality and provide timber. In addition, the strategy aims to develop 'beautiful and green towns with national unique artistic and cultural value', while promoting the use of environmentally friendly construction materials of domestic origin.²⁷⁰

The Forestry Law stipulates rules for processing timber and forest products,²⁷¹ while the Law on Industrial Processing covers the establishment, operations, and administration of industrial and handicrafts processing activities²⁷² The Decree on Promotion of Commercial Tree Plantations (2019) promotes commercial timber production to ensure a sustainable timber supply for wood processing industries.²⁷³

In addition, a range of decisions by the Ministry of Industry and Commerce address Timber Processing Management (2007); Processing Manufacture Standards (2009); Standard of Wood, Rattan and Bamboo Processing Factories (2007);²⁷⁴ and the Form and Size of Timber Products (2008).²⁷⁵



70%

The 70 percent forest cover target would require reforesting around 2.85 million hectares

Application of wood products in the construction sector is not adequately regulated. The Lao Building Code (2016) focusses on safety, strength and duration of construction materials but does not specify the use of regenerative materials in construction.²⁷⁶ The Law on Construction (2009) does not currently include provisions related to the circular economy.²⁷⁷ Finally, the Decision on Quality Inspection of Construction Engineering in Lao PDR (2020)²⁷⁸ requires construction owners to ensure that correct technical principles are incorporated in their construction, but does not include specific requirements related to wood-based construction materials.

Business case

This intervention is linked to the expansion of agroforestry operations as described in Intervention 5. This one focusses on timber production and Intervention 5 addresses agricultural production. Only revenues from timber extraction are considered here. Because there is a ceiling on the volume of wood-based construction materials that the Laotian construction sector can absorb, 86 percent of timber will be exported. TradeComm Prices for Lao PDR were used to estimate export value. The price of \$260/ square metre of timber was used for the 14 percent of

timber sales for construction materials in Lao PDR.²⁷⁹ The combination of export and local timber sales generates potential private sector revenue of over \$12 billion/year.

Industrial timber production requires an initial investment in agroforestry plantations and sawmilling capacity. The trees only yield returns when they are harvested, typically in around seven years.²⁸⁰ In Lao PDR, the initial investment in agroforestry where trees are combined with crops is, at \$575/ hectare, lower than the combination of trees and livestock (\$795/ hectare).²⁸¹ This investment is divided between both interventions 5 and 6, based on the interventions' respective revenues. As such, 98.7 percent of the initial investment, respectively, of \$575/hectare and \$568/hectare are attributed to these interventions, for a total CAPEX of \$1.1 billion. This CAPEX assumes the export and sale of timber and does include processing into cross-laminated timber. The investment in cross-laminated timber factories – approximately \$1 million for 1,000 m³ production capacity/year²⁸² – may be made either in Lao PDR or abroad.

Timber sales within an agroforestry system are profitable. Operational costs of \$9.9 billion/year

can generate an estimated operational profit of \$1.9 billion/year. Thus, the financial payback period is just a few months. However, in practice, the plantations yield returns in seven years, which increases the payback period to seven years. The investment has a net present value of \$30 billion.

Other sources confirm that the production of certified wood in Lao PDR is already highly profitable for planted forests and natural forest management. Investors reported to the World Bank that IRRs for Lao PDR's forest production models are between 6 percent and 24 percent. This is an internationally competitive range.²⁸³

Next steps

Next steps should be aligned with the efforts to increase the production of non-timber forest products, as described in Intervention 5. The next steps proposed to support wood-based construction materials are as follows:

- Develop the capacity to supply verified legal and sustainable tropical forest products by investing in certified forest management and chain-of-custody across the supply chain, eventually leading to the adoption of a timber legality assurance system (TLAS).
- Invest in efficient log processing and sawmills to meet the requirements of high-end final markets. This also requires a more predictable timber supply from either participatory sustainable forest management or forest plantations.
- Provide extension services for decentralized forest management by villages, or 'village forestry' as it is referred to in Lao PDR.²⁸⁴
- Encourage architects to use domestic resources in their building designs. Showcase building projects with modern designs that use local timber resources to help popularize domestic timber.
- Ensure that the Green Building Code and Building and Energy Code are consistent with the ASEAN Green Building Code. This includes an update to existing Lao PDR legislation relating to wood processing, as well as building and construction, to acknowledge recent developments relating to engineered wood products from Southeast Asia.²⁸⁵
- The government should consider developing legislation, guidelines and standards to promote eco-designs that prioritize the use of regenerative construction materials and passive building design. They could be similar to Thailand's National Science Technology and Innovation Policy.²⁸⁶
- Consider implementing financial incentives like

low-interest loans or tax incentives for the design and construction of buildings with a low material and carbon footprint during construction, use and end-of-life.

Impact

To prevent double counting, this Intervention 6 does not take crop revenues into account. In addition, the sequestration potential of the plantations is included in this intervention. This does not overlap with the NDC because it targets 45 million tCO_{2e}/year in sequestration and avoided emissions by increasing forest cover and reducing deforestation.²⁸⁷ Because stopping deforestation yields around 45 million tCO_{2e}/year in emission reductions,²⁸⁸ that activity is assumed to be part of the NDC. Efforts to increase forest cover to 70 percent are included in this intervention. The business case therefore includes the costs of planting new forests.

The 2.85 million hectares under agroforestry could produce 21.9 million tonnes of wood/year. This is based on an average wood yield of 7.7 tonne wood/hectare, when intercropping only in year 1 of the seven-year rotation.²⁸⁹ This is an average yield, considering that agroforestry yields of 4 to 10 tonnes/hectare are reported.²⁹⁰

Wood-based construction materials are already relatively common for low-rise buildings.²⁹¹ Although wood is also used for heavy and civil engineering applications, they are less common.²⁹² To estimate the size of the market for wood-based construction materials in Lao PDR, we assume that these materials are only applied in buildings.

Australia is one of the few countries that analysed the carbon footprint of its construction sector in detail, seeking to shift to 100 percent cross-laminated timber use in buildings by 2050. It found that the sector's carbon footprint is 18.1 percent of national GHG emissions, of which 41 percent was related to the construction of residential and non-residential buildings.²⁹³ This value has been used as a proxy for the share of construction materials that could be replaced with wood-based construction materials in Lao PDR. This is a reasonable estimate as both countries are experienced a peak in infrastructure investments for the years selected for the estimates.

A comparison of two buildings – one made of reinforced concrete and one of industrial wood products – showed that one tonne of wood-based construction materials can replace around 2.8 tonnes of concrete.²⁹⁴ This estimate recognizes that with

wood-based construction, some concrete is used for the foundation. To be conservative, the weight of the metal reinforcement bars is excluded.

The domestic use of mineral construction materials in Lao PDR is around 24.3 million tonnes/year, of which an estimated 10.1 million tonnes are used for buildings. Around 85 percent of this concrete can be replaced with wood,²⁹⁵ requiring around 3.0 million tonnes of wood-based construction materials. The remaining 19.0 million tonnes/year can be exported, significantly reducing the carbon footprint of foreign construction sectors.

The sequestration impact of wood used in buildings is estimated at 0.36 tonnes of CO₂/tonne of wood.²⁹⁶ The substitution impact of wood used in construction and the substitution of conventional construction materials is estimated at 1.8 tonne of CO₂/tonne of wood.²⁹⁷ These estimates do not distinguish where the mitigation occurs. The assumption is that the mitigation potential is attributed to Lao PDR, as the supplier of the wood-based materials. In practice, the mitigation and sequestration impacts may be subject to negotiations

with the importing country, which should be able to guarantee permanent storage of the CO₂ sequestered in the wood, for example, by using it in buildings. This model does not include the emissions associated with transporting the wood.

At an estimated price of around \$300/m³, the additional timber production in Lao PDR would have a value of around \$12 billion, which could support 960,000 jobs in forestry and wood processing industries.

Bamboo can also be used as a construction material and is compatible with agroforestry approaches.²⁹⁸ Current production volumes already total approximately 200,000 tonnes/year, of which 20 percent is exported. The potential is much greater.²⁹⁹ This option has not yet been considered in the impact estimates.

Sectors where the interventions occur

Domestic	Forestry, Construction
International	Construction

IPCC sectors where the mitigation impact occurs

Domestic	2A1 Cement Production, 2C1 Iron and Steel Production, 3D1 Harvested Wood Products
International	2A1 Cement Production, 2C1 Iron and Steel Production, 3D1 Harvested Wood Products

Socio-economic and environmental indicators

GDP potential (million \$)	12,000
Job creation potential (jobs)	960,000
Solid waste avoided (t/year)	0

Business case

CAPEX (million \$)	1,100
Net present value (million \$ over 2022-2050)	30,000
Standard payback (years)	0.56
Marginal abatement costs (\$/tonne CO _{2e} per year)	-41.6

GHG mitigation potential (MtCO_{2e}/year)

2030	5.5
2040	38
2050	48

3.19. Intervention 7: Industrial symbiosis and remanufacturing



Strategy description

This intervention refers to products that last, targeting industries that supply construction materials and vehicles. Industrial symbiosis is possible in cement production and this section also explores international examples in food processing industries.

The Hongsa coal-fired power plant produces an estimated 540,000 tonnes of fly ash, based on estimated fly ash production of 25 tonnes/tonne CO₂ emitted. This is conservative as the ash content of coal is often around 10 percent.³⁰⁰ Because the fly ash content of cement can reach 30 percent,³⁰¹ the 5 million tonnes of cement produced in Lao PDR can absorb all the fly ash produced. Currently, around 23 percent of Laotian fly ash is used.

In addition to this example of industrial symbiosis, Lao PDR has the potential to remanufacture vehicle parts. The motorcycle industry assembles around 232,000 tonnes of vehicles every year; just under half of that is exported.³⁰² In 2010, eight out of 12 motorcycle assembly lines produced over 100,000

motorcycles/year,³⁰³ but with average annual economic growth rates of around 6.5 percent,³⁰⁴ this value has probably increased significantly since then.³⁰⁵ The added value of motorcycle assembly to the Laotian economy is limited because the production lines rely on imported parts and components. This could change if remanufacturing industries were developed in Lao PDR and idle transport capacity was used for reverse logistics, where vehicles are assembled for the export market.³⁰⁶

International examples

In the United States, 74 percent of replacement parts are remanufactured. In Europe, this totals only 10 percent. In China, repaired and directly re-used parts accounted for 40 percent and remanufactured parts total 1 percent. Legal barriers often obstruct the international trade of car parts, which hampers remanufacturing potential.³⁰⁷

Thailand is promoting the bioeconomy in its cassava and sugarcane industries.³⁰⁸ In Lao PDR, these two products make up 24 percent of total agricultural production.³⁰⁹ For Thailand, the bioeconomy is considered crucial to its graduation to upper-income status by generating more value from its agricultural areas and forests. Thailand is exploring options including producing bio-ethanol from sugarcane processing by-products, such as bagasse and molasses. The country realized that to explore the

full potential of sugarcane, it would have to revise old laws restricting sugar cane processing to sugar production.³¹⁰

Thailand already hosts seven bioplastics producers, while producing high-value biochemical products like sorbitol and oleochemicals³¹¹ and promoting the implementation of biorefineries.³¹² In Thailand, the Dutch company Corbion operates the world's largest lactic acid factory, using sugarcane as feedstock.³¹³

Policy framework

The green growth strategy refers to food processing, wood product manufacturing and mineral processing industries as the main development priorities. Issues that hamper the sustainable development of the industrial sectors relate to lack of funding and poor environmental law enforcement. Developing industrial symbiosis to reduce industrial waste volumes is a priority.³¹⁴

Three laws have been identified that are relevant to developing industrial symbiosis and remanufacturing potential in Lao DPR: the Law on Industrial Processing (2013), which covers the establishment, operations, and administration of industrial and handicrafts processing activities;³¹⁵ the Law on Urban Planning (2017),³¹⁶ which outlines principles, regulations and standards on urban planning management and monitoring and covers zoning of different areas including industrial zones; and, the Decree on Special Economic Zone (2018), which states an aim to promote sustainable development and environmental protection but does not explicitly promote industrial symbiosis.³¹⁷

Business case

The business case for industrial symbiosis has been separately assessed for the two main interventions: using fly ash in cement production and remanufacturing vehicle parts.

Data from India and Lao PDR indicate that monetary savings when using fly ash in cement can amount to \$28/tonne fly ash.³¹⁸ With that value, the amount of fly ash produced in Lao DPR would be worth \$12 million/year. No substantial CAPEX is required for this intervention as the fly ash is already produced as a by-product. Operational costs are estimated at \$170,000 per year, generating an operational profit of \$12 million/year. With net present value of \$98 million, the business case for this investment is positive.

Vehicle parts are expensive in Lao PDR.³¹⁹ Additional

remanufacturing and sales of more than 200,000 tonnes of parts generates additional private sector revenue of \$940 million/year. A CAPEX of almost \$100 million is required to set up the actual remanufacturing factories and train employees. With operational costs consisting primarily of wages and some logistics (\$860 million/year in total), an operational profit of \$62 million/year can be made, resulting in a business case with a payback time of close to two years and net present value of \$960 million.

Next steps

To support the development of Lao PDR as a remanufacturing hub and broaden the application of industrial symbiosis, five next steps are proposed.

- The country could build on its improving infrastructural connectivity with surrounding countries to recover car parts and obsolete vehicles. To complement its vehicle assembly industry, the country could seek to attract investments in a remanufacturing facility, building on the example from Renault, which operates a remanufacturing facility in northern France.
- The government should consider promoting industrial symbiosis. Remanufacturing may be able to adapt based on the models already developed by Thailand (EIT Development Programme) and Vietnam.
- Industrial symbiosis and remanufacturing could be piloted in a Special Economic Zone (SEZ), where economic activities could be clustered to optimize opportunities for industrial symbiosis and extend the lifetime of products and components.
- The government could consider developing and incorporating specific definitions of an 'environmentally friendly' business into all relevant Lao legislation, such as the 2016 Law on Investment Promotion,³²⁰ the 2019 Law on Income Tax and the new Law on Environmental Tax.³²¹ This could be informed by the European Union's circular economy taxonomy or the work of Singapore's Green Finance Industry Taskforce. It could include introducing specific tax incentives for businesses that repair and remanufacture goods, employ sharing models, or use secondary materials.
- To promote industrial symbiosis and remanufacturing, Lao PDR could adopt a research and investment programme similar to Thailand's bioeconomy programme, under which scientific institutions and the private sector work together to develop new business based on organic and inorganic waste streams.



232,000 tonnes
The motorcycle industry assembles around 232,000 tonnes of vehicles every year

Impact

Using the remaining 77 percent of fly ash in Lao PDR as a clinker substitute can reduce emissions from the cement industry by an additional 330,000 tCO_{2e}/year.

In Japan, the recycling rate of vehicle parts is expected to reach 75 to 80 percent.³²² It has been estimated that a remanufactured gasoline engine can be produced with 26 to 90 percent less raw materials.³²³ When the Laotian vehicle assembly industry reaches similar levels, foreign emissions in the value chains of vehicles and their parts could be reduced by 180,000 tCO_{2e}. This value is based on

the abatement potential for recycling one tonne of bicycles³²⁴ and applying it to 75 percent of the number of vehicles that are scrapped in Lao PDR every year. When Laotian vehicle assembly lines implement reverse logistics and recover vehicles from abroad, the potential territorial emission mitigation could reach 620,000 tCO_{2e}/year in 2030 and 730,000 tCO_{2e}/year in 2050.

The value retention of remanufacturing and the use of fly ash in cement production yields a GDP totalling \$940 million, which could sustain 170,000 manufacturing jobs.

3.20. Intervention 8: Recover, re-use and recycle construction and demolition waste



Strategy description

Lao PDR produces an estimated 0.58 million tonnes of construction and demolition waste/year.³²⁵ This estimate is based on the ratio of municipal solid waste and construction and demolition waste in Vietnam. Much of it ends up in landfill or is used as filler at construction sites.³²⁶

This waste can be collected and sorted, separating the mineral fractions from the plastics, metals and wood. After sorting, it can be re-used or recycled, thus reducing the need to extract primary resources. Mineral residues can be crushed and used as aggregates for concrete blocks. Lao PDR produces an estimated 10 million tonnes of concrete structural elements/year.³²⁷ In the future, technologies such as the container-sized SmartCrusher can actually recover hydrated and unhydrated cement from concrete, as well as sand and gravel.³²⁸ That would allow construction companies to recycle cement, rather than procure primary cement, which has a high carbon footprint.

Recovering sand and gravel from construction and demolition waste also reduces pressure on river ecosystems. The impacts on river ecosystems of legal and illegal sand mining operations, which provide those materials to construction companies, are significant. Official statistics do not report sand extracted in Lao PDR,³²⁹ but estimates indicate that around 2.3 million tonnes were extracted in the year 2011.³³⁰ When applying the sectoral growth figures from the NDC calculations,³³¹ sand and gravel extraction volumes would amount to 4.0 million tonnes. Extracting sand from rivers is considered to be one of the main activities that cause deltas to retreat, as the volumes of sand extracted exceed annual sediments transported in the Mekong River.³³⁴

International examples

Thailand's National Science Technology and Innovation Policy is intended to drive eco-design. The country has also developed an eco-product directory for consumer use and to stimulate market demand for eco-products.³³⁵ Elsewhere in the region, Indonesia, Malaysia, the Philippines and Thailand have drafted national standards for green public procurement and eco-labelling with support from

the Gesellschaft für Internationale Zusammenarbeit (GIZ).³³⁶

Singapore has achieved a 99 percent recycling rate for construction and demolition waste. After a combination of manual and mechanized sorting, intact materials are reused within the construction sector. The remainder is washed, crushed and used as aggregate for building blocks.³³⁵

In India, the Municipal Corporation of Delhi built a construction and demolition waste recycling facility. It was designed to process 500 tonnes/day but in 2014, capacity was expanded to 2,000 tonnes/day. The plant recycles plastics, metals and wood, while whole bricks and large pieces of concrete are cleaned and sold. Smaller mineral fractions are recovered as sand, stone and ready-mix concrete. These are used to produce paving blocks, tiles, kerbstones and bricks. By early 2015, the plant had sold well over a million tonnes of recycled products.³³⁶ In 2016, the Indian environment ministry made construction and demolition waste management facilities mandatory in larger Indian cities.³³⁷

The Japanese construction company, Kajima, developed a deconstruction technique³³⁸ that allows the company to recycle 99 percent of construction materials.³³⁹ In 2018, it reported discarding only 4.5 percent of materials, close to its target of 3 percent.³⁴⁰

Policy framework

Current legislation does not include provisions for recovery, reuse or recycling of construction waste. Recycling of waste materials is primarily an informal sector in Lao PDR and waste resources are underutilized. The 9th NSEDP – specifically, output 2 of outcome 4 – prioritizes improving the efficiency and effectiveness of waste management through waste segregation for recycling and reuse. However, it does not mention the reuse of construction waste.³⁴¹

The 2016 Lao Building Code focusses on technical design compliance but does not provide specifications for environmentally friendly design or the use of secondary materials³⁴² and the Law on Construction (2009) does not include circular economy-related provisions.³⁴³ However, the Ministry of Public Works and Transport's Department of Housing and Urban Planning is planning to improve the articles relating to the use of construction materials to reduce GHG emissions. Finally, the 2017 Law on Public Procurement does not currently provide for 'green' procurement.

Sectors where the interventions occur

Domestic	Waste management, transport, manufacturing
International	n/a

IPCC sectors where the mitigation impact occurs

Domestic	1A2 Manufacturing Industries and Construction, 2A Mineral Industry
International	1A2 Manufacturing Industries and Construction, 2A Mineral Industry

Socio-economic and environmental indicators

GDP potential (million \$)	940
Job creation potential (jobs)	170,000
Solid waste avoided (t/year)	610,000

Business case

CAPEX (million \$)	100
Net present value (million \$ over 2022-2050)	1,100
Standard payback (years)	1.6
Marginal abatement costs (\$/tonne CO _{2e} per year)	-65

GHG mitigation potential (MtCO_{2e}/year)

2030	0.62
2040	0.67
2050	0.72

International GHG mitigation potential (MtCO_{2e}/year)

2030	0.18
2040	0.18
2050	0.18



10 million tonnes

Lao PDR produces an estimated 10 million tonnes of concrete structural elements/year.

The soon-to-be introduced Sustainable Solid Waste Management Strategy and Action Plan is expected to provide a classification of general waste streams that could help to facilitate the transition from the current 'collect and dispose' approach to a 'waste to resource' model.

Business case

Recovering and recycling construction waste allows for additional revenue from the sale of secondary concrete, glass, metals and plastics. In our business case, these products are sold to the local market in Lao PDR at local prices.³⁴⁴ This generates additional private sector revenues of \$53 million/year for all waste streams.

Investments are needed in sorting facilities, crushing installations and a recycling facility. This would require a total CAPEX of \$270 million. These high upfront investment costs would prohibit commercial viability. Together with operational costs of \$53 million/year, such an investment would yield no operational benefits. Thus, subsidies, landfill tipping fees or carbon taxes would be needed to increase the attractiveness of investments in recovering construction waste. However, at marginal abatement costs of \$170/tCO_{2e}, these incentives need to be

substantial.

Research on the business case for recycling construction and demolition waste in India indicates that high quality non-reinforced concrete products can be produced by replacing natural aggregates entirely with recycled aggregates from construction and demolition waste. The recycled products are cheaper compared to market prices of products made with virgin aggregates,³⁴⁵ but the source does not indicate whether the investment in recycling facilities is attractive without government support or the ability to charge a higher price for recycled materials.

Next steps

A re-use and recycling strategy for demolition and construction waste could include:

- Adjusting the building code to facilitate the adoption of modular design and design for disassembly to facilitate the recovery of materials at a building's end-of-life and integrating other circular principles, such as passive design, into the procurement of design and construction services.
- Coordinating supply and demand – or, rather, construction and demolition activities – so that materials can be re-used and considering whether to develop an on-line marketplace or physical

warehouse for secondary construction materials.

- Considering re-use and recycling in procuring demolition services through circular procurement; this would also include giving demolition companies more time to find a destination for the materials they harvest.

Impact

Significant emissions from the production of primary materials can be avoided when cement, glass, metals and plastics are recovered from construction and demolition waste. Based on data on the composition of construction and demolition waste from India,³⁴⁶ the carbon footprint of Lao PDR's 0.58 million tonnes of construction and demolition waste/year in 2019 was approximately 240,000 tCO_{2e}/year. However, recycling at the 99 percent rate achieved in Singapore also produces GHG emissions.³⁴⁷ As a result, the net potential mitigation impact of recovering and recycling construction and demolition waste would have been around 93,000 tCO_{2e}/year in 2030. Assuming that the

amount of construction waste increases at the same rate as industry growth forecasts (see Annex A),³⁴⁸ this GHG mitigation potential increases over the years.

The GHG mitigation impact of the recovery of gravel and sand is small, as these materials have a relatively low carbon footprint. The same holds for the GDP potential, which is around \$62 million, while the job creation potential is around 4,400 jobs.

Sectors where the interventions occur

Domestic	Construction, Waste management
International	n/a

IPCC sectors where the mitigation impact occurs

Domestic	2A Mineral Industry, 2C1 Iron and Steel Production, 3D1 Harvested Wood Products
International	n/a

Socio-economic and environmental indicators

GDP potential (million \$)	62
Job creation potential (jobs)	4,400
Solid waste avoided (t/year)	570,000

Business case

CAPEX (million \$)	270
Net present value (million \$ over 2022-2050)	-420
Standard payback (years)	1,400
Marginal abatement costs (\$/tonne CO _{2e} per year)	170

GHG mitigation potential (MtCO_{2e}/year)

2030	0.093
2040	0.10
2050	0.11

Products that flow

9–11



3.21. Products that flow

Industry, manufacturing, transport and power generation in Lao PDR contribute 12 percent of GDP and provide 5 percent of employment. Most industrial activities, other than food processing, are in vehicle assembly, chemicals and garments.³⁴⁹ Transport and power generation have been added to products that flow because they are the main consumers of fossil fuels, a carbon intensive product with a short lifetime.

3.22. Material flows

Total material use in industry and transport is 108 million tonnes/year, of which 80 million tonnes are waste rock and tailings from mining operations. The mining products are largely exported. Coal used for power generation constitutes the second-largest flow. In just a few years, coal use for power generation has begun to dominate fossil fuel use in Lao PDR and now exceeds fuel use in transport by a factor of 10 in tonnes/year.

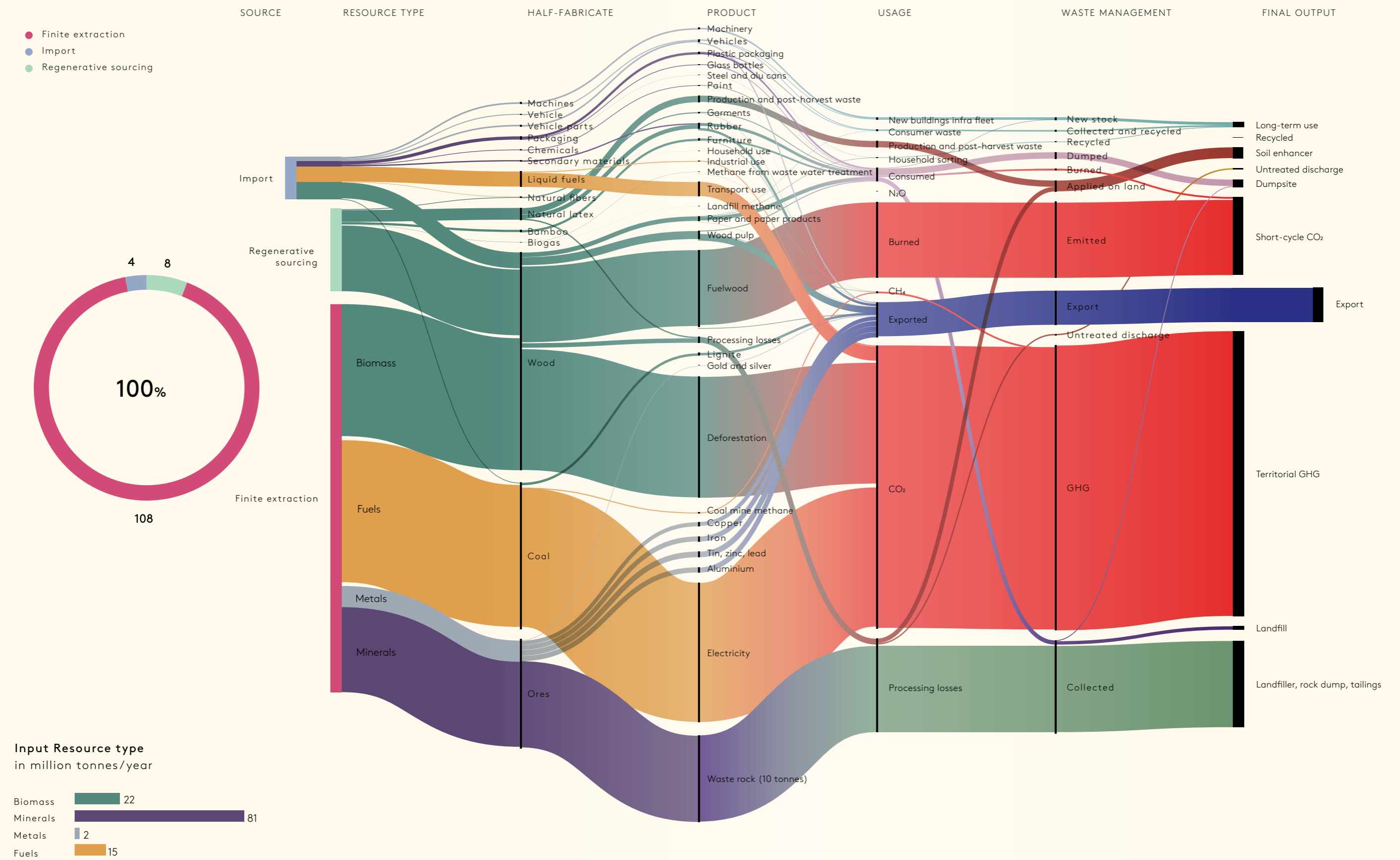
3.23. Current circular economy initiatives

Circular economy initiatives in the category of products that flow focus on substituting plastics with biodegradable alternatives and prioritizing regenerative materials over those that rely on finite resources (See list on page 84).

3.24. Circular GHG mitigation opportunities

SMEs play a key role in carving out alternatives to carbon intensive or environmentally damaging products from industry. Ideally, some of the concepts are scaled to deliver volumes that conventional industries can provide. A circular industrial strategy should be able to inspire the informal sector – and its micro, small and medium-sized enterprises – with opportunities to prioritize regenerative resources, recycle, extend product lifetimes, collaborate with partners in the product value chain and, perhaps, shift to circular business models.

FIGURE 18



Material flows of products that flow³³⁶

Lao Biogas

Household biogas appliances

Lao Biogas distributes household and community biogas systems. Fed with organic household wastes, the system produces biogas for cooking and organic fertilizer for the garden.³⁵¹



Nahm Dong

Bamboo eco-plates

Nahm Dong provides plates and containers made of leaves, mostly areca sheath. The leaves are collected after they fall and the products are biodegradable, leak proof, washable and re-usable (especially areca), microwave and refrigerator safe, and can be used with hot, wet and cold food items. As such, they offer a very sustainable alternative to plastic products.³⁵²



LOCA

Ride sharing platform

LOCA is a taxi and private car service that uses digital technology to connect supply and demand for mobility services, both for passengers and packages. To date, the company has targeted primarily tourists and expat communities.³⁵³ The company has partnered with BYD Electric Cars to provide electric vehicle taxi services.³⁵⁴



Aqua de Bamboo

Bamboo water bottles

The mission of the company Aqua de Bamboo is to educate people on the need to reduce the consumption of single-use plastic items and the damage done by our throwaway culture. It does that by engaging communities in producing responsibly sourced bamboo-based water bottles.³⁵⁵



Danlao Rattan

Rattan furniture

Rattan refers to over 600 species of plant-climber from the palm family, which is native to tropical regions, especially in Asia. It is one of the most valuable non-timber forest products (NTFPs). Danlao Rattan uses this resource to produce furniture.³⁵⁶



Fashion Revolution

Sustainable Fashion Weekend and Design Competition

In 2019, Fashion Lao and Fashion Revolution launched a Sustainable Fashion Weekend and Design Competition. The winner of the competition was chosen based on the designer's zero-waste designs that use only natural materials and plant-extracted dyes sourced from ethnic village tribes.³⁵⁷

3.25. Intervention 9: Increase the modal share of active mobility and public transport



Strategy description

The transport sector is the fastest-growing source of GHG emissions worldwide³⁵⁸ and Lao PDR is no exception. The country's fleet of fossil fuel-propelled vehicles nearly quadrupled between 2010 and 2019.³⁵⁹ This rapid growth of private car ownership comes at a high price. While car drivers and motorcyclists enjoy flexibility and comfort, these modes of transport have the highest spatial footprint per user, create the most congestion, pollution and injuries,³⁶⁰ and do not offer benefits such as improved health and urban liveability.³⁶¹

Continued growth in private car ownership will affect the liveability of Laotian cities for all income brackets and the appeal of these cities to foreign visitors. Some places, such as along the river in Luang Prabang, are already experiencing the adverse impacts of congestion.³⁶²

According to the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), the future of Asia's transport sector lies with public and active transport.³⁶³ This is very consistent with a global trend.³⁶⁴ In small and medium-sized cities in Asia, municipalities should shift away from building infrastructure that focuses on private transport, which only benefits a few.

In larger cities, the focus should be on public transport and active mobility and on promoting a compact urban development pattern with mixed functions³⁶⁵

In a 2020 report, UNESCAP states that "Early decisions to prioritize public transport and non-motorized transport investments over private transport-oriented investments can bring important long-term benefits." It also underscores the opportunity that rapidly developing cities have to slow the pace of motorization, particularly during periods of rapid economic growth and urbanization. The dense cities throughout Asia are particularly vulnerable to the negative impacts of traffic.³⁶⁶

International examples

Other cities are already following this developing model. By investing in walking and cycling, these cities become safer and more liveable and its

population's health improves.³⁶⁷ Examples from Asia include:

- Ho Chi Minh City: Its 6 million motorbikes clog walkways when parked. In 2014, motorbike accidents caused 713 deaths and road accidents were called the 'hidden epidemic'. By investing in bus rapid transit and in active and shared mobility, the city aims to bypass the car-dependant development stage.
- Yangon: After private car use doubled between 2011 and 2015, Yangon decided to invest in BRT, improve the circular railway and replace car lanes in existing transport corridors. The city reported 65 percent of trips with active mobility, 34 percent with public or shared mobility, and only the remaining 1 percent with private vehicles.
- Taipei: YouBike, a public bike-share scheme that could compete with motorbikes was created. The city is implementing 500 km of bike lanes, with YouBike stations always within 10 minutes' walking distance, and is working to double the modal share of cycling.
- Seoul: Data showed that establishing car-free zones did not negatively affect businesses. The mayor described this policy as launching the transition to a human-centred city.³⁶⁸
- Shanghai: The MoBike bikesharing company launched in 2016 has reduced GHG emissions by an amount equivalent to taking 350,000 cars off the road.³⁶⁹

Laotian municipalities can learn from mistakes in other cities. Amsterdam has a modal share of 75 percent cycling in the 1950s. In the early 70s, cyclists were banned from the city's main transport arteries as they were considered as blocking efforts at modernization. Class issues also came into play: cycling was seen as an activity limited to the lower classes and as hindering the advent of a car-led future. Starting in the mid-1970s, a determined social movement, working to achieve a socially-inclusive transport system, helped to establish cycling as socially acceptable for all.³⁷⁰

In this regard, COVID-19 offers an opportunity as it has had a major impact on how we use transport mobility. Public transit shares declined by 70 to, even, 90 percent in some major cities. In addition, the automotive sector suffered from factory closures, causing the supply of vehicles to fall.³⁵⁷ Many regulators have responded to the pandemic by accelerating the transition towards sustainable mobility, for example, by building new bike lanes to support social distancing (Bogotá), and closing traffic lanes (Oakland, California and New York).³⁷²

Policy framework

The National Green Growth Strategy refers to a projected 10 to 12 percent/year growth rate in road transport vehicles. More than 40 percent of that is expected to occur in the capital, Vientiane. Road accidents already cause over 1,000 deaths/year. Creating favourable conditions and safe infrastructure for walking and cycling and improving public transport are urban transport priorities.³⁷³

The 9th NSEDP includes provisions for energy efficient vehicles, bus service improvements and improved transport infrastructure.³⁷⁴ The 2012 Law on Multiple Transport provides guidance on the obligations of road users to ensure transport safety.

The Ministry of Public Works and Transport is working to achieve the sustainable transport ambitions by implementing the Vientiane Sustainable Urban Transport Project. This project includes 11 kilometres of dedicated bus lanes, 24 enclosed stations, and over 90 climate-friendly buses. It will also fund paid parking meters in the city centre, new signal lights at key intersections, a central traffic control centre and a national vehicle registration system.



Business case

Prioritizing public transport and non-motorized transport generates some direct revenues, but should be seen primarily as a societal business case as it yields additional external benefits: including health benefits and reduced healthcare costs due to improved air quality and more physical activity; increased worker efficiency due to less time lost in congestion; and the more efficient use of public space by reducing the space occupied by parked cars. This business case does not quantify these additional benefits, but it is important to take them into account. The direct public revenues from public transport tickets sold and/or subscriptions for all kinds of sustainable transport services are estimated at \$25 million/year.

However, public transport investments are costly. It is assumed that a CAPEX of \$980 million is required for the transition towards (more) sustainable transport in Lao PDR, including bus and railway systems and bike sharing services. Operational costs are very low, at less than \$1 million/year. With operational revenues of around \$25 million/year and a CAPEX of \$1 billion, the payback time is almost 40 years, and the marginal abatement costs \$34/tCO₂e.

The size of Lao PDR's fleet of fossil fuel-propelled vehicles nearly quadrupled between 2010 and 2019

However, this is based on the assumption that investing in sustainable transport modalities is a stand-alone investment. According to UNESCAP, a transition towards sustainable transport does not require the government to increase its investment and infrastructure expenditure, but, rather, to redirect them. Globally, such a shift to sustainable transport could save \$70 trillion by 2050 through improved road safety, reduced air pollution, lower carbon emissions, reduced fuel expenses and reduced congestion costs.³⁷⁵

Next steps

The Ministry of Public Works and Transport should consider developing a national sustainable urban transport strategy that considers all sustainable urban transport options, including additional improvements to public transport infrastructure and encouraging active mobility in urban centres. This could incorporate learnings from the recent UNESCAP report or the E-Mobility Technology Roadmap that has helped Singapore successfully transition to a more sustainable urban transport model.

Lao PDR is already investing in railway infrastructure and urban bus networks. This strategy carries this ambition further, putting active and public transport at the heart of urban development. The following next steps will help Lao PDR achieve a sustainable and liveable urban transport sector:

- Urban planning should be based on a clearly articulated roadmap for sustainable, safe and healthy urban mobility. Following the example of Seoul, consider pilot projects with car-free streets and districts in Lao PDR's major urban centres.
- If successful, the government should consider scaling up the Vientiane Sustainable Urban Transport Project to other major cities in Lao PDR.
- Slow car traffic to make active transport safer and increase the cost of parking to reflect the true cost of car use in urban centres.³⁷⁷
- Prioritize public and active or non-motorized transport investments over private transport-oriented investments.³⁷⁸
- Join the ICLEI EcoMobility Alliance, as did Kleang Town Municipality just across the Thai border.³⁷⁹
- Adopt sustainable city planning to reduce transport demand and establish the prerequisite for efficient and just mobility systems.³⁸⁰
- Rely on data to be able to take well-informed decisions on transport and consider using the data provided by the Asian Development Bank

under the Asian Transport Outlook project.³⁸¹

- Work to transform the interests of existing sectors, such as automotive and fossil fuel industries. The defining task for policymakers is to actively support structural change in these industries to manage their transformation.³⁸²
- Communicate with the public on the benefits of a circular, sustainable transport system. Cities that embed circular economy principles:
 - a. enjoy a greater proximity between where people live, work, and play;
 - b. have cleaner air as vehicles switch to zero-emission engines and congestion is reduced as shared transit increases;
 - c. can improve health and interactions with local businesses and communities as more people walk and cycle to work; and,
 - d. free up valuable land previously dedicated to roads and car parks for green spaces, commerce, offices, houses and recreation.³⁸³

Impact

Data from Lyon and the New Climate Institute show that under plausible transport development scenarios, shared mobility can reduce GHG emissions by 12 percent and public transport by 12 percent.³⁸⁴ Strategies to reduce transport demand and promote active mobility could reduce emissions by an additional 21 percent.

The technical potential of shared mobility is considerably greater and could support a vehicle fleet reduction of 87 percent and a 50 percent reduction in GHG. Although the current situation in Lao PDR is very different from the context of the Organisation for Economic Co-operation and Development (OECD), per capita transport emissions in Asia are rapidly rising towards those levels.³⁸⁵ Current transport policies could seek to optimize shared, active and public transport by 2050, leapfrogging the phase in which excessive private car use affects the liveability and air quality.

Growth forecasts for Lao PDR suggest that transport emissions could reach 8.3 Mton CO₂e by 2050. Based on plausible transport mitigation scenarios, public, shared and active mobility could reduce this to 6.2 Mton CO₂e by 2050, leading to an overall reduction of 2.1 Mton CO₂. This estimate assumes that some 61 percent of global fuel use in transport emissions relate to passenger transport.³⁸⁶

The long-term strategy model developed for the GHG mitigation forecasts uses a long-term timeline and assumes industry growth to be similar to that

set out in Annex A and based on the NDC model.³⁸⁷ If we assume the increase of modal share of active mobility and public transport will take from 2022 to 2040, the expected annual GHG mitigation impact is 1.7 million tCO_{2e}/year. Lao PDR is investing in railway infrastructure and included a combination of active transport and BRT in Vientiane in its NDC.³⁸⁸ The mitigation potential of these investments of 440,000 tCO_{2e}/year has already been deducted from the GHG mitigation potentials.

Sectors where the interventions occur	
Domestic	Transport
International	n/a
IPCC sectors where the mitigation impact occurs	
Domestic	1A2 Manufacturing Industries and Construction, 1A3 Transport
International	1A1 Energy Industries, 1A2 Manufacturing Industries and Construction 2B Chemical Industry, 2C Metal Industry
Socio-economic and environmental indicators	
GDP potential (million \$)	60
Job creation potential (jobs)	n/a
Solid waste avoided (t/year)	0
Business case	
CAPEX (million \$)	980
Net present value (million \$ over 2022-2050)	-1,100
Standard payback (years)	39
Marginal abatement costs (\$/tonne CO _{2e} per year)	34
GHG mitigation potential (MtCO_{2e}/year)	
2030	0.72
2040	1.7
2050	1.8
International GHG mitigation potential (MtCO_{2e}/year)	
2030	0.18
2040	0.41
2050	0.44

3.26. Intervention 10: Accelerate the electrification of the transport sector with service models



Strategy description

Southeast Asian cities suffer from congestion and traffic-related pollution and are experiencing growth in private car ownership rates. Cities also lack the space to support widespread private car ownership. In addition to public and non-motorized transport, mobility-as-a-service is an important part of the solution,³⁸⁹ since shared mobility can reduce fleet size and accelerate the electrification of the vehicle fleet. This electrification is the objective of this intervention.

Even with active and public transport strategies in place, some private car ownership will remain, for example, in rural transport.³⁹⁰ Electrification is important for that segment of the vehicle fleet.

Replacing internal combustion engine vehicles with electric vehicles requires new business models. Under these models, consumers shift from ownership towards mobility, including through mobility-as-a-service (for example ride-hailing, and car-sharing).³⁹¹ These models require smaller vehicle fleets that deliver similar service levels at higher vehicle utility rates. The increased utility rate of each vehicle would accelerate the replacement rate of the smaller fleet and pave the way for accelerated electrification.

In addition, service models can improve vehicle and vehicle parts recovery rates. That would support an increase in remanufacturing and recycling rates of vehicles and their parts in Intervention 7.

The smaller fleet also addresses a different barrier to electrification. Research finds that the scarcity of key minerals for electric vehicles – lithium, magnesium, neodymium, praseodymium and dysprosium^{392 393} – limit the extent to which electrification can reduce transport emissions when mobility relies on structurally underused private vehicles. This is even the case when recycling rates increase. Competition among industries for these resources worsens these scarcity concerns. Electric vehicles, solar and wind power assets require some of the same materials. Further, just a few countries dominate the value chains for these materials; China plays a key role here, with high ambitions for electric

vehicle production. Its goal is for the production of 'new energy vehicles' to constitute 18 percent of total auto production by 2023.³⁹⁴

As a result, electrifying transport is only possible when addressing the exceptionally low use rate of privately-owned vehicles under new business models, shifting also to lighter electric vehicles and small personal electrified vehicles,³⁹⁵ prioritizing active transport modes, and reducing overall transportation demand³⁹⁶ through urban planning.

International examples

China is promoting car sharing initiatives through regulatory reforms at both the central and local levels. The State Council has encouraged the automotive industry to develop and implement innovative car sharing models since 2015. Policy measures include a mix of regulations to protect consumers, which use online platforms, and regulating the suppliers of network products and services for the collection, storage and processing of user data. To support the development of car sharing and carpooling, the National Development and Reform Commission adopted the Guidelines for Promoting the Development of a Shared Economy in 2017. These guidelines try to strike a balance between encouraging innovation and establishing appropriate government regulation of the sector, while ensuring orderly competition.³⁹⁷

Shanghai set clear targets for electric and shared vehicles. In 2016, it set 2020 targets that include 6,000 parking lots for shared vehicles, 20,000 new energy vehicles on the road, and 30,000 charging points for electric vehicles. Car sharing operators could apply for free parking spaces and subsidies were granted for platform development, charging infrastructure, electricity consumption and general operation. In Shanghai's Jiading district, car sharing subsidies reach \$5,800 per new energy vehicle each year. Cities like Chengdu are following Shanghai's example.³⁹⁸

Thailand plans to adopt 53,000 electric motorcycle taxis by 2022 and 5,000 electric buses by 2025. In Vietnam, VinBus plans to introduce up to 200 electric busses and DHL is testing electric motorbikes as part of its efforts to cut emissions to zero by 2050.³⁹⁹

Policy framework

The 9th NSEDP identified greater use of electric vehicles as a solution to reduce fuel consumption.⁴⁰⁰ The draft strategy on Climate Change of the Lao PDR and Vision to 2050 include enhancing and promoting electric vehicle transportation from 2022

\$5,800

In Shanghai's Jiading district, car sharing subsidies reach \$5,800 per new energy vehicle each year



to 2030 as a priority measure. The Law on Excise Tax (2019) already institutes a low excise tax (from zero to 3 percent) on imported vehicles that use clean energy (electricity, solar, wind and other renewable energy).⁴⁰¹

Other concrete initiatives include the development, by the Ministry of Energy and Mines, of an electric vehicle charging station standard, which also includes electric vehicles for some of the office logistics.⁴⁰² The Department of Climate Change, within the Ministry of Environment and Natural Resources, partnered with GGGI and the Ministry of Natural Resources and Environment (MONRE) to promote electric vehicle adoption through private sector engagement.⁴⁰³ JICA supported the government's Low Carbon Transport Initiative in Luang Prabang, which included shifting to electric vehicles for public transport.⁴⁰⁴

Business case

This business case explores the profitability of companies that offer mobility as a service. New mobility business models, such as combining car sharing models with vehicle fleet electrification, will earn revenues from subscription fees. The electric cars as part of the sharing services are

included in this business case, including the charging infrastructure. Total additional private sector revenue from subscription fees is estimated at \$5 million/year.

A total CAPEX of \$5.4 million is anticipated in investments in electrification infrastructure, vehicles and setting-up mobility-as-a-service systems. A profitable business case is possible under these conditions. Operational revenues of \$3.0 million/year are projected, with operational costs of \$2.0 million/year. The required investments are projected to have a payback time of almost two years, while the net present value totals \$40 million.

The costs of further electrification of the car fleet are borne by private car owners and are not included in this business case. To accelerate electrification, the government must stimulate the adoption of electric vehicles, without stimulating further private car ownership. This requires additional investments in electrification infrastructure and incentives for individuals who really need a private vehicle to replace their fossil fuel-based vehicle.

Next steps

The accelerated adoption of circular business models

in transport could involve the following steps.

1. Prioritize active and public transport, along with strategies to reduce transport demand in urban planning. Aim to accelerate electrification for the remaining transport modes that rely on private vehicle ownership.
2. The government should consider tax incentives for private sector investment in sustainable transport, such as establishing electric vehicle charging stations in all major urban centres and initiatives such as the LOCA and BYD pilot programme to accelerate electric vehicle adoption across the country.
3. The government could consider establishing an E-Mobility Technology Roadmap and an Eco Fund similar to the one developed and implemented in Singapore that can invest in electrification of the transport sector. This could include investing in charging stations and electrifying busses and motorcycle taxis, as in Thailand and Vietnam.⁴⁰⁵
4. Strong policies, such as a tax or even a future ban on the ownership or use of internal combustion engines in passenger vehicles, are needed to accelerate the electrification of the transport sector.⁴⁰⁶ As similar efforts are taken globally, demand for transport fuels will decrease, improving their availability.⁴⁰⁷ Policies will have to anticipate the rebound effect of lower fuel prices or improved availability, while protecting those sectors of the population that are vulnerable to changes in transport costs and for whom it is difficult to adopt different transport modalities. In addition, incentives should not encourage private car ownership, including tax cuts for electric vehicles, but, rather, promote replacing of combustion engines.

Impact

The University of Valladolid in Spain developed decarbonization scenarios for transport. It found that under a baseline scenario, global GHG emissions from transport would reach 12 GtCO_{2e} by 2050. Electrifying transport – both four- and two-wheelers – could reduce emissions by, respectively, 30 percent and 15 percent, or 45 percent in total.⁴⁰⁸

In the previous intervention, reduced transport demand and promotion of shared, active and public transport already bring transport emissions down from the baseline of 8.3 MtCO_{2e}/year by 2050 to 6.2 MtCO_{2e}/year by 2050. This only considers passenger transport. With the electrification of four- and two-wheelers, emissions can be reduced to 4.5 Mt CO_{2e}.

This residual value involves primarily road cargo transport where rail is not an option, domestic shipping and a residual fleet of largely rural passenger vehicles. Emissions from international air transport are not included. Furthermore, these estimated emission reductions from electrification consider high vehicle recycling rates, which are necessary to avoid a scarcity of raw materials that could disrupt the supply of electric vehicles.⁴⁰⁹

The NDC already includes an estimated 30,000 tCO_{2e}/year from electric vehicle penetration of 30 percent for 2-wheelers and passenger cars in the national vehicle mix. This has been deducted from estimates of the total GHG mitigation potential in the Laotian transport sector.

As a point of reference, scientific studies point to the GHG mitigation potential of sharing models. In Sweden, office sharing has the potential to reduce national GHG emissions by 164 to 243 ktCO_{2e}/year and car sharing by another 0.5 to 3.7 MtCO_{2e} (if 80 percent of cars in Sweden were sharing cars). Electrifying the car fleet would cut emissions by 8.2 MtCO_{2e}/yr.⁴¹⁰

Sectors where the interventions occur

Domestic	Transport
International	n/a

IPCC sectors where the mitigation impact occurs

Domestic	1A2 Manufacturing Industries and Construction, 1A3 Transport
International	1A1 Energy Industries, 1A2 Manufacturing Industries and Construction 2B Chemical Industry, 2C Metal Industry

Socio-economic and environmental indicators

GDP potential (million \$)	5.2
Job creation potential (jobs)	n/a
Solid waste avoided (t/year)	0

Business case

CAPEX (million \$)	5
Net present value (million \$ over 2022-2050)	40
Standard payback (years)	1.8
Marginal abatement costs (\$/tonne CO ₂ e per year)	-1.3

GHG mitigation potential (MtCO₂e/year)

2030	0.66
2040	1.5
2050	1.6

International GHG mitigation potential (MtCO₂e/year)

2030	0.14
2040	0.32
2050	0.35

3.27. Intervention 11: Reduce plastics and recover recyclable materials



Strategy description

This intervention aims to reduce waste volumes by improving the recovery, sorting and recycling of recyclable materials that are landfilled or incinerated, such as paper, glass and metals. When including organic waste, the recycling rate in Lao PDR is below 50 percent; in Myanmar, it is 70 percent. To increase recycling rates, UNEP recommends developing a modern recycling industry.⁴¹¹

The climate impact of this intervention results from the increased use of secondary materials, which have a lower carbon footprint than materials of primary origin.

Finally, waste flows from food and timber industries can be used to produce biodegradable substitutes for plastic packaging. Lao PDR already has several examples of companies that use leaves⁴¹² and bamboo⁴¹³ as alternatives to plastic packaging. Some retailers are experimenting with refillable packaging.⁴¹⁴ When applied at scale, these initiatives can reduce the use of finite resources for packaging and packaging waste.

International examples

In early 2020, Thailand banned single-use plastics. It expects to avoid the use of 45 billion single-use plastic bags/year and reduce plastic waste by 225,000 tonnes.⁴¹⁵

Policy framework

The National Green Growth Strategy encourages the use of alternatives to plastic bags and plastic packaging, such as cotton bags and leaves.⁴¹⁶

The 2020 Guidelines for Recycling Waste Plastic Plants aim to improve occupational health and safety management and reduce environmental impacts from plastic recycling facilities. The government also aims to increase awareness via the 2018 Notification on the Raising Awareness for Reduction in Use of Plastic Bags for Goods Containers and Other Containers Made of Plastic. This notification outlines activities to raise awareness of the need to minimize the use of plastic bags and other plastic products to promote sustainable economic development.⁴¹⁸

Finally, the 2021 Guideline on Granting Investment Promotion Incentives on Profit Tax and State Land Rents and State Land Concession Royalties introduces incentives for businesses including those involved in renewable energy and recycling.⁴¹⁸

Business case

The sales value of recovered secondary glass, wood, textiles, rubbers, plastics and metals at the local market in Lao PDR⁴²⁰ are estimated at \$59 million/year. However, investments are needed in additional collection vehicles and sorting and recycling facilities. This would require CAPEX of \$80 million.

With operational costs of \$56 million/year, operational profits of \$3 million/year are projected. Investing in recyclable materials recovery is profitable, but the payback time is long: 29 years. That is not attractive to private sector actors and financial incentives are needed to make an investment in recycling more attractive.

However, the disposal of secondary resources represents a major loss, although such subsidies or landfill tipping fees can help avoid this. As a point of reference, the World Bank estimated that less than 25 percent of plastics from Malaysia, the Philippines and Thailand are recovered for recycling. The remainder is lost, representing a loss of \$6 billion in material value.⁴²¹ This value is between \$3.6 million and \$4.0 million for Thailand alone.⁴²²

Next steps

The World Bank developed a series of recommendations for neighbouring Thailand to improve plastics recovery and recycling, while UN Environment examined the role of packaging regulations and standards in driving the circular economy.⁴²³ Building on these and other sources, the main recommendations are as follows.

- Increase the waste collection rate and sorting efficiency of post-consumer recyclables. This could involve small entities and take a centralized or decentralized approach following the guidelines from WasteAid, a British charity created to share low-cost waste management know-how with communities in low-income countries.⁴²⁴
- Set targets for recycled content in products.
- Make 'design for recycling' standards mandatory for products with recyclables.
- Increase the capacity to recycle.
- Restrict the disposal of recyclable materials and illegal dumping.⁴²⁵

- Develop a national 'zero waste action plan' building on the soon-to-be developed Sustainable Solid Waste Management Strategy, as well as regional examples from Thailand, Singapore and Malaysia.
- Consider developing appropriate legislation (e.g., policies and waste classification and sorting regulations) to support implementation of the strategy under development.
- Consider developing legislation guidelines and standards to promote eco-designs, including the adoption of 'design for recycling' standards.
- Consider expanding the 'Green Vientiane' initiative to reduce single-use plastics nationwide.
- Consider developing a modern waste processing and recycling industry to commodify potential pollutants, transforming a liability into a valuable resource.
- Gradually implement a 'polluter pays' principle by which companies or individuals are fined for dumping waste pollution or failing to sort wastes to separate out waste resources.

Trade restrictions, extended producer responsibility or taxes on packaging types that the Laotian waste management system is ill equipped to manage, can help accelerate innovation leading to the use of organic residues, regenerative resources and alternative business models to reduce plastic packaging waste.



Impact

The volume of recyclable materials in municipal solid waste that is landfilled or incinerated totals 1.0 million tonnes/year. This already takes into account that approximately 57,000 tonnes are already recycled.⁴²⁶

If we assume that 30 percent of plastic waste can be avoided by introducing refillable packaging, banning single-use plastics and substituting plastics with bio-based materials, 44,000 tonnes of plastic waste can be avoided.

Recovering and recycling 80 percent of the remaining paper, glass, wood, metals, textiles and rubber could avoid around 470,000 tCO₂e,⁴²⁷ of which some 30 percent abroad. Across all recyclable materials, the value retention is estimated at \$59 million, which could support 3,000 jobs.⁴²⁸

If we assume the intervention is to be implemented in the period 2022 - 2030 and if we take the industry's gradual growth into account, the annual GHG mitigation impact is estimated at 540,000 tCO₂e/year by 2050.

1.0 million t/year

The volume of recyclable materials that is landfilled or incinerated totals 1.0 million tonnes/year

Sectors where the interventions occur

Domestic	Waste management
International	n/a

IPCC sectors where the mitigation impact occurs

Domestic	2A Mineral Industry, 2B Chemical industry
International	2A Mineral Industry, 2B Chemical industry

Socio-economic and environmental indicators

GDP potential (million \$)	62
Job creation potential (jobs)	3,000
Solid waste avoided (t/year)	815,000

Business case

CAPEX (million \$)	82
Net present value (million \$ over 2022-2050)	-80
Standard payback (years)	29
Marginal abatement costs (\$/tonne CO ₂ e per year)	4.9

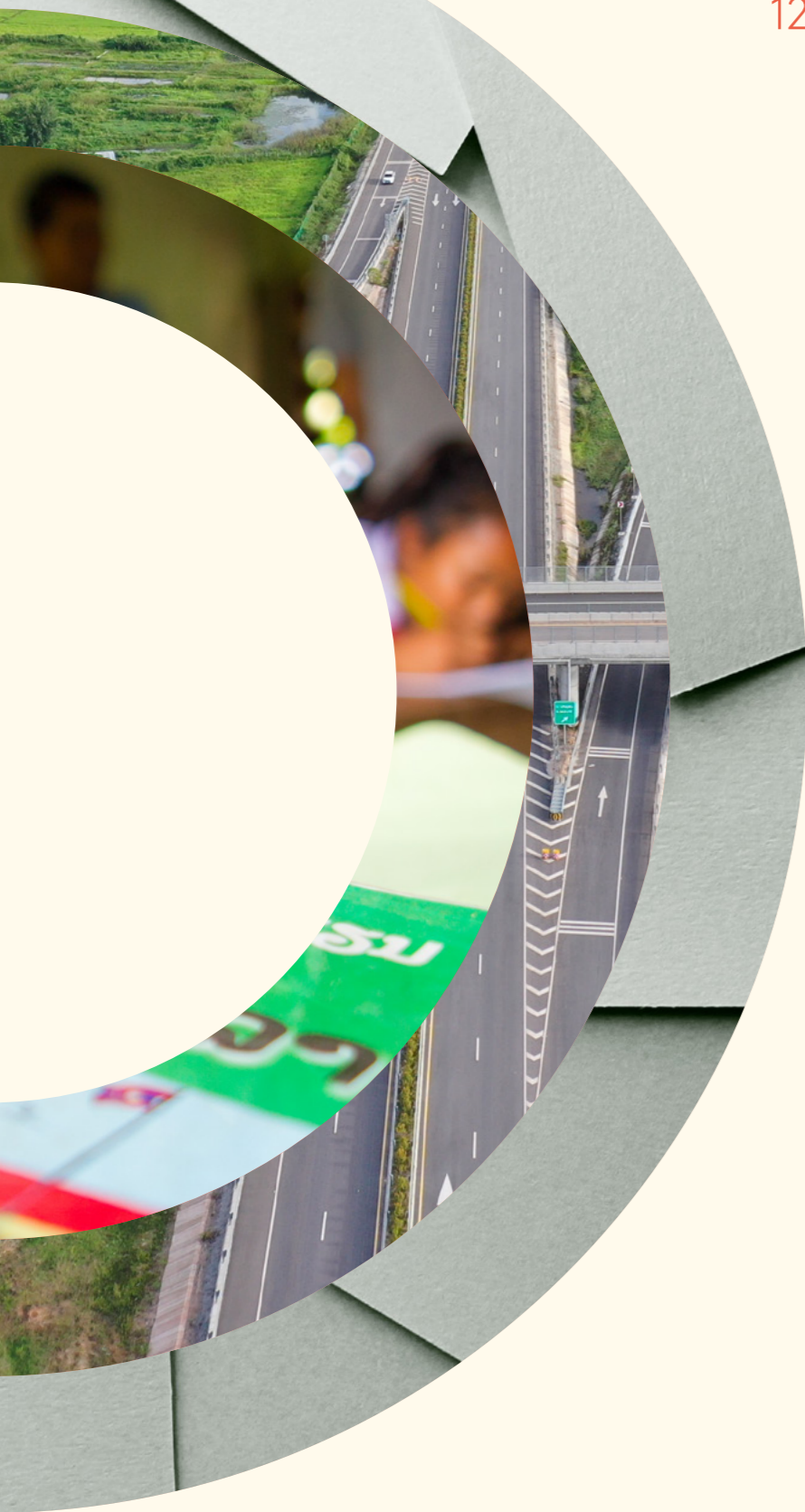
GHG mitigation potential (MtCO₂e/year)

2030	0.46
2040	0.50
2050	0.54

International GHG mitigation potential (MtCO₂e/year)

2030	0.12
2040	0.13
2050	0.14

Public services: the policy framework 12–15



3.28. Public services: the policy framework

Lao PDR's public sector, including healthcare and education, contributes 12 percent to national GDP and provides 4 percent of all jobs. The OECD has described the country's civil service system as strong, career-based and ensuring the stability of its workforce. It also complimented Lao PDR for having the one of the highest proportions of women in parliament in Southeast Asia. It lags only in the use of digital tools.⁴²⁹

The public sector has an important role to play in facilitating the transition to a circular economy. Since the policy interventions aim to support the transition, Interventions 1 to 11 show their impacts. Where the impact of potential policy interventions has been quantified, it is not added to the national total; this avoids double counting emission reduction potentials.

3.29. Policy context

Lao PDR has already made significant progress in its transition to a circular economy with development of a UNDP-supported circular economy strategy for the country in 2017 and integration of the circular economy concept into national development plans, including the 9th NSEDP, Lao PDR's NDC and the National Green Growth Strategy.⁴³⁰ There are also a number of other policy developments, overseas development assistance supported programmes and private sector initiatives that are already supporting Lao PDR's transition to a circular economy. However, it is important that the government, the private sector, development partners and other stakeholders continue to work together towards a circular economy transition to unlock new opportunities and ensure that Lao PDR is not left behind as an increasing number of countries seek to develop economy-wide or sector based circular economy roadmaps and strategies. This also requires integrating the NDC and the circular economy interventions proposed in this report into the next NSEDP.

The Government of Lao PDR already has a National Green Growth Steering Committee. Its terms of reference could be expanded and it could evolve into an inter-agency circular economy taskforce. This would provide an institutional foundation to lead and coordinate efforts in the transition to a circular economy.

Although decision-makers and the private sector understand circular economy-related activities and processes in Lao PDR reasonably well, terms such as 'sustainable' or 'responsible investment' and 'circular economy' and some of the concepts are still relatively new to them. In addition, tax and many other laws promote incentives for 'environmentally friendly' businesses or business activities, but neither is defined clearly and no criteria have been developed. This limits businesses' ability to access these incentives.

A circular economy taxonomy that clearly defines circular businesses, business activities and technologies would raise awareness about these opportunities in Lao PDR, facilitate more positive outcomes from government policies as intended, and provide investors with clear incentives to establish circular business operations. The taxonomy should be aligned with existing international examples, such as the EU's Categorisation System for the Circular Economy or Singapore's circular economy taxonomy, as this would facilitate international coordination and access to high-value international markets.

The government, development partners and the private sector are conducting a host of circular economy-related activities and initiatives in Lao PDR. However, many of these efforts are not well coordinated and this can create inefficiencies, overlaps and competing priorities among stakeholders. For example, government ministries and line agencies often compete for resources, which limits their incentives to collaborate on joint initiatives. In addition, many donor support programmes are designed and implemented without due consideration of current or past initiatives conducted by other development partners.

Would-be investors in circular economy-related developments also lack sufficient policy support and financial access to enable investment decisions. Weak enforcement of legislation in areas such as hazardous materials and waste management create additional barriers to establishing circular ventures.

Developing a circular economy roadmap for Lao PDR will be an important step to providing a clear vision and a cohesive pathway for the transition. The roadmap should include short-, medium- and long-term priorities and responsibilities, as well as opportunities for collaboration within, among and between government bodies, the private sector, development partners, financial and research institutions and other key stakeholders.

3.30. Current circular economy initiatives in Public services: healthcare, education, public administration and science

Many of the initiatives listed earlier in the chapters on products that flow, last and expire involve aspects of policy, research and, sometimes, even knowledge sharing and education. Still, a few initiatives remain that have a significant policy, educational or scientific component (See page 99).

3.31. Circular GHG mitigation opportunities

Four public sector interventions are proposed. They focus on creating demand for circular economy goods and services through public procurement, tax reform, the development of a circular economy roadmap and advancing education on the circular economy.



Lao Friends Hospital for Children

Children's hospital combines waste management with hygiene

The Lao Friends Hospital for Children in Luang Prabang worked with the World Health Organization to improve waste management, adopt recycling, and improve water and sanitation activities.⁴³¹ In 2005, a Japanese scholar estimated that healthcare waste in Lao PDR amounts to 0.62 kg per bed per day in Vientiane municipality and 0.38 kg per bed per day in Bolikhamxay province.⁴³²



Global Green Growth Institute (GGGI)

Recycling banks at schools

The Global Green Growth Institute has initiated waste recycling banks in schools in Vientiane. It is also conducting the Zero Waste project, where young people use creative approaches to address environmental problems through waste management.



Agro-ecology Learning Alliance in Southeast Asia (ALiSEA)

Knowledge sharing and education on agroforestry

Other agroforestry systems initiatives include the Agro-ecology Learning Alliance in Southeast Asia (ALiSEA)⁴³³ and the Agro-Biodiversity Initiative in the Lao PDR (TABI).⁴³⁴ The IDEP Foundation, PERMATIL and GreenHand also developed a permaculture manual⁴³⁵ for Lao PDR in 2019.



Association of Southeast Asian Nations (ASEAN)

Environmentally-friendly schools

The ASEAN Eco-School Programme aims to make schools more environmentally friendly. It has been implemented at the National University of Laos with oversight by the ASEAN Working Group on Environmental Education. This group developed a Guideline on ASEAN Eco-Schools.⁴³⁶



National University of Laos

Plastic Waste Management Training Centre

The faculty of environmental sciences at the National University of Laos launched a plastic waste management training centre, cooperating with universities in Europe and Vietnam and private companies from Laos and Vietnam.⁴³⁷



Ministry of Agriculture and Forestry

Education and R&D to phase out pesticides

The 2017 Decree on Pesticide Management, Article 37, stipulates that the Ministry of Agriculture and Forestry, the Ministry of Education and Sports and other concerned parties should develop curriculum for best practice pesticide management and promote R&D to support the gradual substitution of chemical pesticides with eco-friendly alternatives.⁴³⁸



Department of industry and handicraft

Paper from recycled chopsticks

The Department of Industry and Handicraft in the Ministry of Industry and Commerce is developing energy efficiency audit guidelines for industry and a biofuel strategy. It is working with industries such as the Vern Kham salt processing plant to implement biomass pelletization equipment. With Khammouane Cement Laos, it supports the development of cement bags from recycled plastic and (although this is less circular) the use of refuse-derived fuel in cement production. Working with a chopstick company in Sang Thong District, Vientiane, the department is creating worship paper from recycled chopstick waste.

3.32. Intervention 12: Circular procurement by the government



Strategy description

Circular procurement involves integrating circular economy requirements into the procurement of goods and services. It aims to offer a competitive advantage to more sustainable products and service providers in procurement processes.⁴³⁹ Examples of such requirements include minimizing greenhouse emissions throughout the whole lifecycle of the investment, for example, by requiring a certain amount of recycled or regenerative content in products, requiring that packaging is compostable, or requiring a take-back scheme for the end of a product's lifetime.

Lao PDR's state budget is approximately \$3.4 billion. In 2018, the government allocated \$286 million to infrastructure and public works.⁴⁴⁰ Such public investments in infrastructure create emissions during construction and the production of construction materials of around 143,000 tCO_{2e}/year, while requiring the extraction of 800,000 tonnes of raw materials.⁴⁴¹ Given the raw material requirements of the Boten-Vientiane railway alone and comparing them with the volumes of materials required for a Swedish railway line,⁴⁴² around half of those 800,000 tonnes are used for railway construction.

If the government links circular requirements to the issuance of licences, investments in infrastructure, and issuance of land and concessions, government expenditure and international donor funding can become a driver for circular design, investments and innovation. In addition, in partnership with development partners, the government could emphasize the importance of further reducing the environmental impact of large investments.

International examples

Southeast Asian countries such as Thailand, Malaysia and Singapore are using green procurement. Circular procurement principles could easily be integrated into an existing green procurement programme and in practice, at least some circular procurement principles are probably already part of these programmes.

The Thai Ministry of Natural Resources and Environment introduced the Thai Green Public

Procurement Promotion Plan in 2005. The initial plan ran from 2008 to 2011 and aimed to increase government spending on environmentally preferable products and services. The second stage ran from 2013 to 2016 and expanded the range of products covered and the third stage expanded the target group to include local authorities, private sector businesses, and the general public.⁴⁴³ By 2016, the government reported 52,406 tonnes CO_{2e} in avoided GHG emissions,⁴⁴⁴ doubling the 2014 figure.

The Thai Green Public Procurement Promotion Plan includes:

- specific targets for green procurement;
- rewards for offices with good green public procurement performance;
- rewards for manufacturers or service providers that consistently deliver green products or services;
- comprehensive targets and metrics related to the performance of the Green Public Procurement Promotion Plan, including the measurement of national expenditures on green products, and estimating the GHG emissions saved by green procurement;
- an electronic platform for managing green public procurement information;
- a database of green products and services;⁴⁴⁵ and,
- training workshops.

However, unlike Japan, Thailand did not allocate a specific budget to green procurement.⁴⁴⁶

The Netherlands' Public Procurement Expertise Centre provides trainings and collects and shares experiences on circular procurement.⁴⁴⁷ The institute recognizes the importance of creating demand for circular products and services to drive the transition to a circular economy.⁴⁴⁸ Through a green deal, several banks and large companies made a joint commitment to circular procurement.⁴⁴⁹

In 2015, UNEP identified the potential of product-service systems to reduce the environmental impact of public procurement.⁴⁵⁰ International examples include municipalities that procure services to modernize and operate the municipal lighting network in cities such as Belo Horizonte, Brazil.⁴⁵¹

Policy framework

The main procurement-related legislation includes the 2017 Law on Procurement Using State Funds, which provides the legal framework for procurement using state funds, and the 2019 Instruction on the implementation of the Law on Procurement Using

State Funds,⁴⁵² which covers principles, procedures and procurement criteria using state funds.

Both the law and instruction on public procurement relate to 'business as usual' and emphasize cost, quality and safety. They do not provide instruction or incentives for circular economy-related procurement. Further, the World Bank's support for public procurement through the Lao PDR Public Finance Management Reform Project⁴⁵³ does not include a focus on 'green' or circular economy-related procurement.

Business case

The financial aspects of circular procurement can only be assessed for a specific case. While it might come at an initial cost for the government, because it taps into existing funds for the procurement of goods and services, it can be far more effective than other policies, such as subsidies, in encouraging the private sector to develop circular products and services.

In addition, circular procurement can reduce government spending in the long run by avoiding the negative externalities of linear value chains and encouraging the use of durable products with a higher end-of-life value. Circular contracts, where a service rather than a product is procured, align both contractual partners on the need to minimize resource and product use. This also allows the supplier to mitigate risks associated with access to material resources and price volatility. When the supplier's business model focusses on selling as many products as possible, this conflicts with the interests of the purchasing party and with goals to reduce resource use.⁴⁵⁴

Next steps

Circular procurement in Lao PDR could be implemented by:

- integrating green procurement requirements into existing public procurement policies based on regional examples such as the Thai Green Public Procurement Promotion Plan or Malaysia's Green

Government Procurement Guidelines;

- developing a strong legal framework with support from the national government, which is essential;
- developing clear product criteria and ecolabelling schemes that simplify the green public procurement process;
- building the capacity of procurement staff and other stakeholders;
- introducing monitoring systems to ensure positive social and environmental impacts;⁴⁵⁵ and,
- initiating pilot projects to gain experience.

Impact

The estimates below are based on the 2020 government budget of \$3.42 million. This amount typically produces an estimated 640,000 tCO_{2e} through materials production and during construction.⁴⁵⁶

There is no proxy for the mitigation potential of circular procurement, but assuming that circular procurement can reduce the carbon footprint of government expenditures by 20 percent, this generates a mitigation potential of 129,000 tCO_{2e}/year. Adding circular procurement by investment partners – and considering foreign investment in the Boten-Vientiane railway – increases the potential significantly.

However, this impact overlaps with interventions such as the use of fly ash as a clinker substitute in cement production, the promotion of wood-based construction, and the re-use and recycling of construction and demolition waste. Therefore, it is not included in estimates of the total GHG mitigation and sequestration impact of implementing the circular economy in Lao PDR.

GHG mitigation potential (MtCO _{2e} /year)	
2030	0.14
2040	0.14
2050	0.15

This mitigation potential overlaps with that in Interventions 1 to 11.

3.33. Intervention 13: Align the tax regime with sustainable development ambitions



Strategy description

A recent study in Bangladesh showed that prioritizing environmental levies, rather than income tax, as a source of government revenue can help countries remain on track to achieve the Sustainable Development Goals.⁴⁵⁷ UN Secretary-General António Guterres summarized this approach, saying, 'We should tax pollution, not people.'⁴⁵⁸ A carbon tax is the leading candidate for a pollution tax. A World Bank study found that a carbon tax of \$30/ tonne of CO₂e would provide enough revenue to double the current levels of social assistance in 60 countries.⁴⁵⁹ Similarly, a levy of \$0.12 per litre on diesel and petrol could close historic gaps in budget and investment requirements for adequate road maintenance.⁴⁶⁰

According to the World Bank, unemployment in Lao PDR reached 23 percent in 2020, up from 16 percent at the end of 2019. The sectors most affected by travel restrictions and lockdowns in response to COVID-19 are tourism and transport.⁴⁶¹ In the national statistics, the 2020 unemployment rate reported a lower rate of 9.4 percent.⁴⁶²

Lao PDR has a progressive income tax, with rates rising from 0 percent for annual incomes below \$1,626 to 25 percent for annual incomes above \$81,316.⁴⁶³ In a country with rising unemployment rates, taxing labour may conflict with the goal of creating sufficient job opportunities. It also conflicts with the ambition to shift the Laotian's economy focus on economic growth based on natural resource extraction and capital-intensive infrastructure investments and emphasize human resource development.⁴⁶⁴

Shifting taxes from labour onto pollution and excessive resource use can be a budget-neutral way to support a transition to human resource-oriented, rather than natural resource-oriented, economic development. Introducing a carbon price is an effective way to encourage low-carbon development.⁴⁶⁵ It would also be consistent with regional trends, as China, Thailand and Vietnam are already planning or operating national and sub-national carbon pricing schemes.⁴⁶⁶ Introducing carbon pricing in Lao PDR also reduces the risk that the export of carbon-intensive exports from Lao

PDR become subject to import levies by importing countries that have adopted a carbon pricing policy. An increasing number of countries with carbon pricing instruments in place are considering carbon border adjustments to protect national decarbonization ambitions.^{467, 468}

Lao PDR could also consider protecting its own environment through import restrictions on carbon-intensive goods for which sustainable and less carbon intensive domestic alternatives are available. This could include imposing levies or bans on products that contribute to environmental degradation. Although import restrictions are controversial, as they disrupt the free flow of goods and competition, the WTO supports their use to pursue environmental policy goals.⁴⁶⁹ (Lao PDR has been an WTO member since 2013.⁴⁷⁰)

If the public is to accept subsequent price increases for certain carbon-intensive goods, government communications must link taxes on certain carbon-intensive products to the reduced income tax.⁴⁷¹ In addition, the proper allocation of energy taxes could improve public sector financing.⁴⁷² Revenues from carbon taxes or import levies on carbon-intensive products can be used to support circular entities in Lao PDR and encourage sustainable and renewable means of production, including renewable energy.

International examples

Several countries have adopted environmental tax reforms to cut GHG emissions. Sweden has the highest carbon price, with a carbon tax rate of \$137/tCO₂e.⁴⁷³ The country also reduced its VAT on repair services to extend product lifetimes.⁴⁷⁴ The highest carbon price levels across Asia can be found in Shanghai and Guangdong, at \$6/tCO₂e. Beyond Europe and North America, South Africa has the highest carbon price, at \$9/tCO₂e.⁴⁷⁵

Singapore has established a Green Finance Industry Task Force, convened by the Monetary Authority of Singapore (MAS). One of its tasks is to develop a taxonomy that sets out clear definitions and criteria for green businesses.⁴⁷⁶

Ex'tax is a Dutch foundation that promotes tax reform. It supports counties with an economy-wide analysis of the impact of introducing a carbon tax and reducing taxes on labour. The foundation launched such studies for the EU, Finland, the Netherlands and Bangladesh.⁴⁷⁷



23%

According to the World Bank, unemployment in Lao PDR reached 23 percent in 2020

Policy framework

The government of Lao PDR considers financial policy an important instrument to reduce waste, pollution and GHG emissions.⁴⁷⁸ The Ministry of Finance is developing a Law on Land Tax and a Law on Environmental Tax, which is expected to be enforced by 2025. The current 2019 Law on Income Tax and the 2021 Guideline on Granting Investment Promotion Incentives on Profit Tax and State Land Rents and State Land Concession Royalties introduce incentives for businesses, including those involved in renewable energy and recycling, and allow them to request a tax reduction.

Other tax incentives are:

- Law on Income Tax (2019) – Companies using green technology are subject to a lower Profit Tax of 7 percent;
- Law on Excise Tax (2019) – Imports of vehicles that use clean energy (electricity, solar, wind and other renewable energy) are subject to a low excise tax (0-3 percent);⁴⁷⁹
- Law on Value Added Tax (2018) – Imports of some products, such as raw materials used in the production of bio-fertilizers and equipment or machinery for the agricultural sector, qualify

for VAT exemption; and,

- Law on Investment Promotion (2016) – Environmentally friendly businesses located in remote, impoverished areas without favourable infrastructure qualify for a 10-year profit tax holiday. Similar businesses located in areas with favourable infrastructure qualify for a 4-year profit tax holiday.

These laws and guidelines do not provide a clear definition of what constitutes an environmentally friendly businesses or a 'green technology'. The tax laws also do not currently provide tax incentives for the repair and remanufacture of goods, sharing models or the use of secondary materials.

Business case

Circular business models tend to require more human resources and less finite natural resources. The focus on innovation, customization and more personal attention and customer service than are required in selling mass-produced goods under a 'business-as-usual' approach. Circular business models face prohibitive barriers in regulatory environments where pollution and primary resources are tax-free or, even, subsidized and labour costs are high.⁴⁸⁰

Next steps

The next steps in adjusting the tax regime to support progress on the Sustainable Development Goals could include the following:

- Commission an economy-wide study to examine which tax reforms are most effective in supporting progress across the Sustainable Development Goals, including poverty reduction, decent job creation, climate action and reducing pollution to safeguard the health of people and eco-systems.
- Consider introducing carbon pricing, following examples from neighbouring China, Vietnam and Thailand. A carbon price would discourage the use of carbon-intensive resources in production and manufacturing, giving circular products and design an economic advantage.
- Consider developing and incorporating a specific definition of 'environmentally friendly business' to promote more circular business practices.
- Consider fast tracking development and implementation of the proposed environmental tax.
- Consider using tax revenues to support circular economy-related initiatives, such as decentralized renewable energy and sustainable transport, or, perhaps, reduce the income tax for companies implementing circular economy-related activities or providing circular products or services.

Any effort to align the tax regime should be based on an understanding of how to support the more vulnerable members of the population – specifically, those who lack the means to adapt to changing economic incentives. Tax reforms can be introduced gradually to allow the private sector and the population to adapt. Communication on the tax regime change must convey that the changes are not designed to raise more taxes but to ensure sustainable development to the benefit of all income brackets. The reforms can be designed to be budget neutral or, even, budget positive for the country's lower-income brackets, thereby helping to alleviate poverty.

GHG mitigation potential (MtCO₂e/year)

2030	4.8
2040	5.1
2050	5.3

This mitigation potential overlaps with that in Interventions 1 to 11.

Impacts

According to the IMF, a carbon price of \$25/ tonne CO₂ could reduce Lao PDR's CO₂ emissions by 25 percent. When the tax is increased to \$75/tonne, the mitigation impact would increase to 45 percent. This analysis assumes a carbon price of \$25/tonne CO₂; this would reduce the 21.5 million tonnes of fuel-related CO₂ emissions by 5.4 million tonnes CO₂e/year.

This potential partly overlaps with the mitigation potential from interventions listed earlier, such as modal shifts in transport and the substitution of carbon intensive materials. Because of this overlap, this mitigation potential is not used to calculate the total mitigation and sequestration potential of circular economy interventions.

3.34. Intervention 14: Develop a circular economy roadmap



Strategy description

The Government of Lao PDR could develop a national circular economy roadmap. It could propose a sequence of interventions that support the transition to a circular economy, while assigning tasks and responsibilities to government bodies and non-state actors.

The first activities included in the roadmap should seek to improve the coordination of circular economy efforts within the government and stimulate private sector stakeholders to adopt circular economy principles. To achieve these objectives, the roadmap could propose to establish an interministerial Circular Economy Task Force and a Circular Economy Hub; this proposal was also made during early stakeholder consultations on the policy framework for the circular economy in Lao PDR.

The Circular Economy Task Force could begin by developing a circular economy taxonomy of circular economy activities aligned with international guidance, such as the EU Categorisation System for the Circular Economy or World Bank guidance. This taxonomy is the foundation for government policies and financial incentives that seek to give circular business a competitive advantage over its linear incumbents. Other activities would involve ensuring implementation of the recommendations from the policy analysis,⁴⁸¹ long-term strategy⁴⁸² and metabolic analysis⁴⁸³ that require government involvement.

The hub would foster new collaboration and knowledge transfer intended to share and disseminate information on domestic and international best practices, circular finance, circular business models and insights from the research community. It could also play a role in monitoring progress on the transition to a circular economy through a set of well-defined national circular economy indicators. In support of Intervention 15, the hub could coordinate development of educational programmes on the circular economy. It could also coordinate programmes that are circular by nature but may not yet be described as such and share and develop information on circular economy market opportunities. As such, the hub could support the private sector and the education

and scientific communities to play their role in adopting the recommendations and interventions in the metabolic analysis and the long-term strategy.

The Community of Practice (CoP)⁴⁸⁴ organized in 2020 and 2021 under the auspices of this project could serve as a model for coordinated stakeholder engagement to drive circular change. The community involved repeated interactions with businesses and policymakers through a pre-competitive learning trajectory. Participating businesses have reported experiencing a disconnect from the policy community and difficulties navigating the policy framework, as well as insufficient access to finance and other necessary resources. These obstacles could be overcome through collaboration and knowledge transfer. Moreover, during the Community of Practice gatherings participants were able to share information and best practices. They indicated a need to institutionalize this kind of peer network.

International examples

Several countries have developed circular economy roadmaps, government-led task forces and hubs. Finland launched its roadmap in 2016.⁴⁸⁵ The Circular Economy Initiative Deutschland (CEID)⁴⁸⁶ and cities like Amsterdam⁴⁸⁷ soon followed its pioneering. The Ellen MacArthur Foundation has launched an overview of circular economy opportunities in India⁴⁸⁸ and a Chilean roadmap is being developed.⁴⁸⁹

Singapore's Green Finance Industry Taskforce offers another example from the region. Its mandate is to accelerate green finance.

It includes four initiatives:

1. Develop a taxonomy;
2. Enhance environmental risk management practices of financial institutions;
3. Foster green finance solutions; and,
4. Improve disclosure.

Examples of circular economy hubs include the National Circular Economy Research Hub,⁴⁹⁰ led by United Kingdom Research and Innovation (UKRI). It brings together industry, academics, policymakers and civil society to deliver a more inclusive, restorative and competitive UK circular economy. The Holland Circular Hotspot is a private-public platform through which stakeholders promote knowledge exchange on Dutch circular economy.⁴⁹¹

In addition, the Australian Circular Economy Hub⁴⁹² aims to facilitate the transition to a circular economy in Australia and act as a 'one-stop shop' for all things circular in Australia. Closer to Lao PDR,

the Indonesia Circular Economy Forum⁴⁹³ brings together stakeholders to identify challenges and develop solutions and recommendations to implement Circular Economy movement in Indonesia.

Policy framework

Existing organizational capacity can serve as the basis for building the circular economy. The circular economy hub could be incorporated into Lao PDR's Green Growth Promotion Centre, which was established in 2017. The mandate of the National Steering Committee for Green Growth⁴⁹⁴ could also be expanded to include the transition to a circular economy.

The 2015 Law on Business Competition defines principles, regulations and standards on management and monitoring of business competition. The law does not currently consider beneficial coordination and communication among businesses to support a circular economy. Although earlier studies were commissioned on the circular economy in Lao PDR, no detailed roadmap sets out short and long-term activities and the various stakeholders' responsibilities to support the transition to a circular economy.

Business case

Collaboration for the circular economy has been shown to produce multiple benefits for the stakeholders involved, including optimized financial and human capital, improved access to markets and knowledge, enriched creativity, increased efficiency, access to finance and competitive advantage.⁴⁹⁵

Next steps

Next steps could include:

- Expanding the terms of reference for the existing National Steering Committee for Green Growth⁴⁹⁶ and converting it into an inter-agency Circular Economy Taskforce to promote collaboration among government agencies and with the private sector and development partners to facilitate the transition to a circular economy;
- Recasting the Green Growth Promotion Centre as a Circular Economy Hub supported by the Government of Lao PDR, development partners and private sector stakeholders to facilitate knowledge sharing, education, matchmaking and other activities aimed at accelerating the transition to a circular economy;
- Once the Inter-Agency Circular Economy Taskforce is established, supporting development of a detailed circular economy roadmap; and,

- Assigning tasks to ensure that the recommendation based on the policy analysis, metabolic analysis and long-term strategy is implemented in coordinated fashion; and,
- Developing legislation to support investments in circular economy ventures and which can support securing financing for green procurement, facilitate tax cuts for circular economy activities, green procurement and circular economy solutions to solid and hazardous wastes.

Impacts

The impacts of the roadmap, hub and task force are crucial, but they are hard to quantify in terms of environmental and socio-economic impacts. The main impact lies in creating a coalition of stakeholders interested in scaling the circular economy, paving the way for informal knowledge and information exchange and business partnerships, and jointly addressing challenges to scaling circularity.



The circular economy roadmap could propose to establish an interministerial Circular Economy Task Force and a Circular Economy Hub

3.35. Intervention 15: Integrate the circular economy into school curricula



Strategy description

The circular economy can be both taught and practiced in educational institutions, equipping the future workforce with the qualifications required in a circular future. During stakeholder consultations, participants issued a strong call to integrate circular economy principles into schools' and higher education curricula and improve overall environmental awareness. This call was echoed by government bodies.

The Ministry of Education could take the lead in developing educational programmes that educate students on the principles of the circular economy and create awareness of the environmental issues it could address. Business schools can focus on circular business and revenue models and couple with business incubators that support circular economy start-ups and broker seed funding. Dedicated funds could target rural areas, with educational programmes on green community development and the circular economy.

In addition, educational institutions could adopt circular economy practices, including waste recycling and reduction, circular procurement of goods, services, the circular design of buildings, and, even, collecting and recycling materials such as plastics and composting organic waste.

Education on circular economy business models becomes more compelling when they are put into practice. Dave Hakkens, founder of the NGO, Precious Plastics, developed a platform for open source, do-it-yourself guidelines for building a recycling facility that makes consumer products or art from secondary plastics.⁴⁹⁷ Schools or classrooms could also pilot projects that produce mushrooms from coffee grounds; small-scale starter kits are available.⁴⁹⁸ On a larger scale, crowdsourced plastic waste could be used to manufacture tiles for the façade of a new school building.⁴⁹⁹

International examples

The Finnish Innovation Fund, SITRA, which operates under the supervision of the Finnish Parliament, has developed circular economy teaching materials for primary, upper secondary and vocational schools. These materials include the circular classroom,

sustainability self-tests, and adventure games. Most of the materials are available in English.⁵⁰⁰ For higher education, the Ellen MacArthur Foundation offers learning programme platforms for collaboration among educational institutions that want to incorporate the circular economy into their curricula.⁵⁰¹

WasteAid provides a waste management toolkit for communities in lower- and middle-income countries. The kit includes guides on topics such as producing biogas from organic waste and animal feed from fish waste, composting and creating value from secondary plastics.⁵⁰²

Closer to Lao PDR, the Malaysia-based Circular Asia Association has developed training programs, including Circular Economy Asia. The association is also planning to develop an educational course for the circular economy.⁵⁰³

Policy framework

Under several initiatives, circular economy-related material has been adopted in learning institutions. For example, primary and secondary schools in Lao PDR introduced an environmental science subject to raise awareness on the environment and resource efficiency. To date, specific learning materials on the circular economy have not yet been integrated into educational curriculum in Lao PDR.

The 2020 Law on Higher Education aims to establish principles, manage and monitor the operation of higher education. The core objectives of its strategic plan are to develop human resources who have the mental and physical abilities to help implement the country's socio-economic development plans. The 2020 Decision on Lifelong Learning aims to provide all Lao citizens access to formal and informal learning opportunities to develop their full potential and contribute to national socio-economic development.⁵⁰⁴ Finally, the Education and Sports Sector Development Plan for 2016-2020 and its vision and strategy to 2030 also seek to improve quality of human resources in terms of skills, knowledge and capacities in order to contribute to socio-economic development.⁵⁰⁵

Finally, efforts to improve education should consider promoting access to education for girls and women, particularly to secondary and higher education, to decrease gender disparity.⁵⁰⁶

Business case

Integrating circular economy principles into school

curricula is an investment in human resources for the long-term. It helps create environmental awareness, supporting the creativity that circular design, innovation and start-ups require. It can also create momentum for policy reform and for large corporations to adopt circular business models.

Next steps

The next steps towards implementing circular economy curricula include the following:

- A newly established Circular Economy Taskforce could consider collaborating with development partners to develop circular economy training programmes for government staff and other stakeholders to facilitate the transition to a more circular economy.
- The government should build on existing environmental education initiatives to integrate circular economy concepts into school curricula and training programmes at all levels to help raise awareness and build skills and knowledge about the circular economy. This could involve using and adapting circular economy training materials and

guidelines developed by SITRA, Ellen MacArthur Foundation, WasteAid or, perhaps, the Circular Asia Association.⁵⁰⁷

Impact

The impact of education becomes apparent in the long run when trained professionals enter the labour market. In the short term, the direct application of circular solutions in classrooms can reduce GHG emissions. Most of the impact lies in the long term, however, but it is difficult to make a solid estimate of that potential.

For this analysis, options such as the production and use of biogas, composting and plastics recycling are assumed to avoid 1.0 tonne CO₂e per classroom, or 40 kg per student. For comparison, the carbon footprint of students in nearby China is 3.48 tCO₂e/year.⁵⁰⁸ Lao PDR has some 52,000 classrooms.⁵⁰⁹ The education mitigation potential is not included in the Lao PDR totals, as it overlaps with several of Interventions 1-11.



During stakeholder consultations, participants issued a strong call to integrate circular economy principles into school and higher education curricula

GHG mitigation potential (MtCO ₂ e/year)	
2030	0.055
2040	0.058
2050	0.061

This mitigation potential overlaps with that in Interventions 1 to 11.

Commercial services: Tourism

16



3.36. Commercial services: Tourism

Circular initiatives are not limited to highly material-intensive sectors or public services. Commercial services also play an important role in accelerating the transition to a circular economy.

These services include tourism, wholesale, retail trade, vehicle repair, tourism and transport. They represent 38 percent of GDP and 14 percent of employment. Previous sections discussed interventions related to food value chains and packaging (trade), public, active and shared transport (transport) and vehicle repair (remanufacturing). Only tourism remains.

Lao PDR is an important tourist destination and the leisure industry contributes 3 to 4 percent of GDP. Tourism also deserves specific attention since it is one of the fastest growing sectors in Lao PDR and its sustainable growth is a national development priority.

3.37. Current circular economy initiatives

Commercial services: Tourism. (See list on page 111).



Nam Khan Ecology

High-end ecotourism

The luxury ecotourism resort, Nam Khan Ecology, near Luang Prabang invites guest to reconnect with nature. It has an organic farm that aims to preserve traditional knowledge on agricultural organic production and develop new expertise.⁵¹⁰



Eco-guides monitor nature conservation efforts⁵¹¹

The Nam Ha National Protected Area in northern Lao PDR covers 222,400 hectares. Since 1999, conservation efforts have been linked to generating new income sources through ecotourism. By training eco-guides to monitor threats to biodiversity, they support the work of the under-resourced Protected Area Management Unit.⁵¹²



Green Discovery Laos

Ecotourism to invest in nature protection and communities

As an ecotourism organization, Green Discovery Laos develops tourist tours in nature, involving communities. Some of the revenues are re-invested in the communities involved and in nature protection.⁵¹³



Wildlife Conservation Society (WCS)

Ecotourism to support rangers

In the Nam Et-Phou Louey National Protected Area, the Nam Nern Night Safari aims to protect tigers and their prey. The ecotourism project generates funds to support rangers who go on long patrols collecting snares, looking for signs of poachers, and monitoring wildlife. The project was initiated by the Wildlife Conservation Society.⁵¹⁴



Sea Lao

Equal education, ecotourism and environmental awareness

Sea Lao Project combines ecotourism and volunteer programmes with educational programmes for local communities, developing and selling local products, and promoting environmental awareness. Activities including running organic gardens, biogas systems, sustainable architecture and water projects.⁵¹⁵



Ecotourism Laos

Circular ecolodge design and operation

Although circular design was not a common term in 2005, the Guidebook for the Design and Operation of an Ecology in Lao PDR uses circular design principles. Examples are the sections on the use of local construction materials, selective rather than full clearing of plots, and use of solar heaters.⁵¹⁶



Mekong Institute

Sustainable cargo logistics

The Mekong Institute ran a programme to improve fuel efficiency in logistics, while also supporting transport companies by improving transport safety for dangerous goods and materials. The programme received support from Switch Asia.⁵¹⁷

3.38. Intervention 16: Ecotourism supported by local communities



Strategy description

According to the journal, Nature Climate Change, tourism's global carbon footprint is 8 percent, mostly from travel, shopping and food consumption. With an annual growth rate of 4 percent, it is outpacing the decarbonization potential of technological progress in the sector.⁵¹⁸ Ecotourism can help reduce tourism's environmental footprint.

Lao PDR receives approximately 4 million tourists/year and the number of international visitors is growing.⁵¹⁹ Between now and 2030, ecotourism could become more significant economically by increasing its contribution to jobs and GDP from some 4 percent to 10 percent. This growth would build on the potential of the country's natural assets, such as its evergreen forests, karst landscapes, and montane forest that are home to internationally significant biodiversity. Fifteen percent of the country's land area is already held in a national reserve. By alleviating poverty in communities near or in protected areas, ecotourism can become the largest rural employer,⁵²⁰ thereby eliminating drivers for the unsustainable exploitation of natural resources, including deforestation.

The COVID-19 pandemic has led to a serious decline in tourism. Combined with falling trade volumes and rising food prices, these developments increase food insecurity.⁵²¹ Ecotourism could be one of the pillars of recovery efforts.

International examples

Costa Rica markets itself as an ecotourism destination, offering ecolodges and eco-adventure holidays, backed with a voluntary certification programme. The Dominican Republic's efforts show how community-backed tourism development can help engage local companies⁵²² and Bali's initiatives highlight actions to reduce tourism-generated plastic waste.⁵²³

The benefits of ecotourism extend beyond tourism alone. Experience from Bhutan and Lesoto shows that promoting tourism also showcases a country as an investment prospect: a place to invest, live, study and work. On the other hand, experience from Kyrgyz Republic and Rwanda underscores

the importance of political leadership to coordinate efforts across sectors, ideally guided by a national tourism strategy.⁵²⁴ Lao PDR has done well in that respect, with a comprehensive tourism policy and law.⁵²⁵

Policy framework

Strategies and legislation already support ecotourism in Lao PDR. The 2021 9th NSEDP, Output 2 of Outcome 4, targets the promotion of participatory ecotourism, which both creates jobs and protects the environment. Four documents pursue these objectives.

- The 2020 Order on Strengthening the Strictness of Management, Monitoring and Inspection of Ecotourism Activities in Protected Areas and National Parks, which states that the Government of Laos supports individuals and businesses operating eco-tourism activities in protection forests.
- The 2013 Tourism Law, which defines ecotourism in Lao PDR, while the National Green Growth Strategy anticipates the development and implementation of green tourism standards.⁵²⁶
- The 2006-2020 Lao PDR Tourism Strategy, which aimed to develop Lao PDR as a world-renowned tourism destination by promoting the country's cultural, natural and historical attractions in a sustainable and participatory manner.
- The initiative to develop a tourism recovery roadmap or plan for Lao PDR, which seeks to help the tourism sector recover from the decline in tourism activities as a result of the COVID-19 pandemic.⁵²⁷

In addition, a growing number of businesses now provide ecotourism destinations or services in Lao PDR, such as EXO Travel, Nam Khan Ecolodge, Green Discovery and Phou Lu Eco-Tourism. Development partners providing significant support for ecotourism development in Lao PDR include, but are not limited to, the UN, World Bank, Asian Development Bank, SWITCH-Asia and GIZ. Selected recent examples include the World Bank's support for nature-based tourism as a strategic sector for green growth in Lao PDR.⁵²⁸

Business case

The business case for ecotourism is very site specific. According to the World Bank, the economic significance of ecotourism in Lao PDR could quadruple in 10 years, reaching \$600 million. This growth would also double tourism's contribution to Laotian GDP.

Next steps

Actions to encourage ecotourism include the following.

- The government should consider developing a green financing framework based on the regional examples implemented by ASEAN partner states. This could provide low-cost finance for eco-tourism development.
- Ecotourism operators should consider collaborating with the government, development partners and specialized environmental consultancies to better use environmental market instruments, such as payments for ecosystem services or carbon financing, to promote ecotourism in Lao PDR.
- Private investment in nature-based tourism could be enabled by reducing barriers, streamlining regulations and promoting innovation, while setting clear requirements to ensure that ecotourism activities contribute to preserving and improving the quality of natural assets.
- Provide vocational training in ecotourism and hospitality, including training for local guides and accommodation providers.
- Support international certification of ecotourism initiatives.
- Develop master plans for tourism in national protected areas, including solutions for waste management from tourism activities and last mile infrastructure.⁵²⁹
- Encourage tourism companies to adopt green building standards that rely on domestic construction materials and construction traditions, also applying the 'leave no trace' principle for the long term.
- Prioritize the use of local products to reduce the disposal of waste from tourism activities in areas that lack waste processing capacity to manage non-native waste materials.
- Finally, support modal shifts and transport electrification under Interventions 9 and 10 and prioritize regenerative construction materials (Intervention 6) to help preserve the appeal of urban centres to Laotians and foreign visitors.

Impact

According to UNEP, hotels and restaurants alone contributed 3.5 percent to national GHG in 2015. Applying that to the country's 2019 emissions level and excluding the 23 percent related to international travel, that translates to approximately 2.0 million tCO₂e.⁵³⁰

Ecotourism can shrink this carbon footprint. Staying at small family-run accommodations rather than major hotel chains can reduce the accommodation footprint by 48 percent. Buying local and organic food reduces the food footprint by 5 percent and electrified or active transport modalities can reduce the ecological footprint of local travel by 40 to 100 percent.⁵³¹

Assuming that these ecological footprints are a good proxy for GHG emissions, these mitigation potentials can be applied to the share of the contribution of each emission source to tourism's overall carbon footprint.⁵³² This generates a reduction potential in Lao PDR of 590,000 tCO₂e/year. Since this potential overlaps with the GHG mitigation and sequestration potential estimates for other sectors, it has not been added to estimates of the country-wide totals.

GHG mitigation potential (MtCO₂e/year)

2030	0.75
2040	0.79
2050	0.83

This mitigation potential overlaps with that in Interventions 1 to 11.



Financial services

17

3.39. Financial services

In the sector overviews in section 1.4 of this report, commercial services involve financial intermediation, business activities, postal services and telecommunications. They provide 15 percent of GDP and generate 6 percent of employment. Financing is crucial to enable the transition towards a carbon-neutral and, perhaps, net carbon-negative, circular economy in Lao PDR. However, certain barriers must be overcome to realize that potential. These are addressed in Intervention 17.

3.40. Current circular economy initiatives in finance, insurance and real estate

See list on page 116.

Department of SME Promotion

Specific funding for small- and medium-sized enterprises

The Department of SME Promotion of the Ministry of Industry and Commerce created the SME Promotion and Development Fund in 2010. In 2018, its financial support package was expanded to include access to credit to entrepreneurs at 3 percent interest as well as technical assistance to SMEs.⁵³³



Green Climate Fund

Ecosystem-based climate resilience for cities

UN Environment is implementing a \$1.5 million grant programme to strengthen the natural capacity of ecosystems to regulate water flows and limit the exposure of populations in vulnerable areas to climate effects. Under the ecosystem-based approach, the project moves away from the traditional focus on grey infrastructure, such as dams and concrete drainage systems.⁵³⁴



World Bank

Enhancing SME's access to finance

Providing long-term funding sources for banks to make credit available to small and medium enterprises in Lao PDR. It combines a credit facility, with a risk sharing facility and technical support.⁵³⁵



Switch Asia

Funding for circular economy initiatives

The EU-funded Switch Asia programme targets SDG 12 on Sustainable Consumption and Production. Most of its programmes in Lao PDR focus on ecotourism, boosting national demand for organic food products and clean industrial production.⁵³⁶



Forest Carbon Partnership Facility

Reducing emissions from deforestation and forest degradation

The government of Lao PDR and the World Bank's Forest Carbon Partnership Facility have signed an agreement to provide up to \$42 million between 2021 and 2025 to support the country's efforts to reduce emissions from deforestation and forest degradation (REDD+).⁵³⁷

3.41. Intervention 17: Facilitate increased accessibility to circular finance and carbon finance



Strategy description

The analysis of the business case behind the 11 core circular economy interventions shows that the circular economy offers a \$4.1 billion opportunity to invest in Lao PDR's net carbon neutrality by 2040. For comparison, that capital expenditure is less than the \$5.95 million required for the Vientiane-Boten railway.⁵³⁸ In addition, 85 percent of the GHG abatement potential can be realized with a financial payback of less than six years.

Despite the attractive business cases, financing remains a major barrier that could prevent Lao PDR from becoming one of the first large economies that is net carbon neutral or even net carbon negative. Therefore, Lao PDR should establish a comprehensive green finance strategy aimed at attracting green investment, both foreign and domestic, and improving access to finance for circular businesses.⁵³⁹

The Community of Practice confirmed that 'Domestic private finance has been constrained by high interest rates on commercial borrowing and by lack of access to financing, particularly for small and medium-sized enterprises (SMEs).'⁵⁴⁰ Circular economy initiatives should also have access to favourable loan criteria. Smaller scale projects and activities that are not funded through private sector investment should have access to alternative financing mechanisms, such as seed funding, grants, and microloans. The amended Law on Investment Promotion took an important step in the right direction by eliminating an onerous minimum capital requirement for foreign investors.⁵⁴¹

Overseeing the major domestic and foreign GHG mitigation potential in Laotian food value chains, transport, forestry and wood-based construction, carbon finance can play a major role in attracting sustainable finance. Carbon prices in the European Union Emissions Trading Scheme exceeded \$70/tCO_{2e} in September 2021⁵⁴² and other European countries posted even higher prices. Closer to Lao PDR, subnational Chinese schemes are trading at \$6/tonne.⁵⁴³

Price levels in emission trading schemes have increased, partly by limiting the use of carbon offsets

or certified emissions reductions from sectors or geographies outside of the scheme. On the other hand, while demand for such 'compliance grade' offsets from certain trading schemes is decreasing, demand for voluntary offsets is increasing. These rising carbon prices and the growing awareness that effective carbon sinks are crucial to achieve deep decarbonization present a major opportunity for Lao PDR.

Article 6 of the Paris Agreement encourages international cooperation among countries to achieve deeper cuts in GHG emissions than they would be able to on their own. The modalities and procedures for this article are being developed and have not yet been implemented.⁵⁴⁴ The 26th Conference of the Parties in November 2021 should shed light on the modalities of Article 6, but the outcomes of that conference will be available only after this report has gone to print.

By introducing a domestic carbon price scheme – perhaps a gradually increasing carbon tax – Lao PDR can drive its transition to a circular economy and strategically position itself in negotiations on financial remuneration for products and services that it exports and that allow other countries to reduce their carbon footprint.⁵⁴⁵

The transition to a circular economy in Lao PDR also allows other countries to reduce their carbon footprint. This could amount to 46 million tCO_{2e}/year. At \$6/tonne, using Chinese price levels as a reference, this translates to \$276 million/year. That includes three elements:

- Eighty-nine percent comes from the export of wood-based construction materials produced in Lao PDR, but exceeds the volume that the Laotian construction sector can absorb. The abatement potential covers the carbon sequestration in harvested wood products and mitigation impact of substituting conventional construction materials. In the impact analysis, currently all mitigation potential is allocated to Lao PDR. In practice though, Lao PDR is providing the harvested wood products with sequestered carbon, while the recipient country needs to secure the permanence of the carbon stored, for example in its built environment. That could be a basis to negotiate a split allocation between Lao PDR and the recipient country where the wood-based building is situated.
- Five percent comes from the foreign mitigation potential of reducing the import of carbon intensive materials through circular economy interventions in Lao PDR.



\$276 million/year

The transition to a circular economy in Lao PDR supports GHG mitigation in other countries, valued at \$276 million annually

- Six percent comes from the mitigation potential of hydropower exports, considering the difference in grid emission factors between the importing country and Lao PDR.⁵⁴⁶ However, this is not listed as a circular economy intervention.

International examples

The Kingdom of Thailand's Sustainable Financing Framework⁵⁴⁷ establishes how the country will issue green, social and sustainability bonds and loans. Proceeds will be used to finance and refinance government loans or expenditures. A second-party opinion has confirmed that the framework meets international green bond standards.⁵⁴⁸

The United Kingdom developed a Green Financing Framework which describes how the government will finance expenditures through the issuance of green bonds. These will be used to invest in addressing climate change and other environmental challenges, funding infrastructure development and creating green jobs across the United Kingdom.⁵⁴⁹ Together with the Green Finance Strategy it aims to green financial systems, mobilize finance for clean and resilient growth, and capture opportunities for firms from the United Kingdom.⁵⁵⁰

Policy framework

The policy recommendations for the government are to:

- Consider developing a green financing framework based on the regional examples implemented by ASEAN partner states.
- Develop a circular economy taxonomy aligned with international guidance, such as the EU Categorisation System for the Circular Economy or World Bank guidance. The taxonomy should define circular or 'environmentally friendly' businesses or activities to improve access to existing tax incentives and green investment and opportunities in growing environmental markets.
- Consider introducing carbon pricing, following examples from neighbouring China, Vietnam and Thailand. A carbon price would discourage the use of carbon-intensive resources in production and manufacturing, giving circular products and design an economic advantage. It would also help position Lao PDR in negotiations for compensation for GHG abatement potential related to products that cross Lao PDR borders and whose composition may change as a result of the transition to a circular economy.

Business case

Investing in circular low-carbon development is commercially attractive. The payback time is an important metric to guide decision-making on investments in business environments that are perceived to be relatively uncertain. Six out of the 11 interventions have positive marginal abatement costs, while 85 percent of the mitigation potential has a payback of less than six years, even without the mitigation potential of stopping deforestation. That mitigation effort is not included in the mitigation potential of the circular economy interventions since it is already part of the NDC.

The Laotian government still has an important role in financing green growth,⁵⁵¹ but the regional trend shows growing private sector interest in driving sustainability investments in Southeast Asia. Overall, green investments increased by 60 percent to \$3.2 billion in the first half of 2019 over the same period a year earlier.⁵⁵² In response to COVID-19, many investors in the Asia Pacific region increased their environmental, social and governance investing.⁵⁵³ Facilitating investments in the circular economy would allow Lao PDR to tap into this growing market.

Next steps

The next steps towards enhancing access to finance for circular economy investments are to:

- Implement the National Green Growth Strategy: This includes recommendations to improve the environmental performance of investments, related to the legislative consistency, staff capacity and data availability and addressing 'non ethical and opportunistic practices'.⁵⁵⁴
- Develop a circular economy taxonomy. As already listed in Intervention 14, Lao PDR can ensure that funds are channelled towards the proper activities by developing a sustainable finance or circular economy taxonomy. The World Bank has released guidance for countries on developing these national green taxonomies.⁵⁵⁵

- Identify investment barriers: Lao PDR should commission a study to understand what the existing barriers to investment in Lao PDR and how to overcome them. This study should include options to introduce new incentives for green investments.
- Develop a strategy to attract green investment: Lao PDR should develop a plan to encourage investors, both foreign and domestic, to invest in the circular economy. It should include options to leverage international climate finance.
- Improve access to alternative financing mechanisms: Lao PDR should collaborate with international development partners and carbon and climate funds and allocate public funding to create effective finance mechanisms for circular projects. These could include funding schemes, grants, targeted credit lines and other mechanisms, and would allow businesses and projects that are not funded by private investors to access necessary funding.
- Position itself in climate negotiations: In preparation for the 26th Conference of the Parties, Lao PDR should take a strong position in the negotiations on international cooperation. It could launch Article 6 pilot transactions to gain experience with using the carbon markets to attract international investments to advance wood-based construction. This could be connected to the export of wood-based construction materials.

Impacts

Finance is a prerequisite for Interventions 1-11, which propose the adoption of circular economy principles in product and service value chains. The total investment required is estimated at \$4.1 billion, in addition to the \$4.7 billion already specified in the NDC. It would support and enable an ambition to reach net zero GHG emissions by 2040. The \$4.7 billion for NDC implementation is a prerequisite to realize the mitigation and sequestration of Interventions 1-11, but this potential also overlaps.

GHG mitigation potential (MtCO ₂ e/year)	
2030	17.7
2040	53.8
2050	66.3

This mitigation potential overlaps with that in Interventions 1 to 11.

Intervention	GHG mitigation (tCO ₂ e/year)			
	2030	2040	2050	
	Domestic		International	
Products that expire				
1 Reduce food losses	3.5	3.7	3.9	—
2 Expand climate smart agriculture	2.0	2.1	2.2	—
3 Improve livestock productivity	3.0	4.0	5.4	—
4 Produce biogas and organic fertiliser	1.8	2.1	2.6	0.51
5 Support agroforestry	-0.60	-0.63	-0.67	0.58
Products that last				
6 Prioritize regenerative construction materials	5.5	38	48	—
7 Implement industrial symbiosis ...	0.62	0.67	0.72	0.18
8 Recycle construction waste	0.093	0.10	0.11	—
Products that flow				
9 Promote active, shared and public transport	0.72	1.7	1.8	0.44
10 Electrify transport	0.66	1.5	1.6	0.35
11 Recycle municipal solid waste	0.46	0.50	0.54	0.14
Total/average	17.7	53.8	66.3	2.2
Public services: the policy framework				
12 Strengthen circular procurement	0.14	0.14	0.15	—
13 Align the tax regime	4.8	5.1	5.3	1.0
14 Develop a circular economy roadmap	n/a	n/a	n/a	—
15 Educate on the circular economy	0.055	0.058	0.061	—
Commercial services: tourism				
16 Promote ecotourism	0.75	0.79	0.83	—
Financial services				
17 Mobilise finance	75.9	79.8	83.9	—

Intervention	GDP potential	Job potential	Solid waste avoided	CAPEX
	million \$	full-time equivalent	avoided (t/year)	million \$
	Products that expire			
1 Reduce food losses	1,500	260,000	2,580,000	300
2 Expand climate smart agriculture	1,000	170,000	—	1,100
3 Improve livestock productivity	0,78	150	—	20
4 Produce biogas and organic fertiliser	40	6,900	610,000	56
5 Support agroforestry	260	44,000	—	115
Products that last				
6 Prioritize regenerative construction materials	12,000	960,000	—	1,100
7 Implement industrial symbiosis ...	940	170,000	610,000	100
8 Recycle construction waste	62	4,400	570,000	270
Products that flow				
9 Promote active, shared and public transport	60	n/a	n/a	980
10 Electrify transport	5,2	n/a	n/a	5,4
11 Recycle municipal solid waste	62	3,000	815,000	82
Total/average	16,000	1,600,000	5,200,000	4,100
Public services: the policy framework				
12 Strengthen circular procurement	n/a	n/a	n/a	n/a
13 Align the tax regime	n/a	n/a	n/a	n/a
14 Develop a circular economy roadmap	n/a	n/a	n/a	n/a
15 Educate on the circular economy	n/a	n/a	n/a	n/a.
Commercial services: tourism				
16 Promote ecotourism	n/a	n/a	n/a	n/a
Financial services				
17 Mobilise finance	n/a	n/a	n/a	n/a

3.42. Tabular overview of all 17 interventions

Eleven core circular GHG mitigation strategies and six enablers are proposed. Taken together, they can reduce national GHG emissions by 51 percent by 2030 and reduce them further to reach net zero by 2040. When implemented, these interventions would reduce national solid waste volumes by 5.2 million tonnes. Altogether, the circular economy opportunities identified represent a \$5 billion opportunity, which could create 3.8 million jobs.

Seven of the eleven circular GHG mitigation opportunities identified are in food or forestry value chains, representing 89 percent of domestic circular mitigation potential. The job creation potential of the interventions is also mostly in the agricultural and forestry sectors (See page 120-121).

3.43. Conclusion – Part 3

In conclusion, the metabolic analysis identified 17 interventions which apply circular economy principles to reduce GHG emissions. Altogether, these interventions can bring emissions in the year 2040 down from an emissions level in the baseline scenario of 106 million tCO_{2e}/year to below zero. By also continuing to increase the ambition of the NDC and the proposed circular economy interventions after their implementation is completed by 2030, Lao PDR can remain carbon neutral also beyond 2050. However, since the construction sector of Lao PDR is too small to use all wood-based construction materials which it could produce, the country will need to seek cooperation with trade partners to ensure the permanence of the carbon sequestered in these construction materials.

Depending on whether one considers the marginal abatement costs, the net present value or the payback time, over 85 percent of the circular mitigation potential is commercially viable. For the remainder, additional support will be required, for example by introducing a carbon tax or otherwise considering the negative externalities of linear value chains in government policies.

When all interventions are implemented, they can reduce domestic GHG emissions but also reduce domestic waste volumes with 5.2 million tonnes, and enable a foreign reduction in GHG emissions of 2.2 million tCO_{2e}/year, as a result of reducing the import of carbon intensive products.

Considering also the socio-economic impact, all 17 interventions together could create \$16 billion in GDP by 2040 and provide green jobs to 1.6 million people. These estimates are an indication of the size of the circular economy, not of the future increase in GDP as a result of a transition to a circular economy. This is because the estimates do not consider value reductions in the value chains whose products might be substituted for circular alternatives.

Annex A The metabolic analysis explained

Project activities

This report, and the process that led to its publication, supports an update of Lao PDR's latest Nationally Determined Contribution from March 2021 and provides a long-term strategy to support the ambition to achieve net carbon neutrality by 2050. Some of the project's early findings were integrated into the Nationally Determined Contribution which the Government of Lao PDR submitted to the UNFCCC in March 2021. This submission includes the country's GHG mitigation commitments under the Paris Agreement for the period up to 2030 and an ambition for the period up to 2050.

The project was commissioned by UNDP under the NDC Support Programme, which works in contribution to the NDC Partnership and receives generous support from the German Federal Minister for the Environment, Nature Conservation, and Nuclear Safety (BMU), the German Federal Ministry of Economic Cooperation and Development (BMZ), the European Union and the Government of Spain under the Climate Promise Programme.

This report assembles the results of the following five activities:

1. The metabolic analysis, which is the cornerstone of identifying circular economy opportunities with a high mitigation potential;
2. A stakeholder consultation and training programme, which involved trainings on the principles, business models, financing and policy aspects of the circular economy, along with public, private and combined public/private consultation workshops;

3. A long-term strategy, which included an analysis of the business cases of the circular economy interventions and proposed a long-term strategy to reach net carbon neutrality by 2050;
4. A policy analysis, which analysed the political framework of each of the circular economy interventions and proposed concrete policy interventions; and,
5. A Community of Practice, which brought local and international stakeholders together to collaborate in developing circular strategies to overcome potential barriers to implementing circularity.

Metabolic analysis to understand a circular future

The resource and energy efficiency of an economy is more than the sum of the efficiencies of all its parts. Decoupling economic growth from resource and energy use requires understanding how individual components operate. However, above all, it involves providing an overview of how individual elements interact and work together to deliver a diverse set of services to society.

Mapping the flows and stocks of a supranational entity, country or government subdivision shifts the focus from environmental issues and short-term priorities to the performance of the overall system and “the development of an integrated development perspective that includes all levels and sectors”.⁵⁵⁶ This requires data on resource use and assets to determine how they work together to respond to individuals' needs. Data visualization helps stakeholders develop a consensus on the current situation and, based on

that consensus, explore the most promising circular economy opportunities.⁵⁵⁷

The metabolic analysis is based on a detailed search for country-specific trade, production, processing and disposal data. It is not a predefined model but the flows are identified and distinguished based on the data provided. As a result, the metabolic analysis relies on different data sources, where each source provides, for example, reference data for comparison and verification, indicators for processing losses, the end-of-life fate of products and recycling rates. By prioritizing data sources from Lao PDR, the metabolic analysis aims to rely on the same data sources as the country's key decision-makers.

Resource use and climate change

When envisioning a long-term development perspective for Lao PDR, resource efficiency and GHG mitigation should be addressed in tandem. A major share of the finite resources that the country uses are fossil fuels that contribute to climate change. In practice, most are used to extract, transport and process materials and products. An estimated 67 per cent of global greenhouse emissions are related to materials management.⁵⁵⁸ As a result, only the mutually reinforcing combination of low-carbon development and resource efficiency can put the world on a pathway of 2°C or less.⁵⁵⁹

The circular economy often also makes economic sense. For some sectors, decoupling resource use from economic growth will bring GHG emissions in line with the ambition to keep global warming at 2°C.⁵⁶⁰ This opens a development perspective by which reduced dependency on material resources and fossil fuels can create the financial savings that accelerate economic development. The public debate over the immediate costs of climate change mitigation often overlooks the fact that the economic benefits of resource efficiency and low-carbon development exceed the near-term costs of shifting to a 2°C emissions pathway.⁵⁶¹

Mapping resource flows, stocks and embedded emissions

Material flows distinguish among biomass, minerals, metals, fossil fuels, GHG emissions and water. The flows have been quantified with statistical data from the Lao Statistics Bureau. They flow from the start - on the left, with finite extraction, secondary

and regenerative sources and import - to various end-of-life stages on the right. The product types include food products (products that expire), short-lived consumables like packaging and fuels (products that flow) and long-lived products that contribute to stocks, such as vehicle fleet expansion, and expanding and maintaining the building stock (products that last). Data gaps were addressed by drawing on additional statistical sources, such as the Food and Agricultural Organization and other UN bodies, academic and other sources.

By connecting the flows at product level and breaking them down into different resource types, these flows were traced from their origin to their final destination. Since the aggregated mass of all materials must be maintained during the conversions, comparing the flow totals in each part of the value chain allowed for cross-checking.

Terms and definitions used in the material flows

The following terms and definitions were used in the material flow charts included in this report.

BIOMASS flows include food products of vegetable and animal origin and the wood, rubber and paper used to make products, such as furniture, construction materials and packaging.

MINERALS are primarily mineral construction materials, such as cement, tiles and bricks. They also include oil-based products, including chemicals, fertilizers and the bitumen used in road construction.

METALS include raw and processed metals and their products, ranging from iron plates to copper wiring, vehicles, machinery and metal building structures.

WATER flows include the rivers and rainwater that flow from the inlands into the ocean, part of which is cleaned and used as drinking or irrigation water and discharged.

FUELS are gas, liquid and solid fossil fuels. In Lao PDR, they are used primarily in the transport sector and to generate electricity.

EMISSIONS are GHG emissions, most of which are carbon dioxide or CO₂, followed by methane or CH₄.

Three types of products are distinguished.

PRODUCTS THAT EXPIRE: These are food products with a limited lifetime because they expire after a given time period. Since food products are mostly of vegetable or animal origin, their end-of-life products are also organic material.

PRODUCTS THAT FLOW: Most materials entering the economy every year typically reach their end of life within a year. Examples are packaging and consumables, such as cosmetics, cleaning agents and healthcare products.⁵⁶²

PRODUCTS THAT LAST: The other materials become produced stock or long-term stock and are typically in use for longer than a year. Examples are capital equipment, buildings and infrastructure.⁵⁶³

Four sources of materials are distinguished.

IMPORTS refer to materials and products imported into Lao PDR. They originate from wells, quarries, mines or fields located outside the country.

FINITE EXTRACTION refers to materials and products produced or extracted from national mines, wells, quarries, forests, agriculture and fishing. Where materials are extracted from sources in a way that depletes their stocks, such as sand extraction or wood harvests that lead to a decline in forest stock, they are referred to as depletive.

SECONDARY SOURCING refers to secondary resources from recycling and reused products. This often involves using organic residues as soil enhancers and recovering recyclable materials from national waste streams.

REGENERATIVE SOURCING refers to forest and fish products from stocks that are stable or show improvement over time and agricultural products where soil quality is also stable or improving.

In addition to mapping the materials used, the analysis also shows what happens to waste or products after they are used.

LANDFILL refers to secondary resources or wastes that are dumped or partially burned and then dumped in a dumpsite. As a result of the mixing of resources and their degradation over time, considerable value is lost. In addition, organic material that is dumped decays under anaerobic conditions and causes methane emissions, a potent GHG.

LANDFILLER, ROCK DUMP and TAILING refer to the relatively large waste volumes of waste rock and tailings from the mining sector.

LONG-TERM USE (LTU or products that last) refers to the use of materials over a long period, as in a new building, vehicle or infrastructure.

EXPORTS refer to products and materials that are exported to other countries.

DISCHARGE refers to the discharge of treated or untreated wastewater into surface water.

SOIL ENHANCER refers to materials that are applied on land to retain soil fertility and/or enhance soil organic carbon.

RECYCLED refers to waste that is recovered for processing and then reused. Throughout the recycling process, value that was embedded in the original product is lost. Recycling is thus a suboptimal waste treatment method, although better than landfilling.

SHORT-CYCLE CO₂ involves the short-term or fast cycling of carbon through life forms on Earth, or the biosphere.⁵⁶⁴ In this metabolic analysis for Lao PDR, it refers to CO₂ emissions from the combustion of sustainably produced firewood.

Finally, four types of GHG emissions are identified and quantified.

TERRITORIAL EMISSIONS are those produced in Lao PDR. They are created by the combustion of fossil fuels or the anaerobic digestion of organic materials. When drawing a parallel to GHG accounting for companies, these are scope 1 and 2 emissions from activities within the companies and from their power use.

EMBEDDED EMISSIONS are those produced outside the country during the production of goods and materials that are then imported.⁵⁶⁵ For companies, these are scope 3 emissions, both upstream and downstream in the value chain of which a company is part.

EXPORTED EMISSIONS are associated with goods and materials that are exported.

UPSTREAM EMISSIONS refer to those associated with imported goods and materials that are consumed in Lao PDR and attributed to the country's consumption-based emissions.

Stocks and national assets

Just as a company's health cannot be assessed by looking only at its cash flow, a country's metabolic situation cannot be assessed by looking only at its material flows. A country may invest in or safeguard its natural assets, which would make them more attractive and productive in the future. It may also draw on those assets, which would prevent it from sustaining current production levels in the future. In keeping with the business analogy, the latter can be considered a form of asset stripping. Likewise, understanding the impact of economic activity on a country's national assets, including biodiversity, pollination services, water quality and soil fertility, requires a form of natural capital accounting.⁵⁶⁶

There are different ways to account for natural capital or assets. The analysis in this report relied partly on the UNEP's Inclusive Wealth Index (IWI), which distinguishes among three kinds of capital: human, capital and natural. The Index shows dominant trends in the quality or quantity of the types of assets that are the source of Lao PDR's wealth.

The quality of natural assets and stocks

All flows have an origin and a destination. Some contribute to the quality of the ecosystem from which they originate or at their destination, while others do not. Flora and fauna can recover from extraction, such as fishing, forestry and agriculture, unless the ecosystem's regenerative capacity is exceeded, soils are depleted or extraction methods damage them. Other natural stocks, such as mineral deposits, cannot be replenished. Extracting mineral deposits, such as fuels, ores and sand, is depletive, creating revenue only in the short run – referred to as resource rents – and during the economic lifetime of the product in which the resource is used.

At the end of a flow, organic residues can be used to enrich soils. When organic material decomposes in landfills, it can also cause eutrophication of surface waters or methane emissions. This section reviews trends in natural asset quality, providing insight into the ability of these assets to support life and prosperity in Lao PDR now and in the future.

The natural resource rents indicate the contribution of natural resources to economic output. These earnings are not produced but extracted. Resource rents account for revenues that exceed the cost of extracting the resources. Rents from finite resources,

such as fossil fuels and minerals, and rents from overharvesting of forests indicate that a country's capital stock is being liquidated. The World Bank has written, "When countries use such rents to support current consumption rather than to invest in new capital to replace what is being used up, they are, in effect, borrowing against their future."⁵⁶⁷

Measuring the circularity of national consumption and production

This metabolic analysis for Lao PDR applies a new metric to estimate the circularity of national consumption and production, which was first applied for Vanuatu and The Gambia. This value allows Lao PDR to set a benchmark from which to track progress in the transition to a circular economy.

The approach to calculating the circularity gap follows the rationale developed for the Global Circularity Gap Reports,⁵⁶⁸ which builds on earlier work by Haas et al.,⁵⁶⁹ Krausmann,⁵⁷⁰ Wiedman⁵⁷¹ and the International Resource Panel.⁵⁷²

Lao PDR's approach to calculating the circularity of consumption differs from that adopted in Norway's circularity gap report, which defines circularity as "measuring the share of cycled materials as part of the total material inputs into a national economy every year".⁵⁷³ However, the use of regenerative and imported secondary materials are determining factors in Lao PDR's material footprint. Prioritizing regenerative resources is a key element of the circular economy (see Box 2) and should be captured in the circularity estimate.

By including regenerative resources, this metric seeks to include photosynthesis in the equation. Photosynthesis harnesses renewable energy from the sun and turns it into valuable biomass in forests, marine environments and agriculture. This biomass can be considered regenerative when the natural assets from which it originates – that is, the forest stock, fish stock⁵⁷⁴ and soil – are stable or improve in quality and quantity over time. The metric thus combines an analysis of natural stocks (to determine whether they are degrading or improving) and an analysis of material flows. Flows are considered circular only when they are of secondary or regenerative origin and are cycled after the use phase.

As a result, the 27 percent circularity of domestic consumption in Lao PDR represents the share of all materials used, including the raw material equivalents

of imports from regenerative or secondary resources and that are cycled back into the economic system after use. These include the following materials:

- Food products, including food, food waste and losses, and agricultural residues of regenerative origin whose nutrients are applied on land or otherwise stay within the terrestrial, marine or forest environment from which they originate;
- Construction wood that does not contribute to deforestation and firewood whose extraction does not contribute to forest degradation or deforestation;
- Minerals, metals and fossil fuel-based products of secondary origin and that are recycled after their use, regardless of whether the materials are recycled in Lao PDR or exported for recycling abroad. This applies primarily to plastics, scrap metal, glass and mineral oil residues and to mineral construction materials, such as compressed bricks, that are used in buildings in a way that allows them to be returned to the land; and,
- Imported secondary materials, 8.4 percent of which are assumed to be circular, based on the global circularity gap estimate.

By contrast, flows are considered linear when they are composed of food that originates from overfishing, deforestation or agricultural practices that lead to soil degradation or require high fertilizer and pesticide inputs. They are also considered linear when, after consumption, their nutrients and organic materials are lost to surface waters or the sea, become GHG or contribute to eutrophication. The latter occurs when more nutrients enter the marine environment than are extracted through fishing. For the raw material equivalents of imports, 8.6 percent circularity has been assumed, which is equal to the global average, unless imported goods and materials are clearly of regenerative or secondary origin.⁵⁷⁵

Impacts: GHG mitigation, waste avoidance GDP potential and jobs

Eleven interventions are proposed that, together, help reduce GHG emissions and waste volumes while supporting economic growth and job creation. They do so by reducing reliance on carbon-intensive products and prioritizing low-carbon alternatives. Furthermore, waste volumes can be reduced by tapping into secondary resources. Where the GHG mitigation potential overlaps with the mitigation opportunities identified in the latest nationally determined contribution, this is clarified.

Job creation is important in Lao PDR. The circular economy gives priority to human creativity and resources over the extraction and monetization of primary resources and seeks to preserve and create jobs. Jobs are preserved primarily by securing the regenerative capacity of natural assets. This is particularly important because a large share of the Laotian population depends directly on the quality of the country's forests, soils and water resources. New employment may be created in repair activities, agronomics, trading and transport of secondary resources, and the production of sustainable and perhaps organic food products. In addition to agriculture and forestry, the tourism sector depends directly on healthy and attractive ecosystems, as the degradation of natural resources makes the country a less appealing tourist destination. Some of these jobs may come at the expense of jobs in linear value chains within Lao PDR or in other countries.

In the transition to a circular economy, jobs are both created and displaced. Jobs upstream in extraction are often displaced by jobs further downstream in maintenance, repair and recycling. However, Lao PDR primarily relies for its domestic demand on national products from regenerative resources. Products that rely on depletive resources, such as fossil fuels, metals and minerals, are largely imported, while raw materials from mining operation in Lao PDR mostly serve foreign markets. Finite resources that serve domestic demand are fertilizers, cement and concrete construction materials; Lao PDR has its own industries for these.

The GDP potential of each intervention has been estimated based on the added value of each intervention. Additional value is created when the production of regenerative materials is increased or secondary materials are recovered. That added value, corrected for the growth forecasts per sector, is used as a proxy for future growth of the circular economy's contribution to GDP.

The job potential of each measure has been quantified with the sectoral employment elasticity for Southeast Asia and the expected GDP growth per sector. In some cases, the intervention increases domestic production based on regenerative and secondary resources beyond volumes that the domestic market can absorb. Where increases in production volumes serve foreign markets, the additional jobs created in Lao PDR might come at the expense of foreign jobs or national jobs in linear product value chains. This analysis of the job potential did not estimate a potential loss of jobs in linear value chains.

Business cases

The business case for each intervention has been estimated based on capital expenditures, operational expenditures and revenues. To determine these expenditures and the prices of the commodities and assets involved, market research was conducted in Lao PDR involving literature review, expert interviews and visits to the market and shops to collect price information. The calculations of the business case for each intervention have been verified by government and private sector stakeholders.

Three indicators were calculated to determine whether the interventions make sense from a business perspective.

1. Payback: The simple payback indicates how much time it takes for the initial investment to be recovered from the annual difference between operational revenues and operational costs.
2. Net present value: Net present value shows today's value of a future stream of payments per intervention over the 29-year period from 2022 to 2050. A discount rate of 4 percent has been applied to estimate it.
3. Marginal abatement costs: Combining the GHG reduction potential with net present value, each intervention can be plotted in a marginal abatement costs diagram. For these costs, the net present value (whereby a negative net present value would constitute positive costs in the marginal abatement costs), the total costs over the lifetime of the interventions between 2022 to 2050 were divided between the total GHG mitigation or sequestration in that period. If the marginal abatement costs are positive, there are net costs associated with the mitigation effort and an economic investment is needed to achieve a net GHG reduction. If the costs are negative, the intervention has both a positive climate impact and a positive business case for every tonne of CO₂e that is reduced.

Modelling the long-term mitigation and sequestration potential

In its latest NDC, Lao PDR expressed the ambition to be net carbon neutral by 2050, whereby the sequestration of GHG emissions compensates for any remaining emissions. An analysis of long-term GHG emissions requires a solid baseline scenario. For that purpose, a life cycle assessment approach was adopted.⁵⁷⁶ This is different from the way in which

a national inventory is developed. The latter follows the sectoral approach specified by the Intergovernmental Panel on Climate Change by which all individual emission sources and sinks are quantified. By calculating GHG emissions on a per-products basis, it is easier to determine the impact of circular economy interventions, which, first and foremost, alter resource flows.

In a circular economy intervention, GHG emissions are reduced by using fewer materials, avoiding waste and using less carbon intensive materials. When determining national emissions as an aggregate of emissions per product, the impact of circular economy interventions can be calculated more accurately. Based on the comprehensive overview of resource flows in the 2019 reference year, which was part of the metabolic analysis, and the environmental impact of these materials and products, the overall climate impact in terms of megaton CO₂ (Mton CO₂e) in Lao PDR in 2019 has been calculated.

The metabolic analysis provides an overview of products used on an annual basis within the Laotian economy. It involved three steps to calculate the mitigation potential of the interventions from the metabolic analysis.

1. The list of products was adjusted to correct for double counting of waste-related material flows;
2. Products were distinguished based on whether they are made or consumed within Lao PDR or abroad; and,
3. For each product, the GHG footprint in CO₂e is obtained from an international database with environmental indicators.

The list of products was adjusted to correct for waste-related product flows

When calculating the product impacts, it is important to determine the product's lifecycle phase. Products pass through three main stages, each producing a different impact: cradle, gate and grave. In this study, as with all standard LCA studies, a product's impact is modelled 'from cradle to gate', including all upstream emissions.

Since this study focuses on impacts from cradle to gate, including all upstream emissions, products in the 'grave-stage' that also carry all the upstream impacts of cradle and gate, are excluded. For example, waste products such as crop residue, waste rock and consumption waste also carry emissions from crops, rock and textile garments. To prevent double-counting the impacts, the list of products

from the metabolic analysis is adjusted for waste-related products.

Products were distinguished based on whether they are made or consumed in Lao PDR or abroad

To correctly quantify the impact of products in Lao PDR, it is important to distinguish between the location and purpose of production. Products imported into the country are produced elsewhere. Although it is useful to know the impact of these products, their impact is not attributed to Lao PDR's GHG inventory. On the other hand, products produced in Lao PDR and then exported to other countries have had an impact in Lao PDR, although they are used elsewhere. By distinguishing between these two groups, we can accommodate different ways of attributing GHG emissions. For example, territorial emissions include those from products produced and used in Lao PDR, and consumption-based emissions would include those from products used in Lao PDR, regardless of whether they are produced in or imported into Lao PDR.

For each product, the greenhouse gas footprint is obtained from an international database with environmental indicators.

Each product has its own environmental impact. The internationally recognized LCA database Ecoinvent lists products' environmental impacts.⁵⁷⁷ Where emissions are provided in greenhouses gases other than CO₂, the global warming potential from the International Panel on Climate Change has been used to determine the climate impact in CO₂e. To ensure uniformity in the environmental impact figures, only global impacts in the 'market for' phase are used.

Estimating GHG emissions in the reference year 2019

Following the above methodology, the overall territorial GHG emissions of Lao PDR in 2019 were estimated at 89 million tonnes of CO₂e. Of that total, 75 million tonnes resulted from products that are domestically consumed and 14 Mton CO₂e from products produced for export.

GHG emission scenario till 2050

To estimate how emissions evolve to 2050, sector-specific growth rates were applied to each product

for three distinct time periods: 2020-2025, 2025-2030 and 2030-2050. The growth rates were obtained from the GACMO model.⁵⁷⁸ The sector-specific growth rates from the GACMO model were assigned to products that belong to these specific sectors. The result is a GHG baseline emission scenario that begins in 2020 with territorial emissions of 90 million ton CO₂e, reaching 101 million ton CO₂e in 2030, and 112 million ton CO₂e in 2050.

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