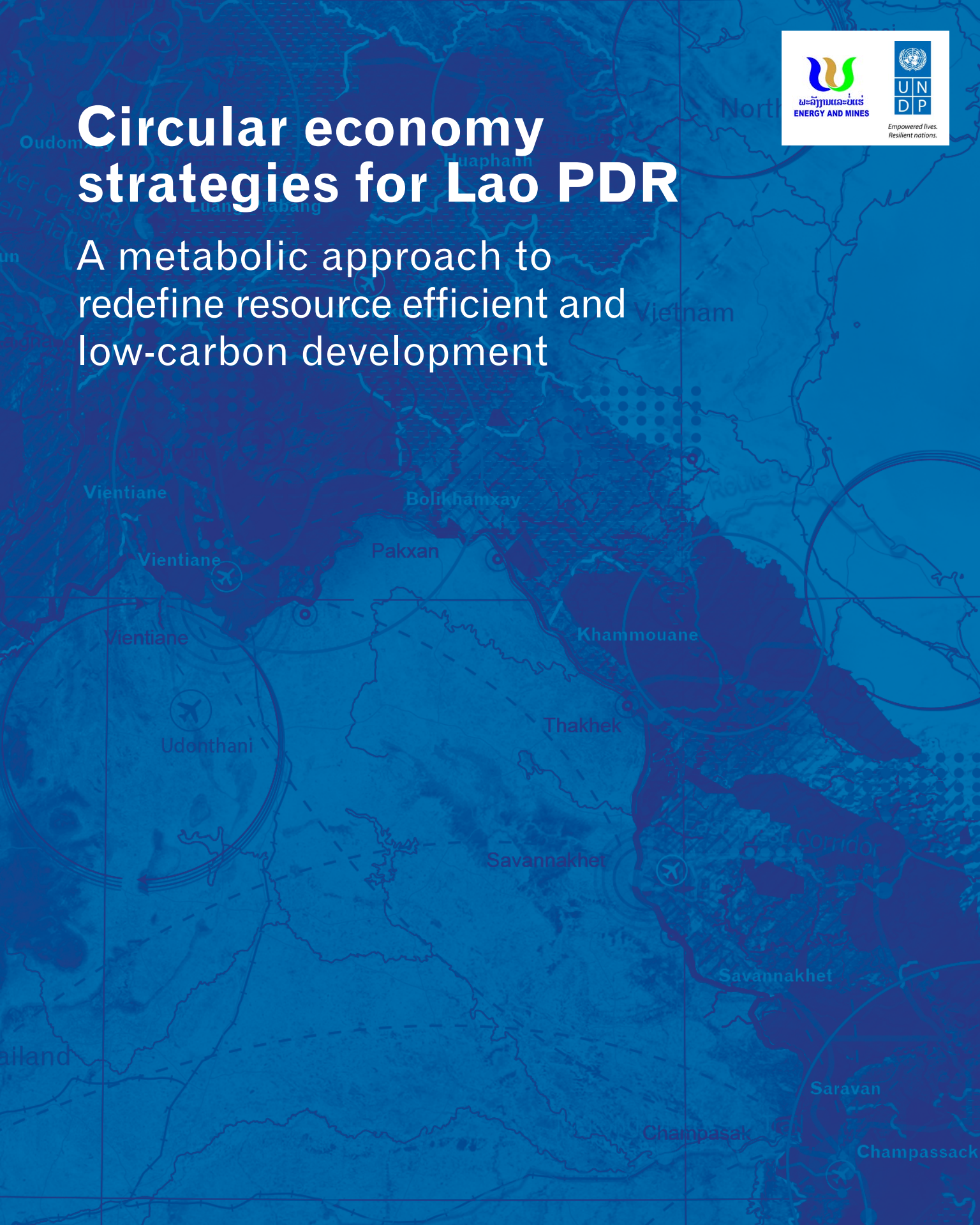
Circular economy strategies for Lao PDR

A metabolic approach to redefine resource efficient and low-carbon development



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Colophon

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Contents

Colophon 2

Foreword 7

Summary 9

Thinking in flows and stocks 13

Combining resource efficiency with low-carbon development 14
The socio-economic metabolism 15
Circular economy strategies 16
Circularity as development paradigm 17
Stainable development and climate action 19
Four steps from the socio-metabolic profile to circularity 19

Development opportunities and challenges in Lao PDR 23

Step 1: The socio-metabolic profile 25

1.1 Resource-driven growth 26
1.2 Resource demand from neighbouring countries 28
1.3 International commitments and economic integration 29
1.4 Sector profiles 30

Step 2: Mapping priority sectors, industries and resources 39

2.1 Selected maps 41
2.2 Resource analysis 37
2.3 Agriculture analysis 44
2.4 Energy analysis 46
2.5 Tourism analysis 48

Circular future 51

Step 3: Circular economy strategies 53

3.1 Circular manufacturing, textiles and waste management: cores, recycled fibres and bacteria 54
3.2 Circular construction materials from forests: circular resorts to advance ecotourism 58
3.3 Circular agriculture, mining: algae farming to clean water in hydropower reservoirs 61
3.4 Overview of technologies and benefits per sector 65
3.5 Contribution to achieving SDGs 65
3.6 International cooperation on climate mitigation supporting circularity 65

Annex 1: List of tables and figures 70

Foreword

The adoption of the Paris Agreement in 2015 marks not only an historic milestone for the global effort to combat climate change but also sends an important signal for accelerated climate action and a dramatic transformation of economies as we know them.

In the strongest ever collective spirit, 195 countries came forward with Nationally Determined Contributions to outline targets for cutting greenhouse gas emissions. These national contribution targets culminated into the Paris Agreement which set the highly ambitious, but vital, global goal to limit temperature increases to well below 2°C and transition to a zero-carbon economy by the end of the century.

Reaching this ambitious goal will, however, require achieving progressively deeper cuts in greenhouse gas emissions. Since these emissions are closely related to resource use, circular economy strategies can guide us onto a low-carbon development pathway.

Therefore, Lao PDR developed a vision of a circular future which combines economic development with safeguarding the country's unique nature and culture. This requires a systems approach which looks beyond isolated challenges or attempts to optimise individual installations.

The central location of Lao PDR, its hydropower resources, a solid agricultural and forestry basis for developing a bio-based economy, the potential to expand ecotourism, its modest wages and the integration into the ASEAN Community (Association of South East Asian Nations) are all major opportunities.

The Institute of Renewable Energy Promotion under the Ministry of Energy and Mines, UNDP and Shifting Paradigms developed a study on 'Circular Economy Strategies for Lao PDR' which analyses the metabolism of Lao PDR to improve resource efficiency and asset use. For the study, a step-wise approach has been adopted which goes from priority setting based on national development ambitions and the metabolic profile of the country, to defining circular economy strategies. Priority setting and strategy formulation were guided by an ambition to optimise resource efficiency and reduce greenhouse gas emissions, seek cross-sectoral impacts and ability to inspire circular innovations across the Laotian economy.

The government of Lao PDR has embraced this approach to redefine a development perspective for the country. It looks forward to continuing its effort to further decouple economic development, from the expansion of the national resource and carbon footprint.

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China
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Khammouane
Thailand
Savannakhet
Saravan
Sekong
Champassack
Attapeu
Cambodia

Summary

Lao PDR is strategically located in the heart of Southeast Asia and a vital organ in the regional economic tissue. It supplies its own industries and consumers with food and resources, while also exporting large volumes of crucial supplies to surrounding countries. The country has an opportunity to leapfrog into a circular future, where economic activities and resource use are regenerative by design and safeguard the natural and cultural beauty which are unique to the country. Analyzing the flows, conversions and stocks of materials and energy which constitute the metabolism of Lao PDR, bring the most promising circular economy strategies to the surface.

The analytical approach looks at Lao PDR as a system and combines resource efficiency with low-carbon development. These two development goals go well together, since 67 per cent of global greenhouse gas emissions are related to materials management. The opportunities build on circular economy strategies, which reduce the input of raw materials, improve the use of existing assets and reduce the output of harmful waste, including greenhouse gasses.

For developing countries, this approach represents a unique opportunity to redefine development and growth, through the lens of metabolic efficiency. For Lao PDR it is an opportunity to skip the catching-up phase and leapfrog into a postindustrial society, where the living organism, rather than the machine from the industrial age, is the main source of inspiration.

Development opportunities and challenges

Between 1990 and 2015 the domestic extraction of resources in Lao PDR increased from 10 to 71 million tons per year. Increased extraction and exports of wood, metal ores and refined copper were the main drivers of economic growth. This is a short-term growth strategy supresses the growth potential of non-extractive national industries.

The central location of Lao PDR in between the large economies of southeast Asia, and on existing and planned international transport arteries, is a major opportunity. Other competitive advantages are its access to hydropower resources, a solid agricultural and forestry basis for developing a bio-based economy and its modest wages. The critical development challenges for Lao PDR are the heavy reliance on:

1. temporary resource rents to stimulate economic growth;

2. raw material exports which prevents the growth of local industry; and

3. the import of construction materials and fuels which can also be sourced locally.

Three pivotal circular strategies

Three circular economy strategies have been selected for their positive impact on resource efficiency, greenhouse gas emission reduction potential, cross-sectoral impact and ability to inspire circular innovations across the Laotian economy. Per strategy, artist impressions provide a preview of a circular future for Lao PDR.

1. **A regional recycling and remanufacturing hub**: Lao PDR can position itself as a recycling and remanufacturing hub in which material cycles are closed. The country can take full advantage of its location on major regional transport arteries like the newly built transit railroads and the

   Mekong river. It could function as a resource hub, through which resources can be renewed and redistributed.

   For example, by importing end-of-life motorcycles and cores, Lao PDR can replace the region's need to import motorcycle parts, produced from newly extracted raw materials. Similarly, the import of synthetic materials can be substituted with local, bio-based alternatives. Additionally, a new technology to sort fibres from waste textiles opens an opportunity to replace the import of new fibres and fabric for the textiles industry, with end-of-life textiles of regional origin. Where the stream of textiles residues is insufficient to meet national demand, organic fibres like hemp can close the gap.

2. **Piloting circular construction methods to support tourism**: The use of local, cross laminated timber and bamboo as the country's main construction materials, instead of imported concrete and steel can reduce the reliance on foreign raw materials and support the construction boom in urban areas and the expansion of infrastructure. The use of local resources in the construction of new buildings

can also preserve a sense of national identity in urban areas and at resorts. The national, eco-tourism ambitions of Lao PDR can benefit from this material transition and enable the tourism industry to be an early adopter of circular concepts.

3. **Algae farming to produce valuable bio-based materials and clean surface water**: Electricity in Lao PDR is predominantly generated by hydropower for both domestic use and export. By mobilising the aquaculture capacity of its hydropower reservoirs, with the production of algae, the country can benefit from a growing and underused national asset. Algae production significantly improves the quality of water, while delivering valuable proteins, fertilizers or raw materials for fish oil or even biofuels. These products can be used to substitute imported meat and synthetic fertilizer, support fish breeding throughout the country or substitute imported fossil fuels.

Three pivotal circular strategies

The systems approach outlined for Lao PDR steps away from focussing on a single sector or industry. It defines collaborative strategies in which sectors cooperate to achieve the country's objectives to reduce greenhouse gas emissions and make more efficient use of its resources. This way of thinking opens new avenues for countries to act on their climate ambitions and Paris Agreement commitments. It also steps away from the negative and often punitive narrative of reducing emissions, to a more positive and inspiring vision of a circular future.

This research has the potential to be replicated and applied to any country with the political ambition to adopt a circular economy. Circular strategies can enable transformational change and maintain the value of resources and products which are already available.

Thinking in flows and stocks

Addressing climate change and improving resource efficiency are a mutually reinforcing combination. Yet, in practice, they are often separate objectives. Consequently, approaches under the Paris Agreement to shift our world economy to a 2°C or even 1.5°C pathway risk overlooking the major mitigation potential of reducing our resource footprint. Its national focus also risks overlooking the mitigation impact which domestic action can have on greenhouse gas emissions in the countries from which carbon intensive materials and products originate. Emissions embodied in international trade represent over 30 per cent of the greenhouse gas footprint of countries.

This requires a systems approach, which looks at all resource extraction, flows, stocks, conversions, imports and exports. Looking at a jurisdiction or industrial cluster as a metabolism, opens development perspectives which cut across sectors and industries. Circular economy strategies can help make the low-carbon and resource efficient development perspective concrete.

Lao PDR has the ambition to graduate from its Least Developed Country status. The predominant trend in developing countries is that economic growth is paralleled by a gradual decrease in resource efficiency. Circular economy strategies can curb that trend and allow the country to grow its infrastructure and building stock, and meet the needs of its society in a manner which already moves away from the linear economic model which has characterized industrialization. An understanding of the metabolism of Lao PDR helps identify promising circular economy strategies which respond to the needs and expectations of society while reducing the input of raw materials and improve the use of existing assets and reduce the output of harmful waste, including greenhouse gasses.

Combining resource efficiency with low-carbon development

When envisioning a long-term development perspective for a country or region, resource efficiency and greenhouse gas mitigation should be addressed in tandem. To feed our world economy, roughly 84 billion tons of raw materials each year are extracted. This is 32 kilograms per person per day. This extraction rate is already exceeding planetary boundaries, but population and economic growth might push this figure to a staggering 186 billion tons per year by 2050.[1] Some resources are already near depletion. In metal extraction, this is evidenced by declining metal content of ores,[2] and causes increasing volatility of resource prices.

A major share of the resources which we extract are the fossil fuels which contribute to climate change. Once extracted, most of these fuels are used to extract, transport and process materials and products. In result, 67 per cent of global greenhouse gas emissions are related to material management.[3] Only the mutually reinforcing combination of low-carbon development and resource efficiency, can shift our world economy to a 2^0C or even 1.5^0C pathway.

This also makes economic sense. For some sectors, effective decoupling of resource use from economic growth is enough to reach the 2^0C benchmark.[4] This opens a development perspective where lower dependency on material resources and fossil fuels can create the savings which accelerate economic development. The economic benefits of resource efficiency and low-carbon development exceed the near-term costs of shifting to a 2^0C emissions pathway.[5]

Still, the focus of climate mitigation action is on production[6] and improving energy efficiency, on promoting renewable energy, reducing non-CO_2 greenhouse gas emissions, improving land management and reducing deforestation. These are also the predominant strategies of "Nationally Determined Contributions", the emission reduction pledges and associated policy intentions which countries submitted to the United Nations Framework Convention on Climate Change (UNFCCC) under the Paris Agreement. While these mitigation options can do some of the heavy lifting towards a 1.5^0C pathway, common approaches to identifying climate policies and investments, risk overlooking the economically feasible mitigation potential of reducing our material footprint.

This asks for a novel approach to development, where resource flows, stocks, conversions, imports, exports and energy use are examined as a system, rather than a set of individual elements. When looking at a national or subnational economy as a metabolism, circular economy strategies point at innovative interventions at system-level.

Box 1: Key definitions

Socioeconomic metabolism: "the set of all anthropogenic flows, stocks, and transformations of physical resources and their respective dynamics assembled in a systems' context".[4] In the context of this analysis, the *metabolism* of Lao PDR constitutes the flows and stocks of resources and energy.

Socio-metabolic profile: "represent dynamic equilibriums of society-nature interactions, and are characterised by typical patterns of material and energy flows." In history, the basic profiles are a) hunters and gatherers, b) agrarian and c) industrial. Bio-geographical factors and resource endowment

1. United Nations Environment Programme (UNEP) and International Resource Panel, *Resource Efficiency: Potential and Economic Implications: International Resource Panel Report*, March 2017. See also World Bank, "Population total", 2017.

2. S. Northey and others, "Modelling Future Copper Ore Grade Decline Based on a Detailed Assessment of Copper Resources and Mining", *Resources Conservation and Recycling* Vol. 83, 190-201, February, 2014.

3. Own analysis of the underlying data of Figure 2 from: B. Bajželj, J.M. Allwood and J.M. Cullen, "Designing Climate Change Mitigation Plans That Add Up", *Environmental Science & Technology*, 47(14): 8062–8069, July 2013.

4. S. Paulik and D. B. Müller, "The role of in-use stocks in the social metabolism and in climate change mitigation", *Global Environmental Change*, Vol. 24, January 2014.

5. S. Hatfield-Dodds and others, "Assessing global resource use and greenhouse emissions to 2050, with ambitious resource efficiency and climate mitigation policies", *Journal of Cleaner Production,* Vol.144, February 2017.

6. H. Schandl, D.B. Müller and Y. Moriguchi, "Socioeconomic Metabolism Takes the Stage in the International Environmental Policy Debate: A Special Issue to Review Research Progress and Policy Impacts", *Journal of Industrial Ecology*, Vol. 19, No. 5, September 2015.

(climate, soil, access to waterways, mineral resources) contribute to the formation of sub-types of regimes with region-specific socio-metabolic characteristics." [7]

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."[8]

Systems' approach: "a focus on the development of an integrated perspective that includes all levels, rather than on the isolated search for readymade solutions for sub-problems."[9]

Nationally Determined Contributions: Submissions to the United National Framework Convention on Climate Change (UNFCCC) of mitigation commitments for 2030, or beyond, by countries under the Paris Agreement.[10]

Sustainable Development Goals (SDGs): "a set of goals to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda" adopted in 2015. Each goal has specific targets to be achieved by 2030.[11]

The socio-economic metabolism

The resource and energy efficiency of an economy is more than the sum of the efficiencies of all its components. Decoupling economic growth from resource and energy use, requires understanding how the individual components operate, but above all, it requires an understanding of how individual elements interact and work together to deliver a diverse set of services to society. When thinking in flows and stocks, the isolated search for readymade solutions for sub-problems is replaced by a systems' approach, which focuses on "the development of an integrated development perspective that includes all levels and sectors".[9]

Looking at a community as a metabolism is the new paradigm for understanding cities[12] and regions.[13] This approach, whether it is used for building design, urban planning or national development planning, requires a large amount of data at different scales. Data visualization is an important means to help policymakers and corporate decision makers to understand the challenges and opportunities. Some of the first examples of this approach are from Brussels in 1977.[14] More recent work covers Rotterdam,[15] Albania[9] and the Dutch province of North Holland.[16]

Box 2: Disciplinary parallels between social metabolism, accounting and biology

A disciplinary parallel can be drawn with accounting, where transactions or flows of value change balance sheets or stocks. This way of thinking in flows and stocks applies just as well to material resources in society. In fact, the mass extraction and depletion of resources which is common to linear economies,[17] can be considered a form of "asset stripping". In accounting, a company which records short-term profits by depleting its resources, will show a decline in the value of its assets. Traditionally, value creation by a nation state is measured as the Gross Domestic Products (GDP), where a decline in valuable reserves and deposits is not accounted for. In recent years, the World Bank has begun to complement GDP measurement with reporting on "resource rents",[18] which are temporary revenues from the extraction of resources.

A metabolism eats, drinks, breathes, uses its senses and excretes waste. An urban or national landscape shows similarly vital flows of resources.[9] In biology, all organisms, arguably except human beings, are part of an ecosystem where hazardous waste does not exist, and chemical conversions take place at low temperature and pressures. That is very different from the industrial systems which humanity employs. Biomimicry[19] is the discipline where biology is a source of inspiration on understanding how to close material loops and dramatically improve our material and resource efficiency.

For developing countries, this approach represents a unique opportunity to view development and growth through the lens of metabolic efficiency. It helps govern-

7. F. Krausmann and others, "The global socio-metabolic transition: past and present metabolic profiles and their future trajectories", *Journal of Industrial Ecology* Vol.12(5-6), 637-656, 2009.

8. Ellen MacArthur Foundation, "What is a circular economy?", 2015.

9. G. Brugmans, M. Francke and F. Persyn, eds. The Metabolism of Albania: Activating the Potential of the Albanian Territory, 2015.

10. K. Blok and others, "Implementing Circular Economy Globally Makes Paris Targets Achievable," 2016.

11. United Nations, "Sustainable Development Goals", n.d.

12. See, for example: www.urbanmetabolism.org, or http://metabolismofcities.org.

13. V. C. Broto, A. Allen and E. Rapoport, "Interdisciplinary Perspectives on Urban Metabolism", *Journal of Industrial Ecology,* Vol. 6, Issue 16, December 2012.

14. MFA Diagrams, "Material Flow Analysis diagrams".

15. N. Tilly and others, eds, *Urban Metabolism: Sustainable Development of Rotterdam*, 2014.

16. Circle Economy, "58 circular opportunities of the province of North-Holland", 2017.

17. W. Haas and others, "How Circular is the Global Economy? An Assessment of Material Flows, Waste Production, and Recycling in the European Union and the World in 2005", *Journal of Industrial Ecology*, Vol. 19, No.5, October 2015.

18. World Bank, "Total natural resources rents (% of GDP), Overview per country".

19. For further information on biomimicry, see: https://biomimicry.org/.

ments conceptualizing a future vision of a resource efficient society as the ultimate objective of national development. They can avoid the development pathway of industrialized countries, which accumulated massive stocks of materials to support a society whose resource use is mostly linear and can be summarized as "take-make-dispose". A circular economy is the nature-inspired alternative.

Circular economy strategies

Circular economy strategies can decouple economic growth from resource use, making material use regenerative, rather than depletive. It does that by proposing strategies which reduce the input of virgin materials, improve the use of existing assets and reduce the output of harmful waste. The circular economy builds on, and combines concepts like Cradle to Cradle,[20] the Blue Economy[21], the Performance Economy,[22] Industrial Ecology[23] or Industrial Symbiosis,[24] and Biomimicry[25].

Not all the materials and products we use are equally susceptible of having their circulation extended.[10] First, about half of the materials extracted today cannot be recovered, or only at high costs, because they are the *fossil fuels* that we combust, the *food* we consume or the gasses, aerosols, liquids or solvents which we disperse.

Second, a large share of the materials extracted are *construction minerals* like sand, gravel and limestone for cement production that we use for the construction of buildings and infrastructure.

Large amounts of raw materials are extracted to build infrastructure in the developing world. These materials are locked into physical structures for many years and are our long-term materials stocks.[4] They can only be recovered when structures are demolished, after which they are typically down-cycled.

Third, the biggest share of the remaining materials is used for *consumer products* like cars, refrigerators, clothing, cleaning agents, personal care products, etc. This is a diverse and complex group of products that generally have short to medium lifetimes.

Seven circular economy strategies target all three material and product categories. On the road to circularity, no country starts from scratch. Several examples illustrate how these circular economy strategies are applied in Lao PDR.

4. **Recovery and Reuse**: Recovering and treating wastes and by-products for reuse as inputs or cascading for other uses. Lao PDR uses sawdust and straw residues from agriculture to produce mushrooms.[26]
5. **Circular Design**: Designing products and assets with minimized resource use throughout the lifecycle in mind.
6. **Material substitution**: Select materials with a low carbon footprint. Burapha Wood is an example of a furniture manufacturer which uses sustainably produced wood, also to replace ceramic floor tiles.[27] Stora Enso is also producing a wood based substitute for carbon intensive construction materials by supplying cross laminated timber as

20. M. Braungart and W. McDonough, *Cradle to Cradle: Remaking the Way We Make Things*. New York, North Point Press, 2002.

21. G. Pauli, *The Blue Economy/Version 2*, USA, Academic Foundation, 2017.

22. W.R. Stahel and G. Reday-Mulvey, *Jobs for Tomorrow: The Potential for Substituting Manpower for Energy*. New York, Vantage Press 1981.

23. For further information on Industrial Economy, see the Journal of Industrial Ecology: http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1530-9290.

24. Kalundborg Symbiosis, "Kalundborg Symbiosis is the world's first working industrial symbiosis".

25. For further information on biomimicry, see: https://biomimicry.org/.

26. UNDP, "New opportunities are sprouting in Lao PDR", 2017.

27. Available from: http://www.buraphawood.com/.

28. Available from: http://www.storaenso.com/.

alternative to enforced concrete.[28] Other examples are the use of insects rather than meat as a source of protein,[29] the substitution of fossil fuels with biodiesel at commercial scale from oilseeds, sugarcane and cassava,[30] the production of 2,400 tons of organic fertilizer in Sayabouly province[31] and organic agriculture which reduces the use of pesticides and synthetic fertilizers.[32]

7. **Sharing and Service Models**: Offering products as a service through pay-per-use models and employing sharing and leasing platforms to maximize the use of products and assets. Lao PDR has 261 accommodations available on Airbnb, an international sharing platform for short-term accommodation.[33]
8. **Product as a service**: Dematerialize by replacing physical products with online equivalents or services like Spotify and use the internet of things to optimize resource use and maximise value.
9. **Lifetime Extension**: Extending the lifetime of products and assets through a greater focus on maintenance, upgrade, and repair, as well as reverse logistics, product takeback, and remanufacturing.
10. **Promote renewable energy**: Move away from the use of fossil fuels. Lao PDR is expanding its hydropower potential to avoid the use of fossil fuels in its power sector.

Circularity as development paradigm

The predominant trend in developing countries is that economic growth is paralleled by a gradual decrease in resource efficiency or circularity. The traditional culture of repair and re-use is dismantled as income per capita increases.[34] In Asia, the deterioration of resource efficiency is aggravated by the relocation of relatively resource intense production stages from more industrialized economies, including the EU, to lower-income Asian countries.[35]

Box 3: Circular economy examples from developing countries.

There are many examples of circular economy initiatives in developing countries which may not yet carry this name, but which can inspire circular development in other developing countries. To name just a few:

Biogas in Lao PDR where manure and human faeces are used to produce biogas and organic fertilizer and improve the sanitary conditions of rural households.[36]

Initiatives to improve the recycling of solar panels and appliances, to avoid the transition to solar energy in Africa creating a new waste issue.[37] Pay-as-you-go schemes are looked at as one of the solutions to retain ownership over the appliances and facilitate reverse logistics.

The Kumasi industrial cluster or Suame Magazine in Ghana is an industrial estate with automotive remanufacturing and repair activities, employing an estimated 200,000 workers. The cluster is a regional hub for car remanufacturing.[38]

Reflow filament aims to leapfrog the development of plastics recycling by creating high-value filament for 3d printers from recycled plastics in India and Tanzania.[39]

In September 2016, Corbion opened a new bio-polymers production facility in Thailand. The bio-plastics from this plant will be a biodegradable substitute to plastic root containers used in the rubber industry. This strengthens Thailand's ambition to become a global bioplastics hub.[40]

When assessing circular economy opportunities in developing countries, or a Least Developed Country like Lao PDR, the policy options and national context need to be considered. Most publications on circular economy stem from countries

29. Y. Hanboonsong and P. Durst, "Edible insects in Lao PDR: building on tradition to enhance food security" Food and Agricultural Organization of the United Nations, Regional Office for Asia and the Pacific, Bangkok, 2014.

30. B. Vongvisith and H. Theuambounmy, "Bio-Energy Science and Technology Innovation and Policy in Lao P.D.R", *Journal of Sustainable Energy & Environment Special Issue* Vol. 13 No. 18, 2015.

31. Government of Lao PDR, "8th five-year national socio-economic development plan (2016-2020)", Ministry of Planning and Investment, June 2016.

32. V. Panyakul, "Lao's Organic Agriculture: 2012 Update", United Nations Conference on Trade and Development 2012.

33. Airbnb, 2017,

34. R. Gower and P. Schröder, "Virtuous Cycle: How the circular economy can create jobs and save lives in low and middle-income countries", Tearfund 2016.

35. A. Schaffartzik and others, "The global metabolic transition: Regional patterns and trends of global material flows, 1950–2010, *Global Environmental Change*, Vol. 26, May 2014.

36. IEA, FAO, IRENA, Country Presentation on status of Bioenergy development in Lao PDR, Bangkok, July 2014.

37. Lighting Africa, "SolarAid Partners with University of Edinburgh on Managing Waste from Solar Lights", April 2014.

38. Institute of Development Studies, "Africa's biggest recycling hub?", November 2015.

39. Reflow Filament, 2017.

40. N. Waramit, "Developing a bioeconomy in Thailand", *Journal of the International Society for Southeast Asian Agricultural Sciences*, Vol. 18, No.2.2012.

with an industrial socio-metabolic profile. Only a selection of these best practices can be transposed to a developing country context, which is that of a transition from an agrarian to an industrial profile.

1. **Leapfrogging progress**. Developing countries can skip the catching-up phase and leapfrog to a post-industrial age where the living organism rather than the machine is main source of inspiration. Replacing products with services and developing modern asset sharing platforms does not require going through the same development stages as OECD countries. For example, sorting and processing waste plastics for 3D printing would benefit from low labour costs.[41] Another example is the historic investment in waste-to-energy schemes like in the Netherlands, which create a lock-in of the waste sector into the combustion of valuable waste resources. The waste sector in Lao PDR is currently at this crossroads.
2. Involve the **base of the pyramid** and consider the informal sector. The artisan repair, reuse and recycle industry has mostly been eliminated in the developed world but is still very much alive in many developing countries. It is a vital source of revenue to many, but often part of informal economic activity in a country. Circular development calls for involving and organizing this workforce, improving their working conditions and safeguarding their role in a circular economy.[42]
3. **Entrepreneurship**. Circular economy concepts ask for pioneering and testing new product designs, consumer-producer relations and replacing products with services. This requires innovation and entrepreneurship and points at an important role for the emerging private sector in Lao PDR.[31]
4. **Declining versus increasing material stocks**. Material stocks in developed countries may decline because of material efficiency improvements. An example is making vehicles lighter to reduce their energy consumption during usage. Stocks in developing countries on the other hand will continue increasing as they expand their infrastructure. Converging stocks will lead to a redistribution of material stocks between world regions,[4] where Lao PDR could be on the receiving end.
5. **Degree of market saturation**. The sales of new cars in Germany is very close to the numbers of cars scrapped. This points at a high level of market saturation. Some circular economy business models are good at managing risks in saturated markets.[43] Markets in developing countries are typically less saturated.
6. **Low-carbon energy supply**. Circular economy strategies put little emphasis on renewable energy development. This terrain is already well-covered by climate policies. The energy supply of Lao PDR relies predominantly on hydropower and biomass. These two energy sources have a low carbon footprint and, when operated and designed well, can be relatively sustainable.

A best practice for policymakers is to shift taxes away from what deserves encouragement, to what should be discouraged. A tax system should make the consumption or extraction of virgin resources more

41. See, for example: http://reflowfilament.com.

42. A.G. Fernandes, "Closing the Loop: The benefits of the circular economy for developing countries and emerging economies", Tearfund, 2016.

43. A.B. Lovins, A new Dynamic – Effective business in a circular economy 2014.

expensive, and labour cheaper.[44] Such tax reform is less relevant to the Lao context. Wages in Lao PDR are amongst the lowest in the Southeast Asian region. Compared to its Southeast Asian peers, this makes resources already relatively expensive, while labour is available at low cost.

Sustainable development and climate action

The Sustainable Development Goals guide the 2030 Agenda for development. The impact of circular economy strategies cuts across a range of SDGs. Improving circularity touches upon several SDGs, like reducing poverty, improving food security, water quality, access to clean energy, economic growth, innovation, responsible consumption and production, sustainable communities and climate action.

Enhancing circularity contributes to mitigating climate change under *SDG 13, Climate action* and achieving national commitments under the Paris Agreement. However, the potential mitigation impact of circular economy strategies reaches well beyond national borders. Through international trade, they can reach the blast furnaces, refineries, wells, quarries and mines from which the imported materials and product originate. Emissions embodied in international trade represent over 30 per cent of the greenhouse gas footprint of countries.[4 » p. 14]

Box 4: Accounting for embedded emissions under the Paris Agreement

The carbon accounting framework of the Paris Agreement is based on inventories of national or territorial emission sources. This is a practical way to arrive at an estimate of global emissions, but does not indicate over which emissions a country has control[4 » p. 14] or bears responsibility (Scope 3 emissions)[45] but which occur upstream or downstream in the value chain of the reporting country. It is these indirect emissions, or emissions embedded in the carbon footprint of imported products, that are the key to bringing our cumulative international commitments in line with a 2°C or even 1.5°C pathway.[10 » p. 15]

The Paris Agreement should encourage the development of climate policies which target the emissions embedded in imported materials and products. This is an opportunity for the negotiations on UNFCCC guidance, and the modalities and procedures, which will be drafted under Article 6. This article governs the international cooperation on mitigation action and the potential exchange of mitigation outcomes. Article 6 can be used to develop incentive schemes for countries to account for foreign emission reductions, if they are a clear result of national action.

Low-carbon development strategies developed under the Paris Agreement should also put into question the mere existence of industries which are inevitably carbon intensive, rather than devoting effort to making them more efficient. An example is the production of steel, cement and paper from virgin resources, which accounts for a major share of global emissions. The greenhouse gas mitigation potential in the production of these materials is limited. Reducing international demand for these materials is the prime low-carbon development pathway for these industries.[46]

Four steps from the socio-metabolic profile to circularity

The first step is to develop an understanding of the socio-metabolic profile of Lao PDR, based on its imports and exports, land use, and anecdotal information on specific locations (*Figure 1*). This economy-wide data set supported priority setting in a workshop with government representatives. Priorities were identified based on national development ambitions, land-use conflicts, cases of loss of material value or underused assets, and pressing environmental issues.

By setting priorities at a relatively early stage, data collection was more focussed and the timeframe up to the delivery of the first report was shortened. When using this approach to, for exam-

44. The Ex'tax Project in cooperation with Cambridge Econometrics, Trucost, Deloitte, EY, KPMG Meijburg, and PwC. "New plan. Europe: A Fiscal Strategy for an Inclusive, Circular Economy"' Utrecht, 2016.

45. Greenhouse gas protocol, FAQ. "The GHG Protocol Corporate Standard classifies a company's GHG emissions into three "scopes". Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions."

46. S. Hashimoto and Y. Moriguchi, "Resource Management for Carbon Management: A Literature Review", *Global Environmental Research*, Vol 17, 2013.

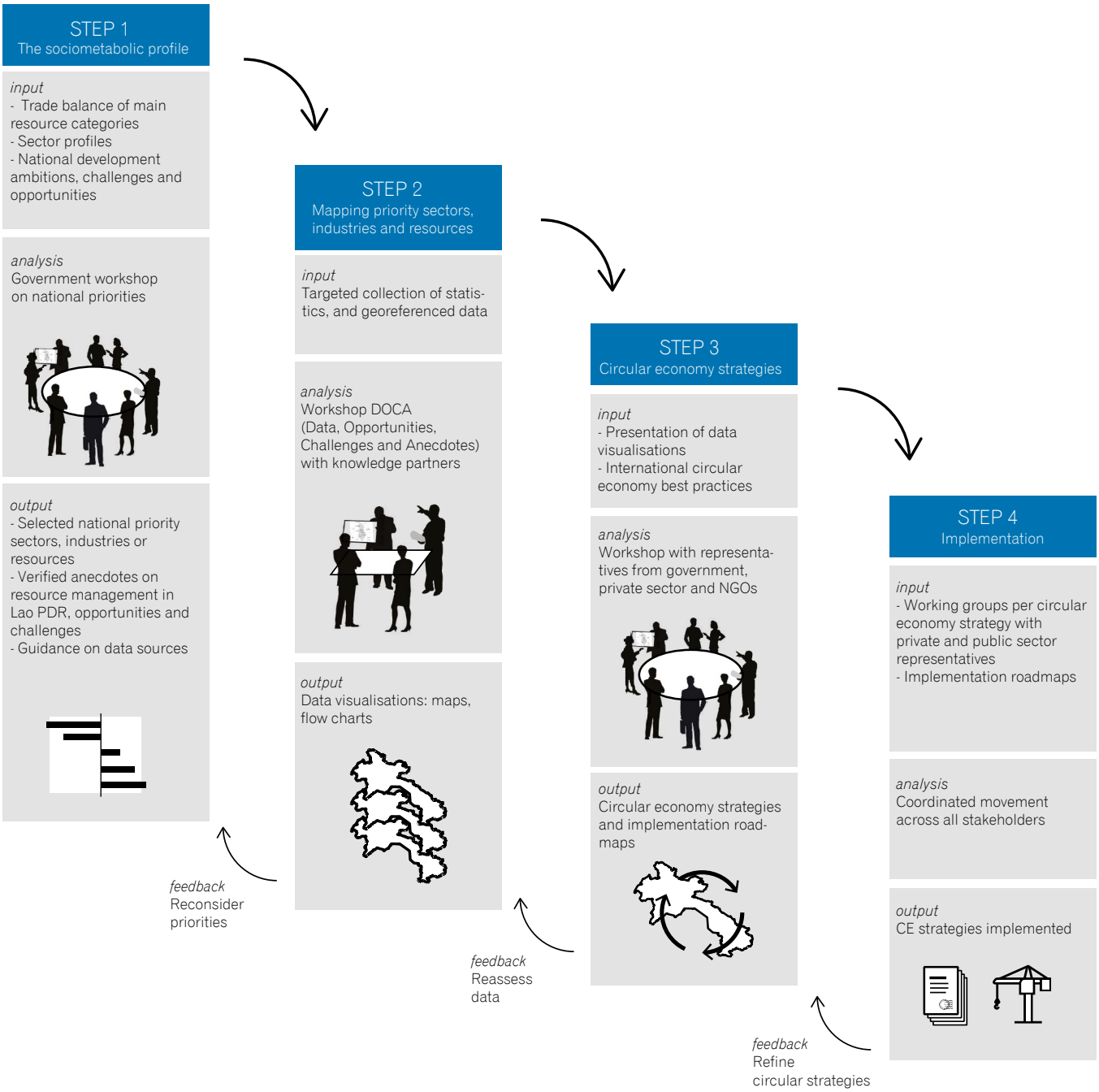
ple, increase the ambition of a Nationally Determined Contribution, the focus can be on the mitigation impact. In addition, if the timeframe is more generous, the mapping under step 2 could still have an economy-wide character. National development priorities will then not guide data collection but only make the identification of circular economy strategies more focussed.

In Step 3 all available data and visuals were compared with international circular best practices, to identify circular economy strategies for Lao PDR.

The first three steps have been taken before the publication of this report. The approach has been amended since the workshop with representatives from government, private sector and NGOs in Step 3, was postponed until the implementation phase. Therefore, the data visualizations and circular economy strategies proposed in this report are not the outcome, but rather the starting-point of a workshop with private and public sector stakeholders in Lao PDR. The objective of that workshop should be to verify or amend the circular economy strategies proposed in this report. After that, the implementation roadmaps can be developed.

Another amendment to the approach depicted in *Figure 1* has been that the priorities were not identified as a selection of sectors, but as a development priorities which cut across resource flows and sectors, and geographic regions and environmental concerns.

Many choices have been made throughout the study which were informed by anecdotes, views and opinions from stakeholders in Lao PDR, as well as consultations with experts in the Netherlands. These choices on which data to use, what topics to examine and which opportunities to elaborate, have determined the recommendations. The loops in *Figure 1* are opportunities to reconsider these choices and explore other development avenues with the data already available.



▲ Figure 1: A four-step approach towards a circular economy

Development opportunities and challenges in Lao PDR

Step 1: The socio-metabolic profile

Lao PDR has a large surface area, with a relatively small population and a low income per capita. Although domestic demand for products and services is keeping pace with strong growth in Gross Domestic Product, most of the demand for resources comes from neighbouring countries.

Between 1990 and 2015, Gross Domestic Product grew from US$866 million to US$12.3 billion. This growth was paralleled by a growth in resource extraction from 10 to 71 million tons per year. The government has taken bold measures to keep the country on a sustainable development pathway and it stopped issuing new mining concessions and banned the exports of raw wood.

Cooperation with neighbouring countries is crucial to reduce the reliance on resource rents and move away from the large material exports which hamper development of non-extractive national industries. A circular economy will lead to a more resilient society, less vulnerable to changes in commodity prices or availability and with a smaller carbon footprint. This is an immediate opportunity for Lao PDR, but also requires that the country responds adequately to circular economy ambitions in countries with which it maintains economic ties.

The development priorities of the country are rural development and diversification, agriculture and food security, eco-tourism, renewable energy, assembly and industrial development, reforestation, sustainable mining and protecting the quality of water resources. For these sectors, the focus will be on reducing resource rents, reducing raw material exports and developing local industries and avoiding the import of materials and products which can be sourced locally with a smaller environmental impact.

In Step 2 the priorities and development challenges guide further data collection and mapping, after which they are integrated into three circular economy strategies in Step 3.

1.1 Resource-driven growth

Lao PDR is a country with abundant national resources.[47] Its fertile soils support large forestry and agricultural systems, while covering deposits of gold, copper, zinc, lead, tin, iron, aluminium, potash, limestone, gypsum and coal.[48] The country's surface area is comparable to that of the United Kingdom, but has about ten times fewer inhabitants.[49]

The metabolic profile of a country consists of the typical patterns of material and energy flows and characterizes the interaction between nature and society.[7 » p.15] Lao PDR has an agrarian socio-metabolic profile with a low population density and low material and energy use per capita.[50] It has a relatively large rural population; 73 per cent of its work force is concentrated in the agricultural sector.[51] This sector provides 80 per cent of the population with a source of income, despite a declining contribution to GDP.[52] The extraction of ores and minerals mostly serves industries in surrounding countries, which have a more industrialized profile. The revenues from these exports are altering the Laotian economy, and can accelerate its transition towards a more industrialized profile.

Between 2004 and 2010 the domestic extraction of resources, excluding water, increased from 17 to 49 million tons per year (*Figure 2*).[53] During these years, increases in the extraction and export of wood, metal ores and refined copper were the main drivers behind economic growth.[54] The extraction rates exceed the country's ability to replenish reserves; 18 per cent of its Gross Domestic Product (GDP) is made up of resource rents from the extraction of ores and wood.[55] This is significantly higher than any of the surrounding countries [18 » p.15] and causes "Dutch disease"– where revenues from resource extraction strengthen the national currency, raise the prices of other domestic products like consumer products, handicrafts and tourism, and reduce their ability to compete on international markets.[52]

The 8th Five-Year National Socioeconomic Development Plan expresses the country's ambition to graduate from its current least developed country status by 2020, and become an upper middle-income country by 2030. Graduation from least developed country status requires that the country increases its scores on Gross National Income (GNI), the human assets index (nutrition, health, education and literacy) and the economic vulnerability index.[56] With a GNI per capita of US$1,740 in 2015, Lao PDR already meets the graduation threshold on income, but still falls short on the human assets and economic vulnerability indexes.[57] Circular economy strategies can support the country's graduation by decreasing its dependence on extracted and imported resources. Most of the poverty is concentrated in rural areas.[52,58] Tackling rural poverty is also where the most potential lies for improving scores on human assets and economic vulnerability. This argues for a focus on rural circular economy opportunities.

The ambition of Lao PDR is to combine "sustainability of development by emphasizing economic development which should include cultural and social progress, natural resource preservation and environment protection, with

47. World Bank, "Program Information Document Green Growth (Concept Stage)", 2016.

48. Department of Mines – Ministry of Energy and Mines Lao PDR, 2012, "Mining activities in Lao PDR."

49. Lao PDR spans 236 square kilometres. That is close to the 244 square kilometres of the United Kingdom. Lao PDR has a population of 7.0 million. The population of the United Kingdom is at 64.4 million, nearly 10 times larger. Central Intelligence Agency, *The World Factbook*.

50. World Bank, "Energy intensity level of primary energy (MJ/$2011 PPP GDP), Overview per country", 2016.

51. Central Intelligence Agency, *The World Factbook*.

52. Jayant Menon and Peter Warr, "The Lao Economy: Capitalizing on Natural Resource Exports", Asian Development Bank Economics Working Paper Series, No 330, January 2013.

53. UN Environment, "Science and data for people, Natural Resources: Resource Efficiency Indicators".

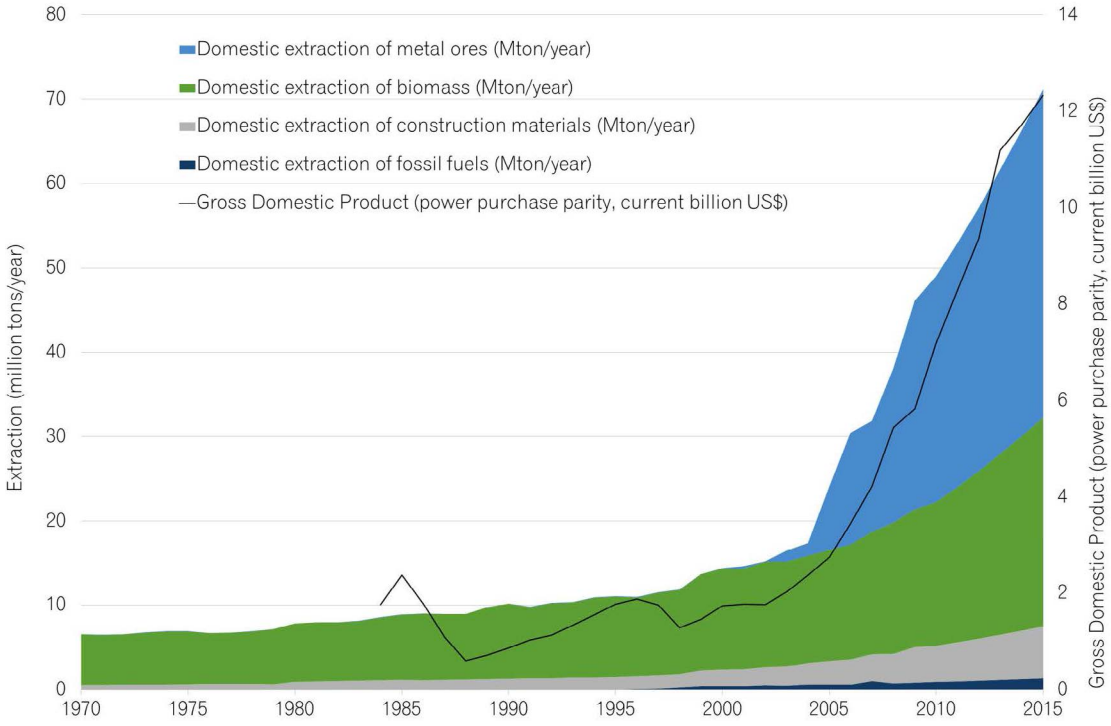
54. The Observatory of Economic Complexity, "The Atlas of Economic Complexity, Mapping paths to prosperity: Laos".

55. In 2014, 9.4 per cent of GDP came from forest rents and 9.0 per cent from mineral extraction. World Bank, Lao PDR country data.

56. UN-OHRLLS, "Criteria for Identification and Graduation of LDCs", 2017.

57. UN Economic and Social Council, Official Records 2015 - Supplement No. 13 Committee for Development Policy - Report on the seventeenth session - (23-27 March 2015).

Figure 2: Resource extraction and GDP in Lao PDR



widened regional and international integration".[31 » p.17] The country welcomes the revenues from the export of raw resources, and the jobs which mining activities create in rural areas. Diversifying job opportunities away from typical subsistence farming would make the rural economy more resilient. Such diversification should go beyond hydropower and mining alone.[59] The government confirmed during the workshop, that it is its ambition to develop the mineral, forestry and agricultural resources, and tourism potential. When sustainably managed, these sectors provide a sound basis for both short and long term growth.[31 » p.17]

Box 5: Norwegian Sovereign Wealth Fund

The country's development ambition asks for a new direction in which economic growth and development is decoupled from resource extraction. Slowing the rate of absorption of resource revenues can reduce the symptoms of Dutch disease and financially support this transition. An example is the Sovereign Wealth Fund in Norway.[52 » p.17] This fund invests Norwegian oil proceeds in companies abroad, and the government can draw down no more than the fund's expected annual returns.[60] Lao PDR is committed to invest revenues from resource extraction in education, health and basic infrastructure. This contributes to the graduation ambition from least developed country status.

The emerging private sector in Lao PDR is an opportunity for the development and adoption of circular economy strategies. The country has been open to private sector development since 1980. It is hoped that the private sector will increase the country's labour productivity and invest in its human resources.[59] The concept of a circular economy should be the paradigm which guides that effort.

58. H. Coulombe and others, "Where are the poor? Lao PDR 2015 Census-based Poverty Map: Province and District Level Results", Lao Statistics Bureau, Centre for Development and Environment, The World Bank Lao PDR County Office, The World Bank, 2016.

59. Ministry of Industry and Commerce, Lao PDR,2012, Trade and Private Sector Development Roadmap.

60. "How not to spend it", *The Economist,* 24 September 2016.

1.2 Resource demand from neighbouring countries

Located on the crossroads of three major Asian economies: China, Vietnam and Thailand, Lao PDR is surrounded by large and demanding markets. It serves these mostly with the extraction and export of raw materials, like metal ores and wood. This causes landscape degradation, deforestation, biodiversity loss and, due to the chemicals used in the metal extraction process, surface water pollution.

In agriculture, contract farming is another example of natural resource and asset use, with low added value for the Laotian economy. In the north, Chinese investors rent land from farmers and mobilize Chinese labour and resources to produce agricultural products for the Chinese market. The forestry sector on the border with Vietnam also serves the Vietnamese market, while employing Vietnamese labour for the extraction and export of raw wood.[61] This puts the country on a development path which creates short-term revenues but compromises long-term development with declining ore grades, deforestation, soil erosion and surface water pollution.

In response, the government of Lao PDR has taken bold measures to keep the country on a sustainable development pathway. In a moratorium from May 2016, it banned the export of logs, timber, processed wood, roots, branches, and trees. Production forests must submit forest management plans and project developers are no longer allowed to use timber to co-finance infrastructure development. Another example of bold policy development, is that the government stopped issuing new mining concessions, shifting its attention to forcing compliance of substandard mining operations with environmental standards.[62]

However, compared with the surrounding countries, the adoption of environmental legislation is slow and enforcement is weak.[63] The moratorium on timber exports is an example of legislation which faces enforcement challenges.[64] This attracts economic activities where a competitive advantage can be gained from running industrial operations below international environmental standards. The objective of environmental policy development could go beyond bringing these operations within environmental limits. When building on a vision of a circular future, it could even help companies become circular. Promoting such a vision can attract innovative foreign investors to Lao PDR; investors to whom sustainability is a moral business principle extending beyond compliance with environmental regulations.

Lao PDR must cooperate with its bordering countries when carving out a long-term development pathway which relies less on virgin resources. Several cooperation frameworks with that objective are already in place. One of these is the Mekong River Commission. This commission focusses on resource use with the objective "to jointly manage the shared water resources and the sustainable development of the Mekong River."[65] Lao PDR joined the Association of Southeast Asian Nations (ASEAN) [66] in 1997. This Association promotes cooperation and economic integration with all neighbouring states except China. "ASEAN Plus Three" was founded to further integrate

61. Forest Trends and DFID, "Timber Markets and Trade between Laos and Vietnam: a Commodity Chain Analysis of Vietnamese Driven Timber Flows", 2010.

62. Xinhuanet, "Laos to continue suspension of mining concessions", July 2015. Radio Free Asia, "Pollution From Copper Mining in Northern Laos Destroying Local Livelihoods", 24 July 2015.

63. Government of Lao PDR, "Strategic framework for national sustainable development strategy for Lao PDR", Water Resources and Environment Administration, 2008.

64. Radio Free Asia, "New Lao Prime Minister Issues Ban on Timber Exports", 17 May 2015.

65. Mekong River Commission.

66. ASEAN, available from: http://asean.org/.

and improve ties with China, Japan and South Korea.[67]

China is important for the development ambitions of Lao PDR. The Chinese government adopted a Circular Economy Promotion Law in 2009. It set the objective to improve resource efficiency by 15 per cent by 2016 and used the concept as a development model.[68] For some sectors in the Laotian economy, cooperation with China is a precondition for important steps to circularity. An example is removing certain trade restrictions. While some sectors benefit from import tariffs like wood processing and cement, motorcycle assembly has fewer concerns over international price competitiveness.[69] On the contrary, this sector would benefit from low-cost reverse logistics for remanufacturing.

1.3 International commitments and economic integration

Circular economy strategies provide practical implementation options which respond to a range of development ambitions of Lao PDR. A circular economy will lead to a more resilient society, less vulnerable to changes in commodity prices or availability and with a smaller carbon footprint. This is an immediate opportunity for Lao PDR, but also requires that the country responds adequately to circular economy ambitions in countries with which it maintains economic ties.

The economy of Laos is strongly integrated with the surrounding countries and relies on supply chains which extend to consumers and producers in other continents. With the circular economy high on the agenda within many OECD countries, it is important that Lao PDR understands its position within these international value chains. This is a condition for ensuring that industries which rely on foreign markets, secure themselves a place at the table where the circular future of these markets is designed.[70]

Lao PDR communicated an ambitious mitigation action plan before the Paris climate negotiation round in 2015. It seeks support with exploring innovative emission reduction avenues, to complement its current efforts on expanding renewable energy, electrifying rural areas, increasing forest cover and reducing transport emissions.[71] Circular economy strategies are estimated to be able to deliver significant emission reductions in OECD countries.[10 » p.15] They can do just the same in Lao PDR. Since the current emission level per capita in Lao PDR is already far below OECD levels, mitigation action in Lao PDR is mostly about maintaining a low-carbon economy alongside economic growth, rather than reducing the country's current carbon footprint.

The Sustainable Development Goals (SDGs) guide the 2030 Agenda for development. Lao PDR is very committed to progress on the SDGs and the it is the first country which defined a country-specific 18th SDG, which is "Lives saved from Unexploded Ordnance". The following SDGs can inform priority setting for circular development:

- SDG 1 *No poverty*: Lao PDR has halved its national poverty rate over the past decade, from 46 per cent in 1992 to 23 per cent in 2015.

67. ASEAN, available from: http://asean.org/asean/external-relations/asean-3/.

68. De Groene Zaak, "Circular Economy Promotion Law", n.d.

69. L. Leebouapao, S. Insisienmay and V. Nolintha "ASEAN–China Free Trade Area and the Competitiveness of Local Industries: A Case Study of Major Industries in the Lao People's Democratic Republic", ADB Working paper series on Regional Economic Integration No. 98, July 2012.

70. An example is the circular textiles initiative in the Netherlands. 67 per cent of European imports from Lao PDR are textiles.

71. United Nations Framework Convention on Climate Change, "Intended Nationally Determined Contribution, Lao PDR", 2015.

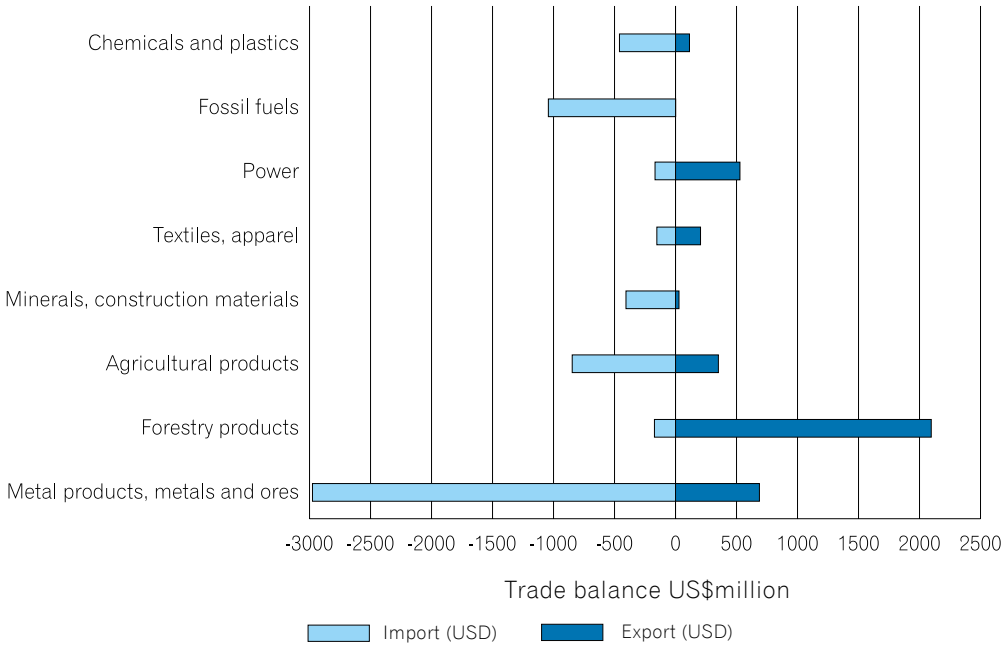


Figure 3: Import and export data on major resource types and related products

- SGD 2 *Zero hunger*: 18.5 per cent of the population in Laos today is still undernourished.
- *SDG 6 Clean water and sanitation*: 24 per cent of Lao PDR's population are without safe water.
- *SDG 7 Affordable and clean energy*: Laos has a low rate of energy consumption and a relatively low population density, a good starting point for sustainable use of energy.
- *SDG 8 Decent work and economic growth*: 70 per cent of employed people in Laos work in the agriculture or fishery sector.
- *SDG 9 Industry, Innovation and infrastructure*: How can Laos transform itself from a subsistence farming society into an industrialized country, boosting rural productivity and resilience?
- *SDG 11 Sustainable cities and communities*: Migration to urban areas, especially Vientiane, the capital, is growing quickly, with challenges including rising inequalities and sanitation.
- *SDG 12 Responsible consumption and production*: 76 per cent of all households in Laos grow rice. 99 per cent of agriculture sector workers are in vulnerable employment.
- *SDG 13 Climate Action*: Lao PDR was hit by 21 floods and storms between 1990 and 2015, with the more severe ones affecting over 500,000 people.[72]

72. UN in Lao PDR, "SDG Kickoff".

1.4 Sector profiles

Strategic priorities for sustainable development of Lao PRD lie with agriculture and food security, eco-tourism, renewable energy, sustainable mining and sustainable transport. Products like timber, textiles, minerals and coffee are of strategic

Table 1: Sectors and industries and the most relevant materials used or produced

Sector or industry	Main materials
Mining	Metals, ores
Manufacturing (vehicles only)	Vehicles and vehicle parts
Forestry	Wood, rubber, paper
Agriculture	Vegetables, meat, coffee, tea, tobacco
Construction	Cement, lime, stone, iron bars
Textiles	Fibres, leather, apparel, headwear, footwear
Power and energy	Electricity, fossil fuels
Waste	All resource categories, no data on cross-border trade of waste
Tourism	All resource categories, notably services

importance for trade development, export promotion and market liberalization.[6 » p.14]

An analysis of cross-border resource flows in Lao PDR, shows eight major resource categories which are internationally traded (*Figure 3*). Some of these, like agricultural products, forestry products and textiles and fibres, can be directly linked to a sector or industry. Other resources are used in more than one sector or for certain products it is unclear whether they are related to production and assembly, or only consumption in Lao PDR. Following the development priorities from the Laotian government, the sector profiles cover eight sectors or industries with high relevance to the Laotian economy. These sectors are listed in *Table 1*.

The **mining** industry has been the driver behind recent export-driven economic growth in Lao PDR. Its contribution to national GDP grew from 0.5 to 10.3 per cent over the period 2002 to 2011.[49 » p.26] The government has designated mining as a priority and a driver for local community development and poverty alleviation.

The trade balance in metals is negative in monetary terms (*Figure 4*). The value of copper and ores exports is US$2.3 billion below the value of the import of vehicles and articles of iron steel and aluminium.[55 » p.26] In reaction, the government aims to attract processing industries, to be able to export higher added-value products. The 8th five-year plan also aims to strengthen the metal smelting industries, notably iron, lead, aluminium, zinc, and gold. [31 » p.17]

The impact of the mining sector on the natural resource base of the country is a concern and the government plans to reduce the discharge of waste, chemicals and toxic and hazardous substances in rural areas. Both mining and hydropower development support the objectives of job creation, economic diversification in rural areas and infrastructure development. The concern is their adverse impact on forest and water resources.[31 » p.17]

Another challenge facing the mining sector is to ensure long term income for local communities. People value jobs which remain after the mining operation

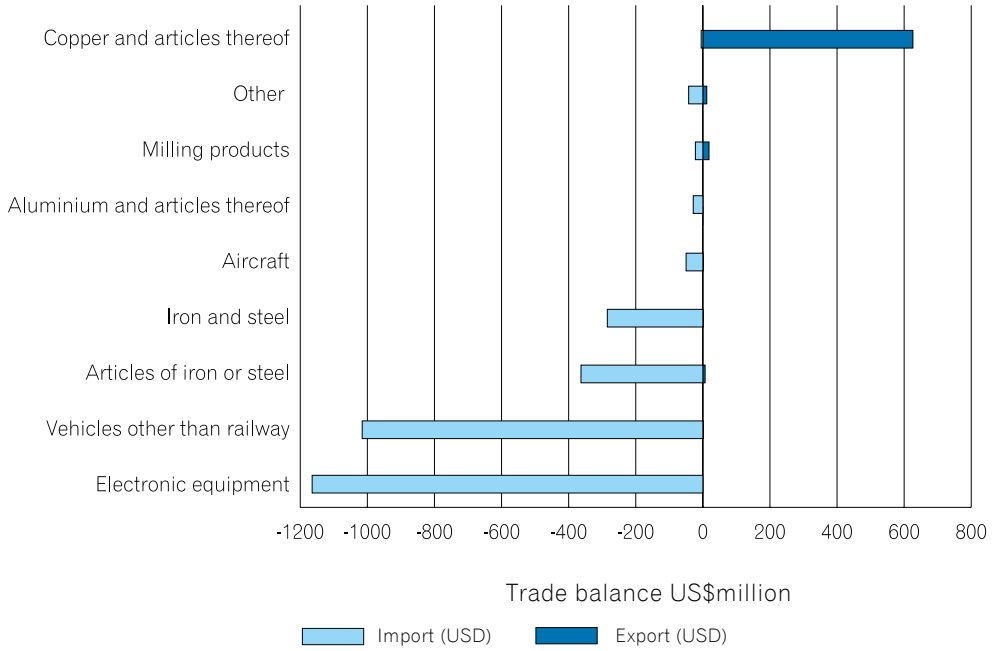


Figure 4: The trade balance of metal products and materials

has been terminated and fear being left with a deserted, barren mining landscape. Another challenge is avoiding Dutch disease, whereby the revenues from resource extraction appreciate the national currency and undermine the competitive position of other industries.[73]

The **manufacturing** industry, other than textiles which is discussed separately, is concentrated on vehicles and electronics. Import and export statistics in *Figure 4* show large imports of electronic equipment, vehicles and vehicle parts. Twelve vehicle assembly lines in Vientiane import motorcycle components and assemble them for the national market. Since all components are imported, the added value to the Laotian economy is low.

The **forestry** sector is the largest source of exports both in volume and monetary terms (*Figure 5*). The net export value of rough and sawn wood is US$1,9 billion. Mostly to Vietnam and China. Forestry operations in Lao PDR range from well-managed and sustainable plantations to uncontrolled illegal logging. Deforestation alone created CO_2 emissions of 42.7 million tons of CO_2e out of a total of 43.8 million tons of national CO_2 emissions in 2000.[74] The added value of the sector is underdeveloped, since the logging operations attract Vietnamese labour and most wood processing takes place in Vietnam. Also, illegal logging remains a concern and impedes improving circularity in the forestry sector.

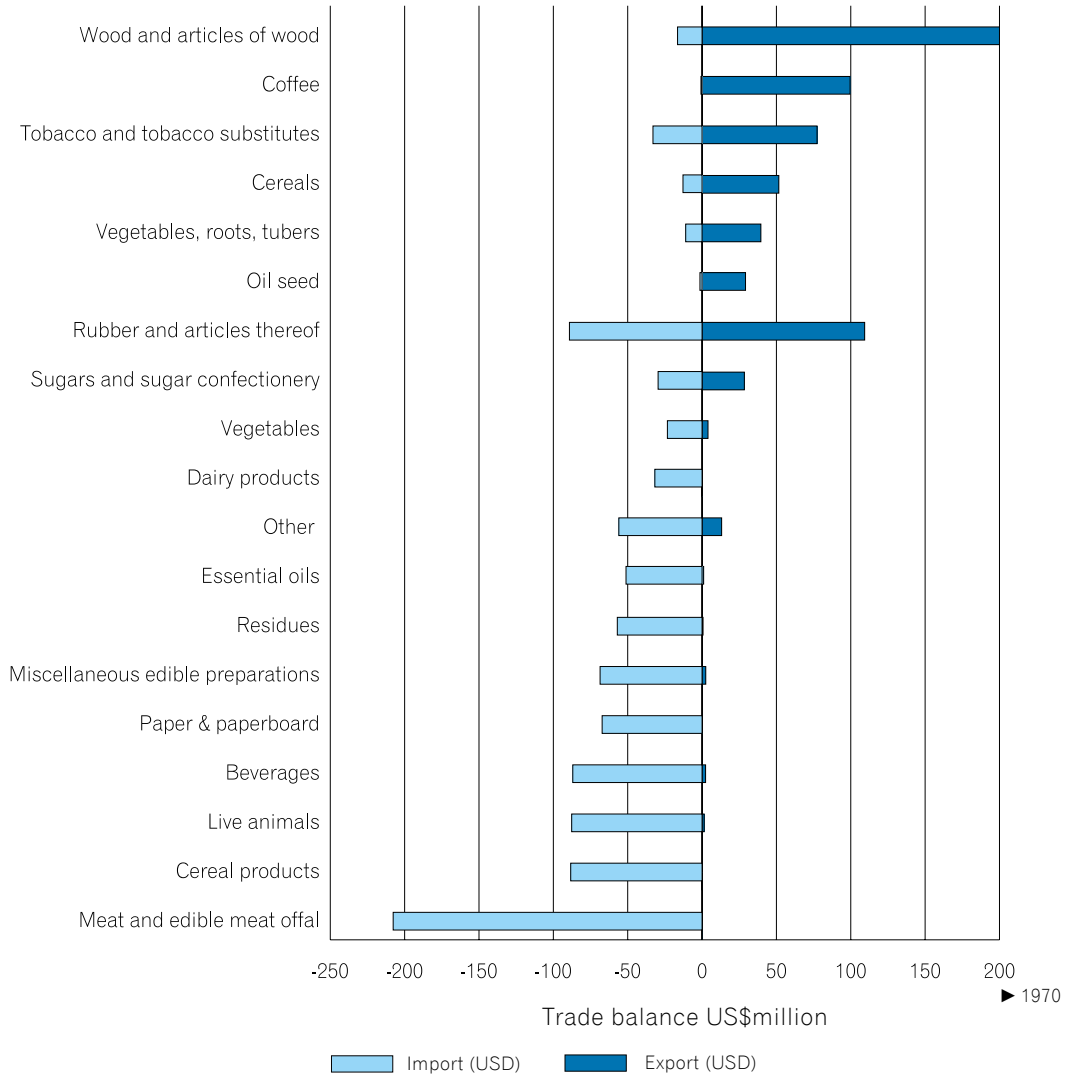
The government aims to reduce illegal logging with a moratorium on the export of wood. This is a vital step towards protecting natural assets and increasing forest cover. Another government aim is to increase forest cover by 8.2 million ha, to 70 per cent of the country's surface, by 2020.[31] » p. 17, 75

73. Ministry of Energy and Mines, "Utilizing mining and mineral resources to foster the sustainable development of the Lao PDR", 2011. UNDP and UNEP, "Economic, Social and environmental impacts of investments in mining", Poverty-Environment Initiative (PEI) Lao PDR Issues Brief, 08/2010.

74. 2nd National Communication Lao PDR, page 33.

75. World Wildlife Fund, "Lao Government aims to restore forest cover to 70 percent by 2020".

Figure 5: The trade balance of forestry and agricultural products and materials



Agriculture provides a source of income to about 80 per cent of the population and is a potential lever to alleviate rural poverty. Its development aligns well with the national objective of stepping away from resource-driven growth by tapping into national forestry and agriculture resources. On the other hand, the government aims to make rural areas more resilient "by increasing the ratio of non-agricultural sectors".[31 » p. 17] The sector struggles with coordinating production with processing and market demand. Overproduction in some regions conflicts with the national objective to increase yields.[31 » p. 17] The distribution issue is also evidenced by the combination of local overproduction and the food and nutrition insecurity in some of the south-eastern and northern regions of the country.[55 » p. 26]

The **construction** sector benefitted from a boom as resource extractive industries started pushing the national

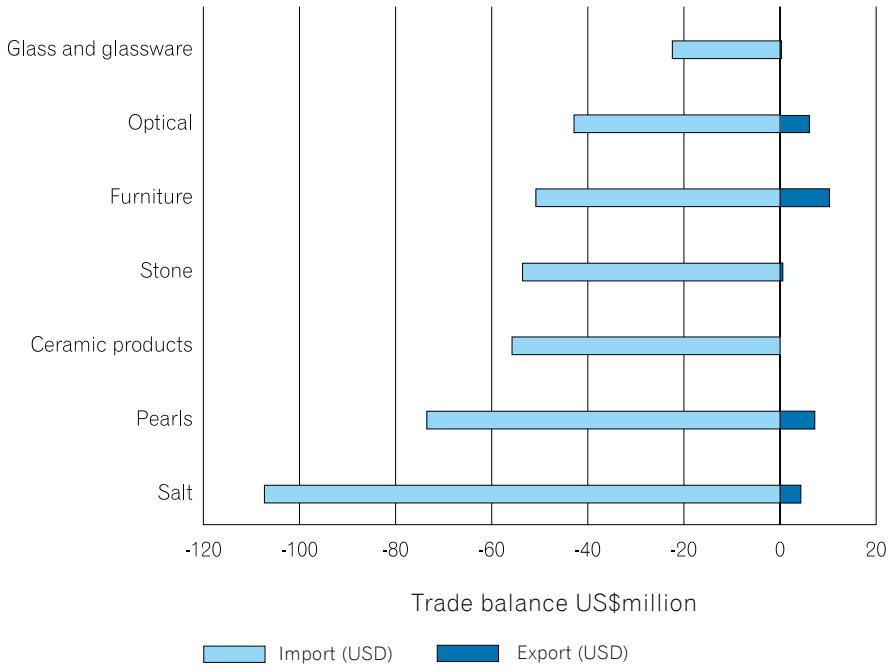


Figure 6: The trade balance of construction materials and minerals

GDP upwards; 35 per cent of government investments go into the construction of roads and offices.[31 » p. 17]

The construction sector is expected to continue growing. For the Kunming-Vientiane railway (also referred to as the Vientiane–Boten Railway Project) alone, an estimated 3.6 million tons of cement is needed. This exceeds the national production capacity which stood at 1.5 million tons/year by 2014.[76] Expanding cement production is one of the activities foreseen in the 8th five-year plan.[31 » p. 17]

Figure 6 shows the import and export of construction materials and minerals. When looking in more detail into construction materials, Lao PDR is a net importer. For example, the salt includes net imports of US$94 million worth of Portland cement and US$1.7 million worth of bricks. Glass includes US$149,000 worth of insulating glass and includes US$46 million raw iron bars which can be used for enforced concrete.

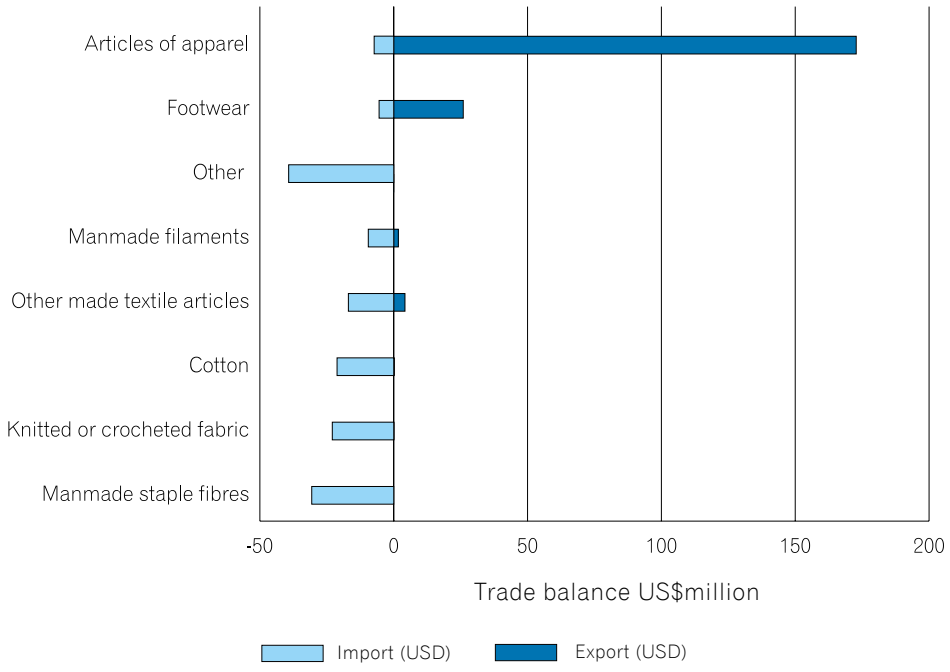
The **textiles** industry stands out for its positive trade balance (*Figure 7*). In 2015, it exported higher added value garments while importing fibres, creating a positive trade balance of US$111 million per year on top of the US$88 million worth of imported fibres.[55 » p. 26] Its 100 to 120 factories are concentrated in the Vientiane and Savannakhet regions.[77] The textiles industry is internationally oriented. For example, 67 per cent of the import value of the EU from Lao PDR is clothing.[55 » p. 26] In acknowledgement of its importance, the 8th five-year plan mentions the textiles industry as a priority within specific industrial zones.[31 » p. 17]

The **power and energy** sector of Lao PDR is dominated by export of hydropower and import of fossil trans-

76. USGS, "2012 Minerals Yearbook – Laos" [advance release], "2013 Minerals Yearbook – Laos" [advance release].

77. Factsheet Laos - Lina Stotz - Facts on Laos' Garment Industry.

Figure 7: The trade balance of textiles and fibres



port fuels. The country installed 6.4 GW hydropower capacity in parallel with increasing the household electrification rate from 16 per cent in 1995 to 92 per cent in 2016.[78] This is only a fraction of its 26 GW potential. The country has a lower use of primary energy per unit of GDP than its neighbours and a low national power demand.[50] » p. 26 Thus, Lao PDR can afford to export over 80 per cent of its power mostly to Thailand, creating a revenue of US$533 million in 2015. To provide electricity to some remote border areas, Lao PDR purchases US$170 million worth of power from neighbouring countries.[55] » p. 26

The reservoirs have a major impact on the flow of resources, ranging from extending the retention time of the water, to altering the flow of sediments and water-borne substances. Further development of the hydropower potential and electrification of rural areas are national development priorities.[31] » p. 17

Lao PDR imports all its transport fuels (*Figure 8*) from Thailand and Vietnam. The value of imported transport fuels was US$785 million in 2015 and is expected to reach US$1,430 million by 2020 and US$2,296 million by 2030. The country has the ambition to produce biofuels while some development partners consider promoting electric vehicles in parallel.[79] To satisfy a demand for liquid fuels, Lao PDR intends to produce biofuels from plastics and used vegetable oil but also develop the cultivation of energy crops like oleaginous fruit trees.[31] » p. 17 Some estimates show that agricultural engines could run 100 per cent on biofuels by 2020, and road vehicles could use 20 per cent blended biofuel by 2020.[80] These activities would put additional pressure on scarce land resources, which are already

78. World Food Programme, Food and nutrition security atlas of Lao PDR, 2013.

79. Japan International Cooperation Agency, Ministry of Public Works and Transport, (JICA, MPWT) "The preliminary works for the technical cooperation on low-emission transport system in Lao PDR (LETS EV)", 2014. JICA, MPWT, "Basic Data Collection Study on Low-Emission Public Transport System in Lao PDR". 2012.

80. Engineering and Consulting Firms Association, Japan, Japan Development Institute (JDI) Japan Bio-Energy Development Corporation (JBEDC) Lao Bio-Energy Corporation (LBEDC) JDI, "Decentralized Biofuel Supply Chain Development Study in Lao PDR - Application of Biofuel Supply Chains for Rural Development and Lao Energy Security Measures", Study Report, March 2008.

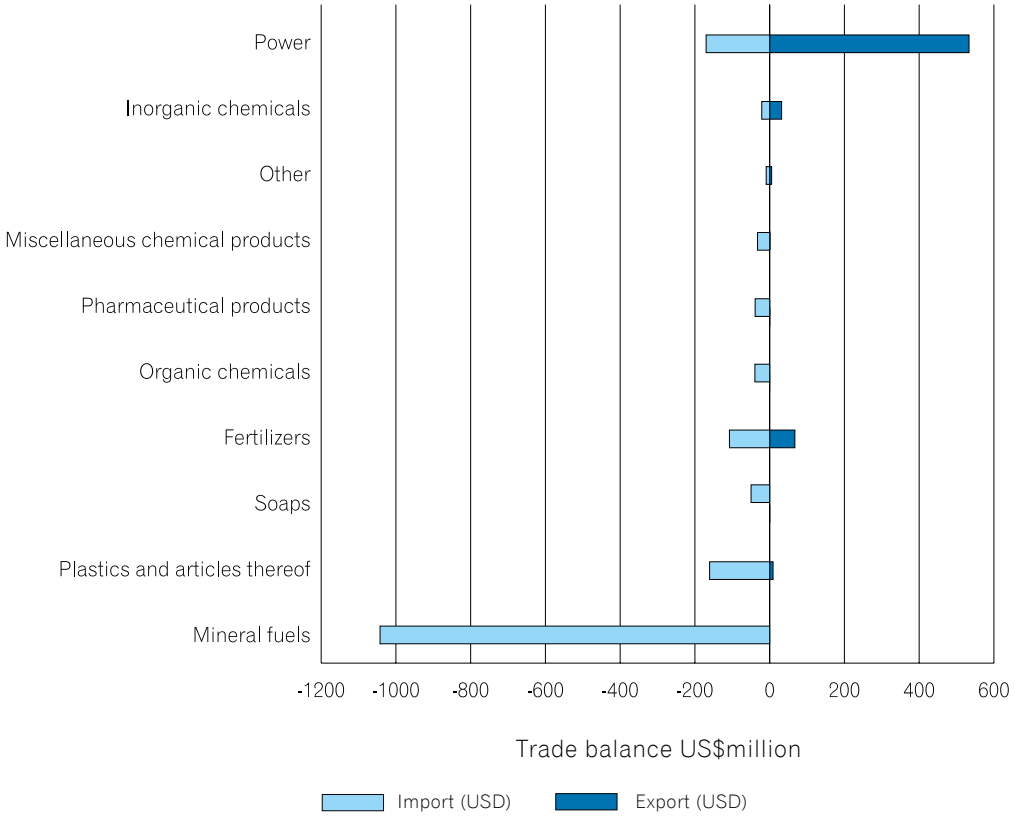


Figure 8: The trade balance of plastic and chemical products and materials, mineral fuels and power

destined to provide space for the development of forestry, agriculture, hydropower, mining and tourism. The challenge here is to find development directions which could respond to the need for biofuel development without putting further pressure on available land.

Waste sector. The net imports of plastics into Lao PDR cost over US$150 million per year (*Figure 8*).[55] » p. 26 On the other hand, plastics make up 12 per cent of the waste generated from urban centres. A similar imbalance is reflected in the flows of nutrients and fertilizers. While Lao PDR imports a net US$ 40 million worth of fertilizers, and the same value of organic chemicals, its municipal waste consists of 40 per cent food and vegetables and 19 per cent wood and cuttings.

The waste sector in the larger cities of Lao PDR is targeted by several development organizations which are exploring ways to improve waste collection, generate fuels from plastic waste and improve composting. Apart from municipal solid waste, the food processing and mining industry have an important role in protecting surface water quality. The water quality of the Mekong river is a clear indicator for the success of national water discharge policies and international treaties on river water quality. The Mekong river shows an increase in the concentration of phosphorous[81] and organic matter, resulting in a decline in

81. Kongmeng Ly, Henrik Larsen, Nguyen Van Duyen, *2013 Lower Mekong Regional Water Quality Monitoring Report*, MRC Technical Paper No. 51, 2015, Mekong River Commission.

Table 2: Waste composition in the larger cities Vientiane, Luangprabang, Savannakhet, Champasak

Waste composition	Weighted average (%)
Food, vegetables	40
Wood, grass, trees, leaf	19
Paper	6
Plastic	12
Glass	5
Metal	2
Textile	2
Other	14

the dissolved oxygen which supports aquatic life.[82]

Tourism represents 5 per cent of the world GDP. It contributes to around 5 per cent of global greenhouse gas emissions while offering about 6-7 per cent of global employment. In Lao PDR, the sector is designated as one of the main levers to lift the country out of its least developed country status. The tendency towards farther travel over shorter time periods, increases transport emissions from tourism. Improving energy and resource efficiency is expected to reinforce local hiring and sourcing, and might help preserve local cultures. Tourism is also a sector where a relatively high share of the income and revenues accrue to poor households. it can thereby contribute to progress on the human assets and economic vulnerability indexes, and help the country graduate from its least developed country status.[83]

Tourism is a national priority and the 8th five-year plan sets a target of six million tourists by 2020, and seeks to encourage a longer average stay of more than ten days per head. The sector is set to generate a minimum annual revenue of US$ 953 million, compared with US$406 million in 2011, making it amongst the largest export sectors. The "promotion and development of eco-and cultural tourism through implementing community based tourism projects" is one of the stated objectives for this sector, along with the promotion of "eco-tourism facilities in forests and biodiversity-rich areas". This resonates well with the objective to divert "more labour from rural agriculture to work in the industrial and service sectors".[31] » p. 17

82. World Bank, Lao PDR Environment Monitor 2014.

83. UNEP, *Towards a Green Economy, Pathways to Sustainable Development*, "Tourism, investing in energy and resource efficiency", 2011.

Step 2: Mapping priority sectors, industries and resources

Resource flows have a spatial component which tells where development opportunities and challenges lie, or where ambitions overlap. With respect to the development priorities, four maps show where raw material extraction, agriculture and energy production have an impact on the landscape, creating both opportunities or challenges. Since tourism is a sector where the government expects a lot of growth, a map with tourism potential and challenges has been added to identify development hotspots.

A lot of the development ambitions of Lao PDR require land, whether it is expansion of the mining sector, increasing agricultural produce, reforestation, the production of biofuels or the expansion of infrastructure. In addition, they show several opportunities to position Lao PDR as a hub in the flow of resources in Southeast Asia. If it takes advantage of these opportunities, the country can make best use of current and future cargo infrastructure, while substituting some of the import of high-value products and materials, with domestically produced alternatives.

2.1 Selected maps

The development priorities for Lao PDR are rural development and economic diversification, tourism, mining, hydropower, reforestation, assembly and industrial development, and clean water. The spatial aspect of these priorities is explored in a series of maps which show opportunities and threats for the parallel development of national ambitions.

The first map depicts the resource flows. Most raw materials extracted and produced in Lao PDR are exported. This **resource analysis map** connects the centres of production and processing of wood, food, minerals and metals, with product destinations in Lao PDR and abroad. It looks for opportunities to close the loop, and investment opportunities to make the linear outflow of raw materials circular.

The **agriculture analysis map** explores the imminent land-use conflict which is embedded in the combination of development ambitions which Lao PDR has. It looks for alternative production sites for organic matter which can fuel a bio-based economy.

The third map looks at Lao PDR's ambition to become the battery of Southeast Asia. Expanding hydropower has a major landscape impact, while also altering the flow of rivers and sediments. The **energy analysis map**, therefore shows hydropower development together with water flows and power infrastructure, looking for ways in which the expanding hydropower reservoirs can support circular development in other sectors.

Tourism is an interesting development priority, since advances in the circularity of the tourism sector can spill over to other sectors. Its international exposure can make tourism a frontrunner in the adoption of circular concepts. The **tourism analysis map,** therefore, has a sectoral focus and looks at the locations of interest for tourism, the main points of entry, accommodation, spatial opportunities for tourism development, while also depicting the developments which pose a threat for tourism, or where tourism poses a threat to vulnerable landscapes and nature.

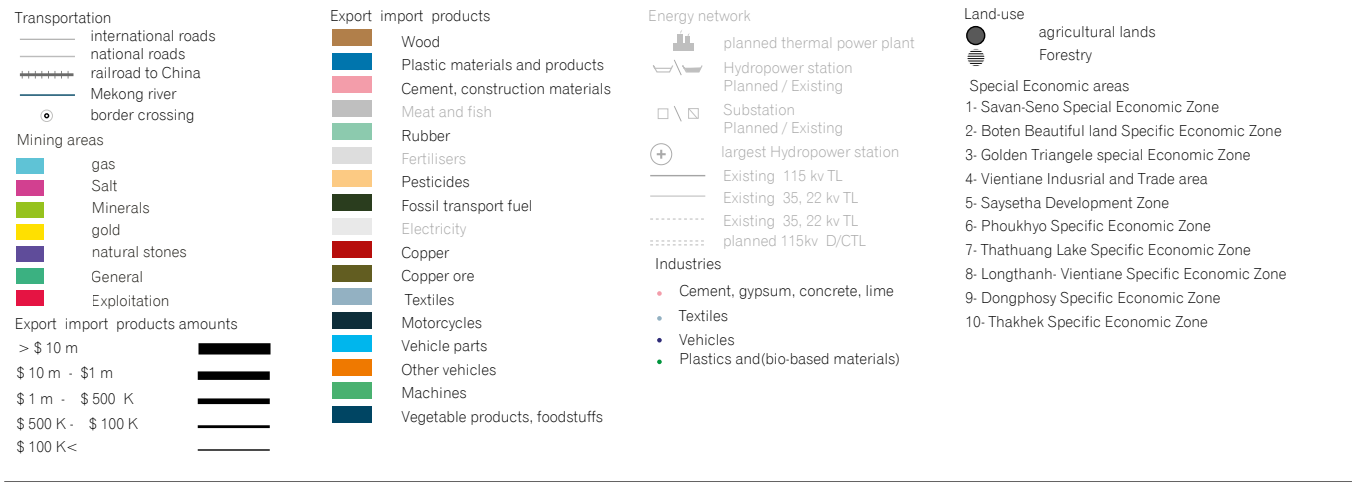
The choices made here and the information which has been selected for each map represent a certain angle of looking at resource use in Lao PDR. Many others remain unexplored but deserve attention as well. The data which has been collected can support additional analysis tailored to a specific industry, resource type, supply chain, national development ambition, specific city, province or industrial area, or even a specific opportunity.

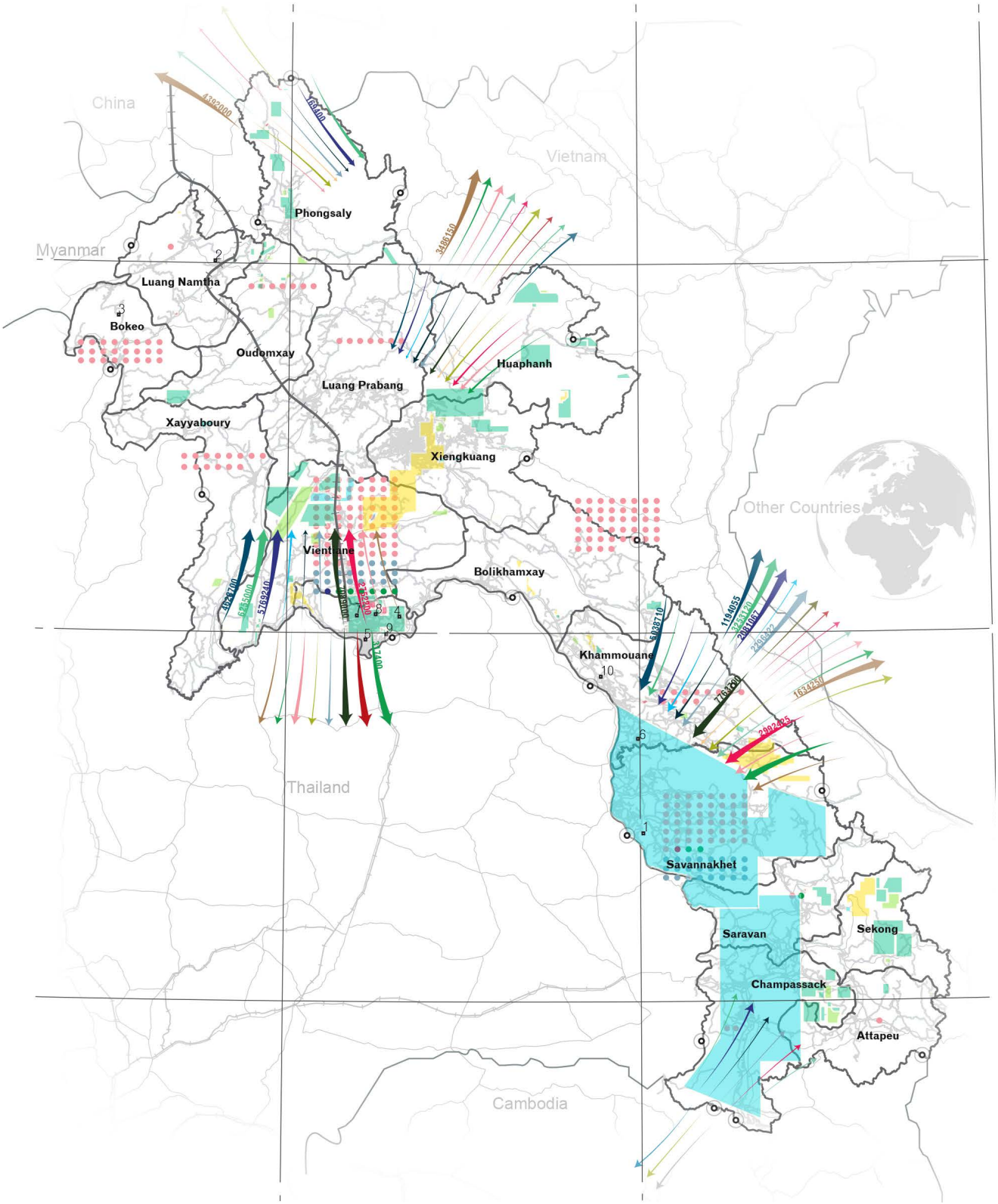
2.2 Resources analysis

Mapping resource flows in Lao PDR confirms that there is a net outflow of resources. In monetary terms, the flow of metals, mostly copper and gold to Thailand and China, is large. In terms of volume however, the export of raw timber is the largest cross-border resource flow. While exports are mostly of raw materials, imports are rather higher-added value or refined products like electronic equipment, vehicles, petrol and cement.

This raises the question whether some of the imports can be substituted with national products. When building an industry in Lao PDR which uses domestic resources and processes these for the domestic market, it might in future also be feasible to replace the export of raw material with higher added value products.

► Figure 9:
Resources analysis




China
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Xiengkuang
Vientiane
Bolikhamxay
Khammouane
Savannakhet
Saravan
Sekong
Champassack
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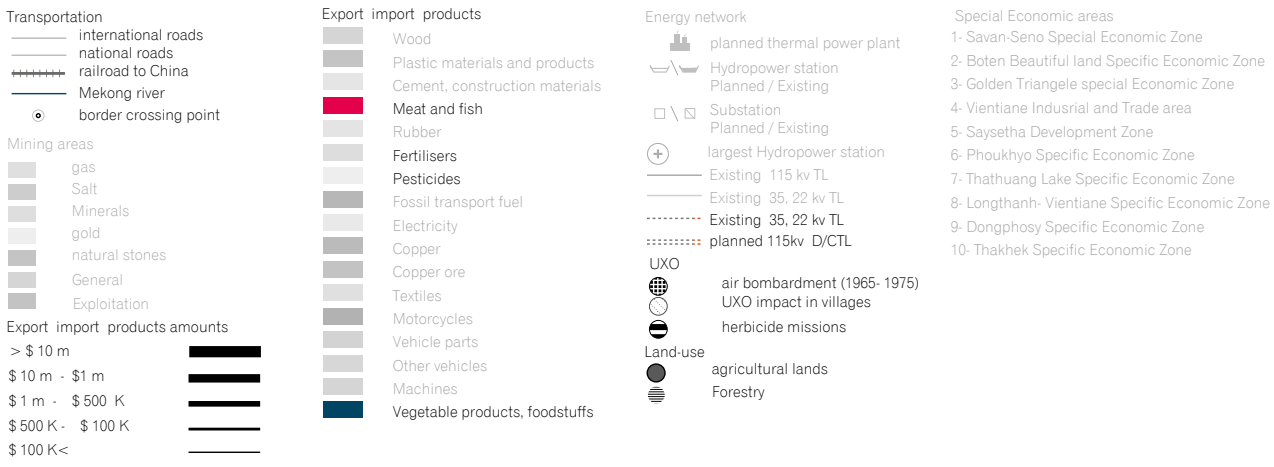
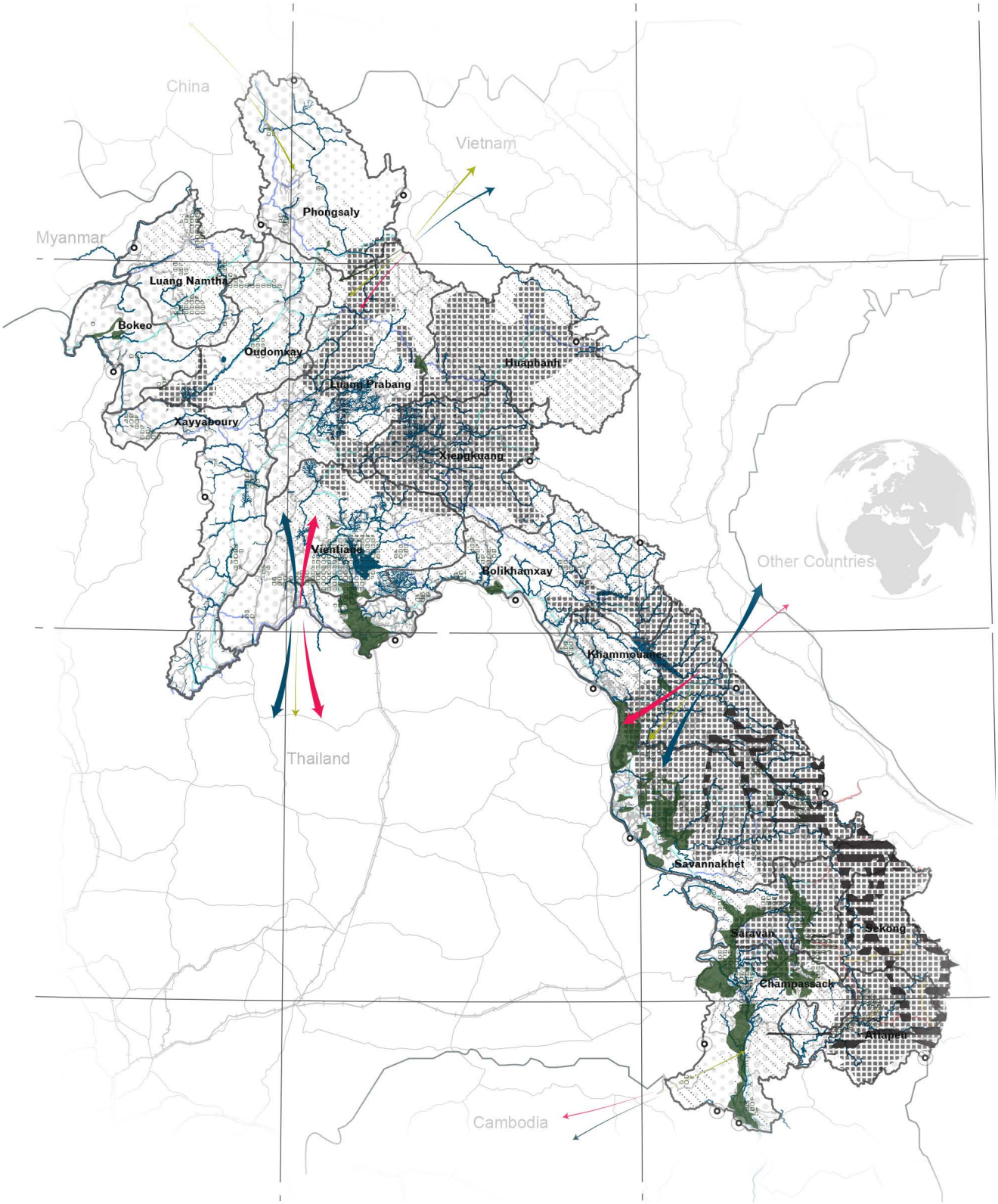
2.3 Agriculture analysis

Food production in Lao PRD is concentrated in the south and in the area around Vientiane. The presence of Unexploded Ordnance (UXO) impedes access to agricultural lands in the west and southwest of the country, aggravating land scarcity. This is a challenge for the biofuel ambitions of the Laotian government. By 2014, Lao PDR had 33,000 ha of oil seed plantations but significantly larger areas are needed for biofuels to be able to substitute a significant share of the national fossil fuel imports.

The food processing industries are a major source of organic residue. Four large sources of biomass in Lao PDR are sawdust, rice husks, corncob and bagasse. These four alone represented 1.3 million tons in 2007.[30] » p. 17 The energy potential of these resources needs to be balanced against using biomass as a material resource. Since Lao PDR produces a vast amount of electricity, while importing plastics and construction materials, the latter might be the preferred option.

► Figure 10:
Agriculture analysis

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Xayyaboury
Xiengkhuang
Vientiane
Bolikhamxay
Other Countries
Khammouane
Thailand
Savannakhet
Saravan
Sekong
Champassack
Attapeu
Cambodia

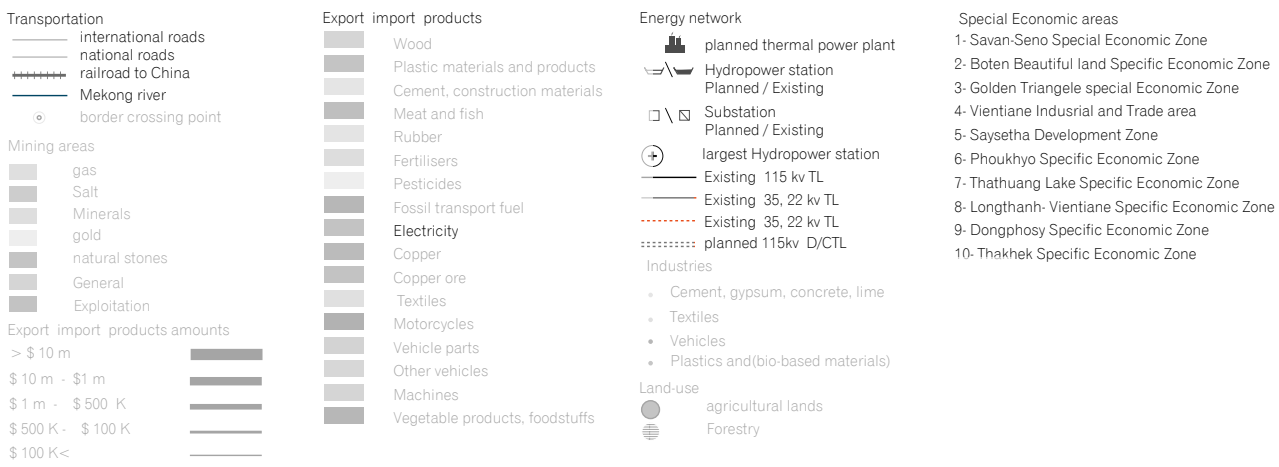
2.4 Energy analysis

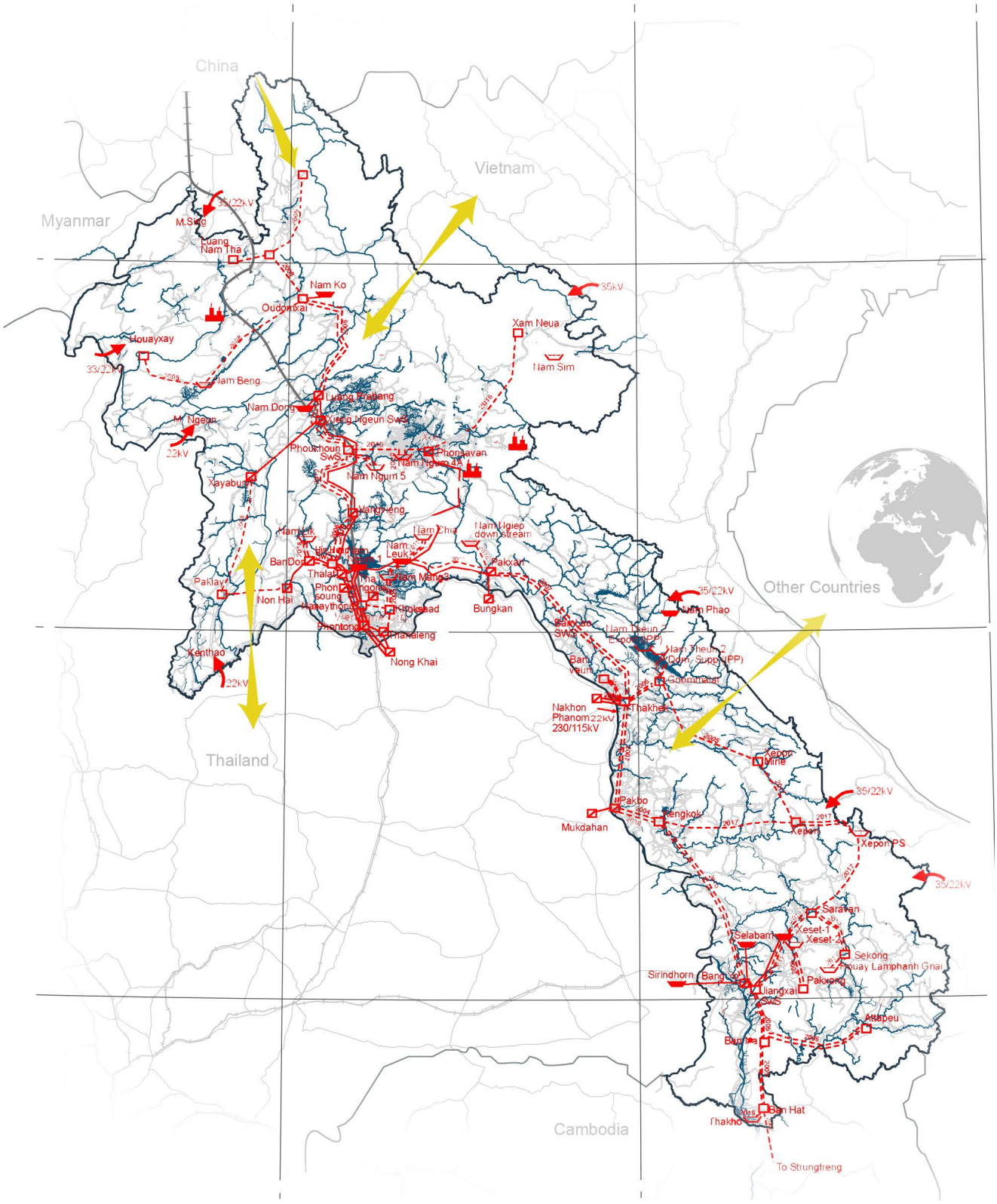
The Laotian power grid is interconnected with surrounding countries. The country exports power mainly to Thailand and is negotiating offtake contracts with Malaysia and Singapore. It is also a transit country for power from China destined for Thailand. In addition, in border regions, neighbouring countries sometimes supply power to remote areas which are not yet connected to the Laotian grid.

ASEAN has a Power Grid Consultative Committee which aims to connect power supply and demand in the Southeast Asia region. New connections are planned between Lao PDR and Thailand, Vietnam and Cambodia, while other power lines also connect Brunei and the Philippines to the mainland grid. These plans strengthen the ambition of Lao PDR to be the battery of Southeast Asia.[84]

84. ASEAN Centre for Energy.

► Figure 11:
Energy analysis

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Myanmar
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Other Countries
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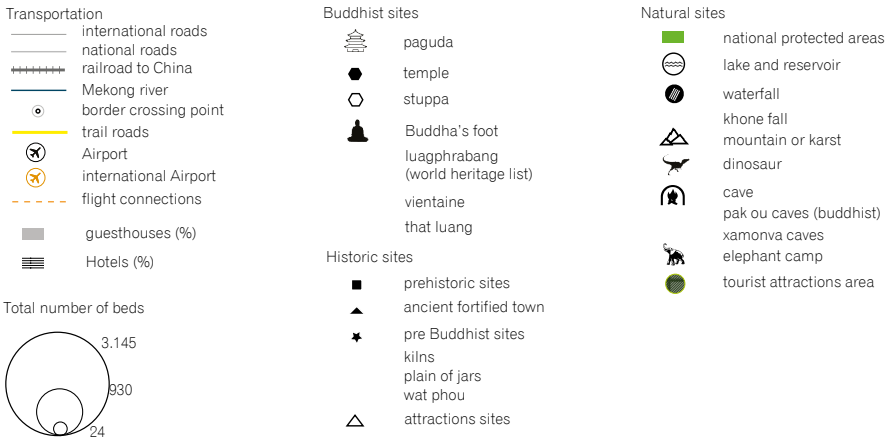
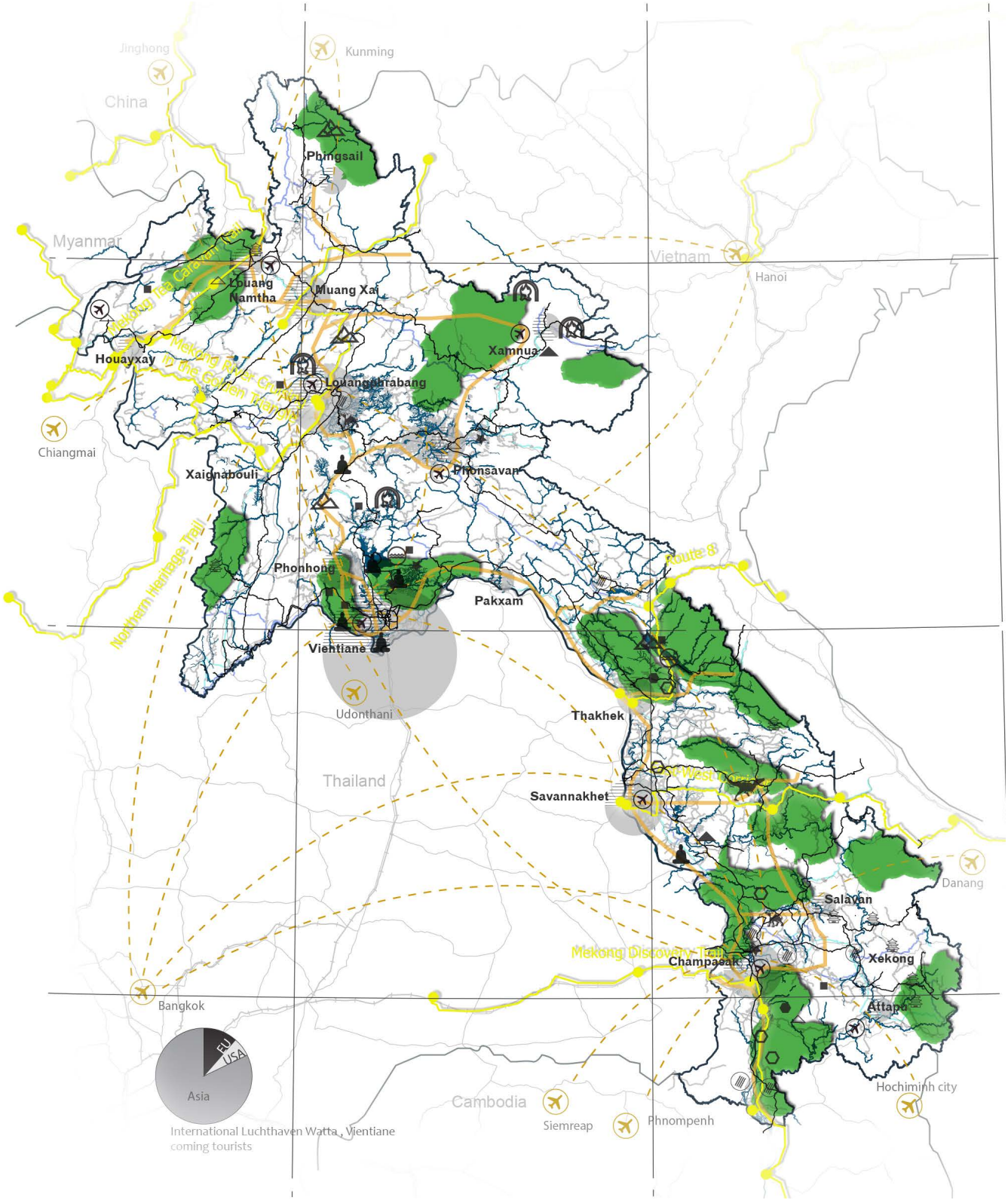
Luang Nam Tha
Nam Ko
Oudomxai
Houayxay
33/22kV
Nam Beng
Nam Dong
Luang Prabang
Xieng Ngeun SwS
Mr Ngeun
22kV
Phouthoun SwS
Phonsavan
Nam Ngum 4A
Nam Ngum 5
Xayabury
Vangvieng
Nam Chia
Nam Ngiep down stream
Nam Leuk
Pakxan
Paklay
Non Hai
Bungkan
Khoksaad
Thanaleng
Nong Khai
Kenthao
22kV
35kV
Xam Neua
Nam Sim
35/22kV
Nam Phao
Nam Theun 2 (Dom. Supp (IPP)
Nakhon Phanom 230/115kV
22kV
Thakhek
Xepon Mine
35/22kV
Pakbo
Mukdahan
Xepon
Xepon PS
35/22kV
Saravan
Xeset-1
Xeset-2
Selabam
Sekong
Houay Lamphanh Gnai
Sirindhorn
Bang
Jiangxai SwS
Pakxeng
Attapeu
Ban Hat
Thakho
To Strungtreng

2.5 Tourism analysis

Lao PDR receives 4.2 million tourists per year, of which 2.0 million come from Thailand, 1.0 million from Vietnam, 0.5 million from China and 0.3 million from Europe and North America. Most of the tourist highlights are in the southern and central parts of the country, and often within or close to natural parks. This requires a tourism concept which preserves the natural qualities of the landscape and its vegetation and wildlife and can also help diversity rural economies and help lift people out of poverty.

► Figure 12:
Tourism analysis




Jinghong
Kunming
China
Phongsali
Myanmar
Vietnam
Hanoi
Louang Namtha
Muang Xai
Houayxay
Xamnua
Louangphrabang
Chiangmai
Xaignabouli
Phonsavan
Northern Heritage Trail
Phonhong
Route 8
Pakxam
Vientiane
Udonthani
Thakhek
Thailand
Savannakhet
Danang
Salavan
Mekong Discovery Trail
Champasak
Xekong
Attapu
Bangkok
Hochiminh city
Cambodia
Siemreap
Phnompenh
EU
USA
Asia
International Luchthaven Watta , Vientiane
coming tourists

Circular future

Step 3: Circular economy strategies

Existing industries in Lao PDR can make better use of recycled or bio-based materials. When positioning the country as a hub for secondary resources, and developing reverse logistics for national products, national industries can grow without increasing imports of half-fabricates or raw materials. Examples are the recovery of end-of-life motorcycles or vehicle parts in the motorcycle manufacturing industries in Vientiane, and the use of recycled and sorted fibres in the textiles industries in the Savannakhet region. Finally, technological advancements in the use of bacteria to extract valuable metals represents an opportunity for the safe and efficient recovery of metals from e-waste.

The second strategy aims at substituting the import of carbon-intensive construction materials like steel and concrete with domestically produced cross laminated timber and bamboo. International experience is being gained through erecting multiple storey buildings with these two materials. Circular procurement by the government and using circular construction materials in the tourism sector can make this opportunity part of broader ambitions for sustainable building standards and eco-tourism.

The third strategy focusses on overcoming the overlap in land-use ambitions. The hydropower reservoirs represent a large underused asset with potential for tourism and fishing. It can also help substitute imports with the production of protein, fertiliser and even biofuels by farming algae. Algae also help improve water quality.

▲ Figure 14: Tailor-made motorcycles with use of cores

3.1 Circular manufacturing, textiles and waste management: cores, recycled fibres and bacteria

Circular economy strategy

Position and develop Lao PDR as a resource hub for recycling and remanufacturing.

Technologies

- Extend the lifetime of motorcycles by recovering and remanufacturing end-of-life motorcycles and motorcycle components.
- Use new technologies to process and sort end-of-life textiles and use these to substituted imported virgin fibres. If needed, complement the available fibre residues with organic fibres.
- Consider the use of bioleaching to extract metals from electronic waste or e-waste.
- Use idle inbound cargo transport capacity for reverse logistics of end-of-life products and materials.ambition.

Lao PDR exports large volumes of metal ores, forestry and agricultural products. This net outflow of materials implies that there is idle transport capacity in the reverse direction. This reverse cargo capacity is available at low cost and can be used for reverse logistics of end-of-life products to stimulate the growth of the Laotian recycling and remanufacturing industries.

The country is in the heart of Southeast Asia. This enables it to connect supply and demand between the larger economies of Thailand, Vietnam, China and possibly Malaysia and Singapore. The construction of a railway line between Kunming, a city with 6.6 million inhabitants in south China, and Vientiane,[85] the capital of Lao PDR, will place Lao PDR on a major transport artery between China and other countries on mainland and maritime Southeast Asia (*Figure 13*).

The railway is another opportunity for Lao PDR to develop remanufacturing, recycling, assembly or packaging industries which can add value to the raw materials and products which this new railway is expected to transport. This strategy can help to prevent Lao PDR from becoming only a transit country, with cargo flows creating little added value. In this case, the low labour costs in Lao PDR are a competitive advantage since remanufacturing and recycling activities are often labour-intensive.

The **motorcycle industry** has potential for remanufacturing. The twelve motorcycle assembly lines, concentrated in the Vientiane region, produce for domestic and foreign markets. Their added value to the Laotian economy is limited since they rely on imported parts and components. This can change by developing remanufacturing industries in Lao PDR and using idle transport capacity for the reverse logistics.[86] At the national scale this requires organizing the recovery and remanufacturing of end-of-life motorcycles and parts (also referred to as *cores*) from Lao PDR. The expansion of the Laotian railway network connects motorcycle assembly in Vientiane with markets in China. This can also support recovery of end-of-life motorcycles, or their components, to undergo remanufacturing and re-enter the market.

Figure 14 shows what remanufacturing of historic, classical motorbikes could mean for both assembly and local retail businesses. An ecosystem of suppliers, refurbishment industries, catalogue operators and store housing could position Lao PDR as regional hub for cores. A collector from China can find the unique missing component for their precious classic motorcycle; repair industries in Southeast Asia can find remanufactured vehicle parts which last forever; and this is where a diversity of "typical Lao motorbikes" can find their way into the local markets and tourism.

Motorcycle remanufacturing becomes a vibrant industry, creating new jobs and economic activity on the streets. Tourism companies organizing trails and renting out motorbikes and bicycles quickly catch up on the trend, happy that Lao PDR has found a way to really distinguish itself in the tourism market of Southeast Asia.

On the back of developing remanufacturing industries, the conversion of motorcycles to electric can help make urban transport cleaner. Developing its ambition as the battery of Southeast Asia, Lao PDR can lead the labour-intensive conversion of vehicles to electricity, taking away combustion engines as a prime source of air pollution in cities in Lao PDR and surrounding countries.[87]

The **textiles industry** can substitute its use of virgin fibres and fabric with recycled textiles. The Laotian textiles

85. Prashanth Parameswaran, "China, Laos to build $6 billion railway by 2020", *The Diplomat*, 16 November 2015.

86. Syviengxay Oraboune, "Lao PDR's Industrial Development Policy and Intermediate Goods Trade", in Mitsuhiro Kagami, ed., *Intermediate Goods Trade in East Asia: Economic deepening though FTAs/EPAs,* BRC Research Report No.5, Bangkok Research Center, IDE-JETRO, Bangkok, Thailand.

87. "Convert your classic car to battery power", *The Telegraph*, 16 April 2013.

industry mostly serves European fashion markets[55 » p.26] which are looking for a "closed loop textiles industry" where no material is lost. Innovations like Fibresort[88] will enable sorting of the different fibre types used in clothes.[89] That will have implications for the Laotian textiles industry. By adopting similar technologies in Lao PDR, the Laotian textiles industry can substitute the import of virgin fibres, with a value of US$87.5 million in 2015,[55 » p.17, 90] with the import of low-cost end-of-life clothes. This will complement the over 2,000 tons of textiles waste which was estimated to be available within its four larger cities as early as 1998.[91] Current figures probably far exceed that value.

When adopted in Lao PDR, the Fibresort technology could position the textiles industry as a recycling hub for the Southeast Asia region. Imported, low-value end-of-life clothes can then be sorted, upgraded and supply the Laotian, Cambodian and Thai textiles industries with raw materials.

Vientiane is attracting **e-waste processing and recycling companies**, which is an industry that does not yet appear in the official statistics. These companies are attracted by shortcomings in the regulation in Lao PDR on e-waste processing and sometimes operate outside the law. Since e-waste contains a variety of toxic substances, this is both an environmental and health risk. If Lao PDR has a competitive advantage for the processing of e-waste it makes sense to formalize this sector[92] and support its development while improving labour conditions, extraction techniques and resource management.

Proper recycling of e-waste requires design for disassembly and recycling, and safe methods to recover and recycle materials. The extraction of metals present in e-waste has technical parallels with the

88. Available from: http://www.valvan.com/products/equipment-for-used-clothing-wipers/sorting-equipment/fibersort/.

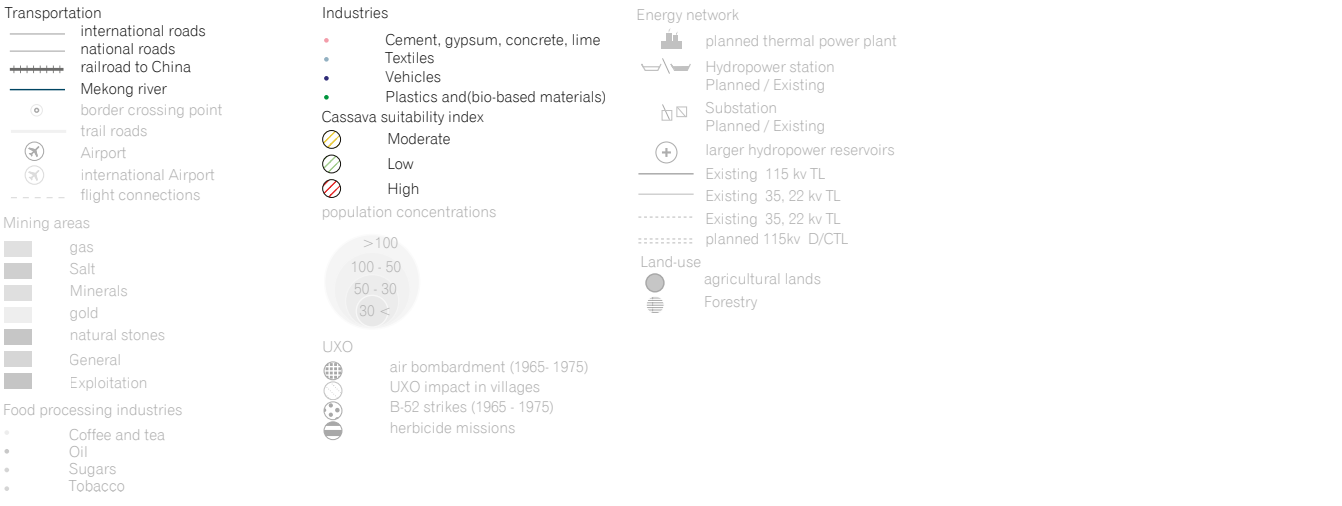
89. Available from: https://www.circle-economy.com/fibersort-project-successfully-enters-phase-2-of-the-interreg-north-west-europe-nwe-funding-programme/.

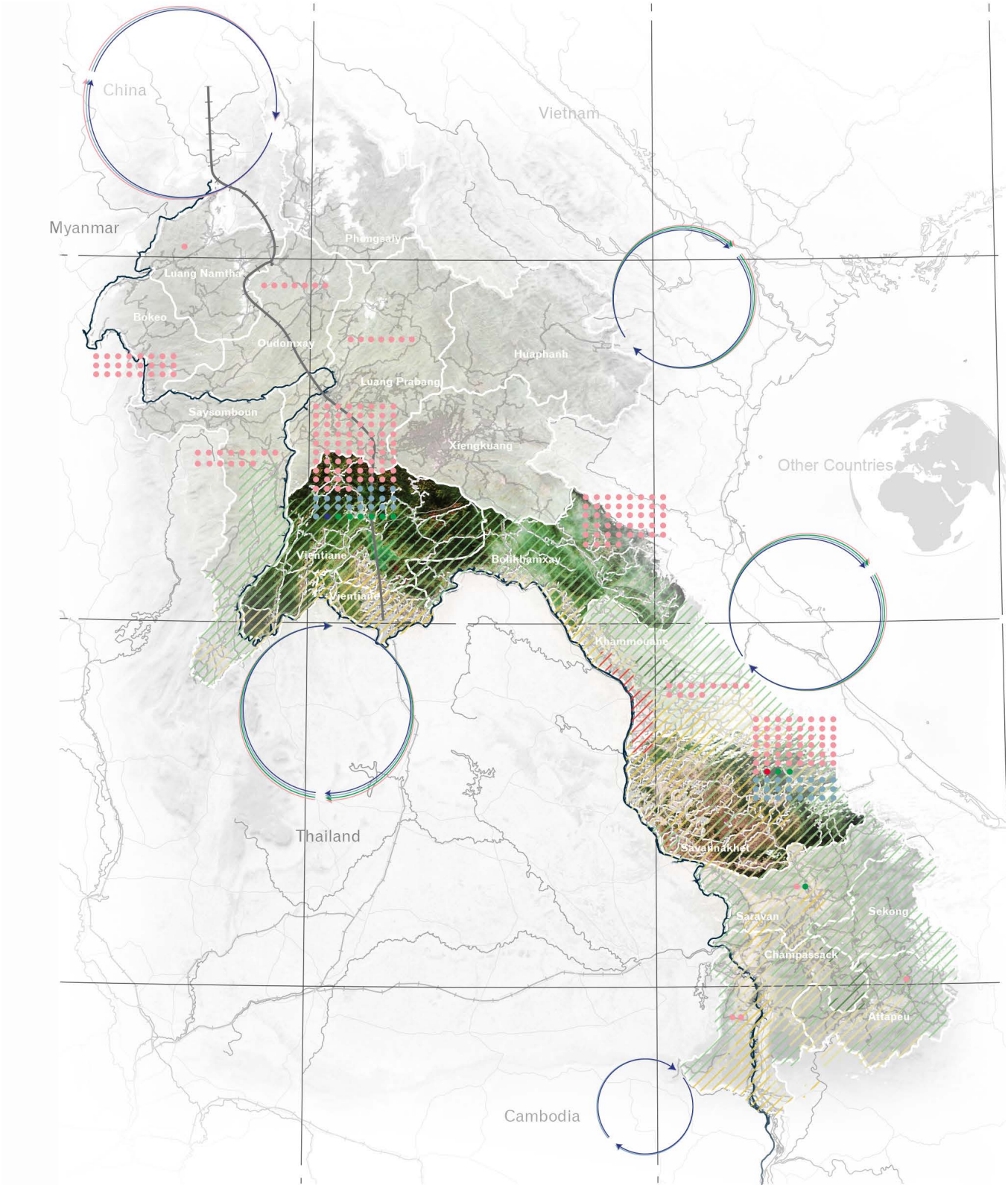
90. The US$ 87.5 million is the value of the import of cotton, knitted or crocheted fabric and man-made staple fibres.

91. Janya Sang-Arun and Krakanh Pasomsouk, IGES, A guide for improving municipal solid waste management and promoting urban organic waste utilization in Lao PDR, IGES Working Paper No. SCP-2012-01, 2012.

92. I. Nnorom and O. Osibanjo, "Electronic waste (e-waste): Material flows and management practices in Nigeria" *Waste Management*, Vol.28, Issue 8, 2008, pp.1472–1479.

► Figure 13:
Remanufacturing and recycling opportunities




China
Vietnam
Myanmar
Phongsaly
Luang Namtha
Bokeo
Oudomxay
Huaphanh
Luang Prabang
Saysomboun
Xiengkuang
Other Countries
Vientiane
Bolikhamxay
Vientiane
Khammouane
Thailand
Savannakhet
Saravan
Sekong
Champassack
Attapeu
Cambodia

extraction of metals from ores during the mining process. Bioleaching is a technology with benefits for both mining and e-waste processing.[93] It is an extraction method which makes use of bacteria rather than hazardous chemicals, like arsenic or cyanide, for the extraction of copper, zinc, lead, nickel, gold and silver from ores or e-waste. It is an opportunity to reduce the environmental impact of the e-waste processing industries but also reduce the risk of severe water and soil by mining industries. For the government, the ability of mining and waste processing industries to adopt processing technologies which guarantee a clean material recovery process,[94] should be a precondition for issuing a licence to operate.

3.2 Circular construction materials from forests: circular resorts to advance ecotourism

Circular economy strategy

Substitute imported construction materials with cross laminate timber and bamboo

Sectors

Construction, forestry, tourism

Rationale

- Use cross laminated timber and bamboo to replace imported concrete and steel as the prime construction materials which support the construction boom in urban areas and expansion of tourist infrastructure.
- The use of domestic resources, can preserve a sense of national identity in the architecture used in urban areas and touristic resorts.
- Pilot new building methods in the tourism sector and further elevate the circularity of the tourism sector, in line with the national ecotourism

There are four main circular strategies in the construction sector: material substitution, material cycling; modular building; and asset sharing. Vientiane is experiencing a construction boom and these strategies should take a central position in supporting further growth, while using domestic rather than imported resources, maintaining a degree of flexibility in the function of buildings and safeguarding a national architectural character. A very promising strategy is material substitution. In Lao PDR, the use of bamboo and wood are very good candidates.

The possibilities for the use of bamboo and wood as construction materials are expanding. Stora Enso[95] is a Finnish company which sources sustainable wood from plantations in Lao PDR. The company produces cross laminated timber which is used for several-storey buildings and complex structures and arguably, offers higher comfort and better aesthetics than high-carbon alternatives like enforced concrete would.[96, 97] The same is true for bamboo.[98]

Selecting circular construction materials, choosing an architecture which allows for the building to serve different purposes and modular design, can become the basis for country-wide building standards. These standards could require considering landscape features in building design, and prioritize the use of nationally available building materials. They would acknowledge and expand on traditional construction methods while still allowing for a modern architecture.

Circular procurement by the government of Lao PDR could stimulate the development of a circular construction

93. Deepak Pant and Others, "Chemical and biological extraction of metals present in E waste: A hybrid technology", *Waste Management*, Vol 32, Issue 5, 2012 pp.797-1058.

94. Abhishek Kumar Awasthi, Xianlai Zeng and Jinhui Li, "Integrated bioleaching of copper metal from waste printed circuit board—a comprehensive review of approaches and challenges", *Environmental Science and Pollution Research*, Vol. 23, Issue21, 21141-21156. And see also P. Kiddee, R. Naidu, and M. H. Wong, "Electronic waste management approaches: an overview", *Waste Management*, Vol. 33, Issue 5, May 2013, pp 1237–1250.

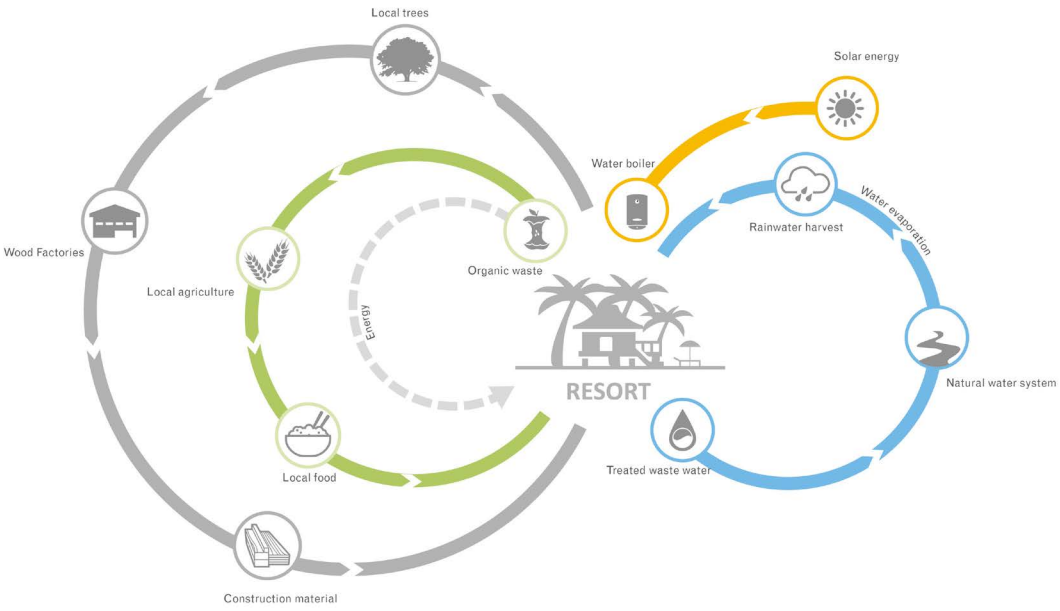
95. Available from: http://www.storaenso.com.

96. Layne Evans, "Cross Laminated Timber, Taking wood buildings to the next level", American Wood Council, 2013.

97. Designboom, "Wooden skyscrapers: a roundup of tall timber buildings", 2016. See also Inhabitat, "Cross Laminated Timber".

98. Available from: http://www.circular-tourism.com/news/cole-company-creates-bamboo-cocoons-to-protect-laos-wildlife/.

Figure 16: Diagram of circular resort design and operation



99. The Global Sustainable Tourism Council.

sector in the national and provincial capitals; 35 per cent of government investments go into the construction of roads and offices.[31] » p. 17

The tourism sector could be another early adopter of new building materials, as an important part of a broader ambition to enhance the sustainability of eco-tourism. The sector has a direct incentive to build and operate resorts while avoiding or minimizing their impact on natural surroundings, resources and even culture. Furthermore, high-end and high-value tourism is attracted by high standards of sustainability.

Sustainable tourism is expected to grow six times faster than the sector-wide growth rate.[83] » p. 37 Certification by the Global Sustainable Tourism Council (GSTC) allows companies and programmes to obtain recognition for their greening efforts.[99] Considering its impact on the environment and the attraction of pristine nature, the ambition of the tourism industry should strive to become completely circular.

Circular resort design requires that the resource flows and stocks guide its architecture and aims at full site restoration when the resort has reached the end of its lifetime or has become obsolete for other reasons (*Figure 16*). Local construction methods allow for small-scale approaches which are common to ecotourism in Lao PDR. Such accommodation is relatively easy to integrate into the landscape. It becomes challenging when looking at the larger resorts which are planned in the Special Economic Zones. However, the use of construction materials like wood and bamboo can help preserve a national character and distinguish tourism in Lao PDR from large-scale resort development in surrounding countries.

During **resort operation**, circularity may imply stepping away from

▲ Figure 17: Impression of a circular resort

bureaucratic environmental management systems, towards allowing a resort and its staff to be guided by a unique vision of circularity, which would also inspire its guests (*Figure 17*). This could include sourcing food locally and recycling nutrients back to the land from which the food products originate. This could build on the vision of Lao PDR for the crop sector,[100] expertise from existing programmes to promote organic farming in Lao PDR,[101] or experience from entrepreneurs which already connect organic agriculture with tourism.[102]

Operation of the resort can also be inspired by the way in which local communities produce food, use water and recycle food waste. Where they are circular in essence, studying, documenting and applying these approaches in the resort will provide experience with application at a larger commercial scale. This may allow for replication in other communities, which have already lost their traditional, nature-based approach to food production, house construction, water use, waste avoidance and nutrient management.

100. Ministry of Agriculture and Forestry, Department of Agriculture, "Development Strategy of the Crop Sector 2025 and Vision 2030", 2015.

101. Asian Development Bank, "Organic Crops Help Small Farmers out of Poverty in Lao PDR", June 2014.

102. See, for example: http://www.laofarm.org/.

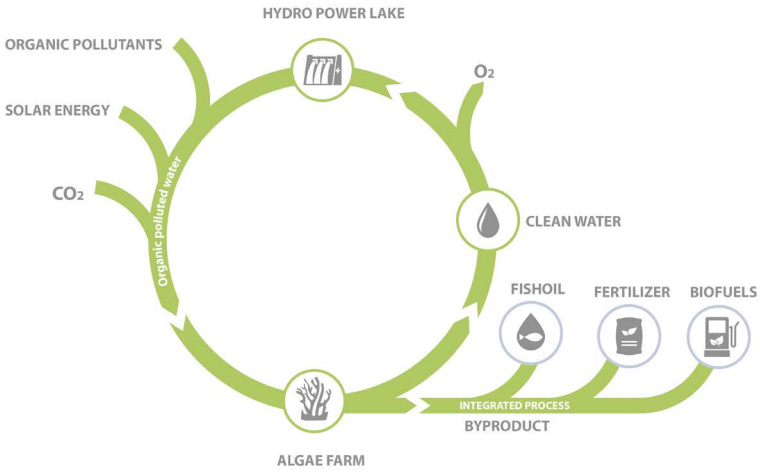


Figure 18: Diagram of algae production in hydropower reservoirs

When envisioning a resort in a rural area in Lao PDR, local communities should be the main source of labour, and their lifestyle a source of inspiration. Rural communities in pristine areas of Lao PDR have long relied on locally available resources to sustain their community and provide the construction materials, food and clothing which they need. Not all practices are sustainable, however. For example, swidden agriculture is common practice in rural areas of Lao PDR and is one of the drivers of deforestation.

When selecting those practices which preserve or even enhance the local resource base, a resort could be designed as an ecological community or eco-village, whereby nearby producers can supply the food and resources.

3.3 Circular agriculture and hydropower: algae farming to clean water in reservoirs

Lao PDR has an installed capacity of 6,441 MW of hydropower,[103] including 16 stations with a reservoir. The largest reservoir belongs to the 39m high Nakai dam and covers 450 km^2. The reservoirs represent a large underused asset and host only some tourism and fishing activities.

The ambition of Lao PDR to restore is forest cover to reach 70 per cent of the landmass, while also aiming to expand its agricultural production, produce biofuels, expand mining and hydropower activities. This makes land increasingly scarce and points at the hydropower reservoirs as a large, underused asset.

Mobilizing this underused potential should consider the water quality in Lao PRD, which is threatened by discharges from agriculture and mining. Water quality measurements in the Mekong river show an increase in the concentration of phosphorous [96] and mines are reported to pollute water resources with metals and chemicals. In 2013, water quality monitoring in the Mekong river reported an alarming increase in organic matter, resulting in a decline in the dissolved oxygen which supports aquatic life.[85]

The relatively high temperature of the water in the reservoirs, as well as the nutrients from upstream agricultural

103. International Hydropower Association, "Hydropower Status Report 2016"

areas make the reservoirs a fertile location to produce algae. Algae can be used as **bio-fertilizer**,[104] and in the long-term potentially also as **source of protein,**[105] raw material for **biofuel** or **bio-kerosene** production[106] or the extraction of **fish oil** if that technology also becomes available for freshwater.[107]

On the other hand, taking the hydropower reservoirs into production also creates an additional requirement to protect the surface water quality. Mining activities are a potential source of pollution with heavy metals and extraction agents like cyanide and arsenic. **Bioleaching** is a way to extract metals from ores with the use of bacteria. This avoids the use of dangerous chemical substances, and can seriously reduce the risk which mines pose to water quality.[108]

Deteriorating water quality is a risk to drinking water quality, agriculture, tourism development and vegetation and wildlife. Algae production in reservoirs can further **improve water quality**. Studies with industrial wastewater show that freshwater algae can remove certain pollutants from water, by:

1. reducing electric conductivity by removing metal ions from industrial discharges;
2. removing dissolved organic matter and reduce the related chemical oxygen demand;
3. removing dissolved solids; and
4. reducing eutrophication by removing nitrate and phosphorous.[109] » p. 64

These are all a concern for the water quality of the Mekong River.[96] Safeguarding water quality also makes reservoirs more attractive to tourism (*Figure 20*). One method of producing algae, one of the fastest growing plants on Earth, is with photobioreactors.[110] » p. 64 These are floating flexible tubes, where algae use energy from the sun, carbon dioxide and

104. O. Uysal, F. O. Uysal and K. Ekinci, "Evaluation of Microalgae as Microbial Fertilizer", *European Journal of Sustainable Development*, Vol. 4, No. 2, 77-82, 2015.

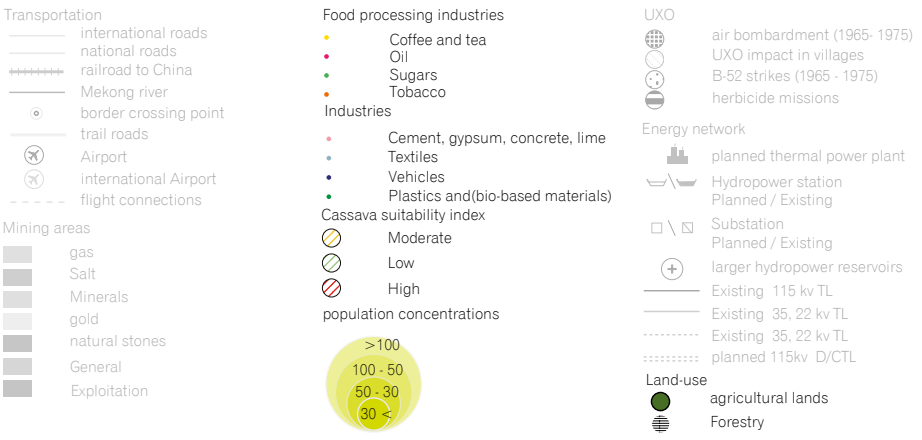
105. E. W. Becker, "Micro-algae as a source of protein", *Biotechnology Advances*, Volume 25, Issue 2, pp 207–210, 2007.

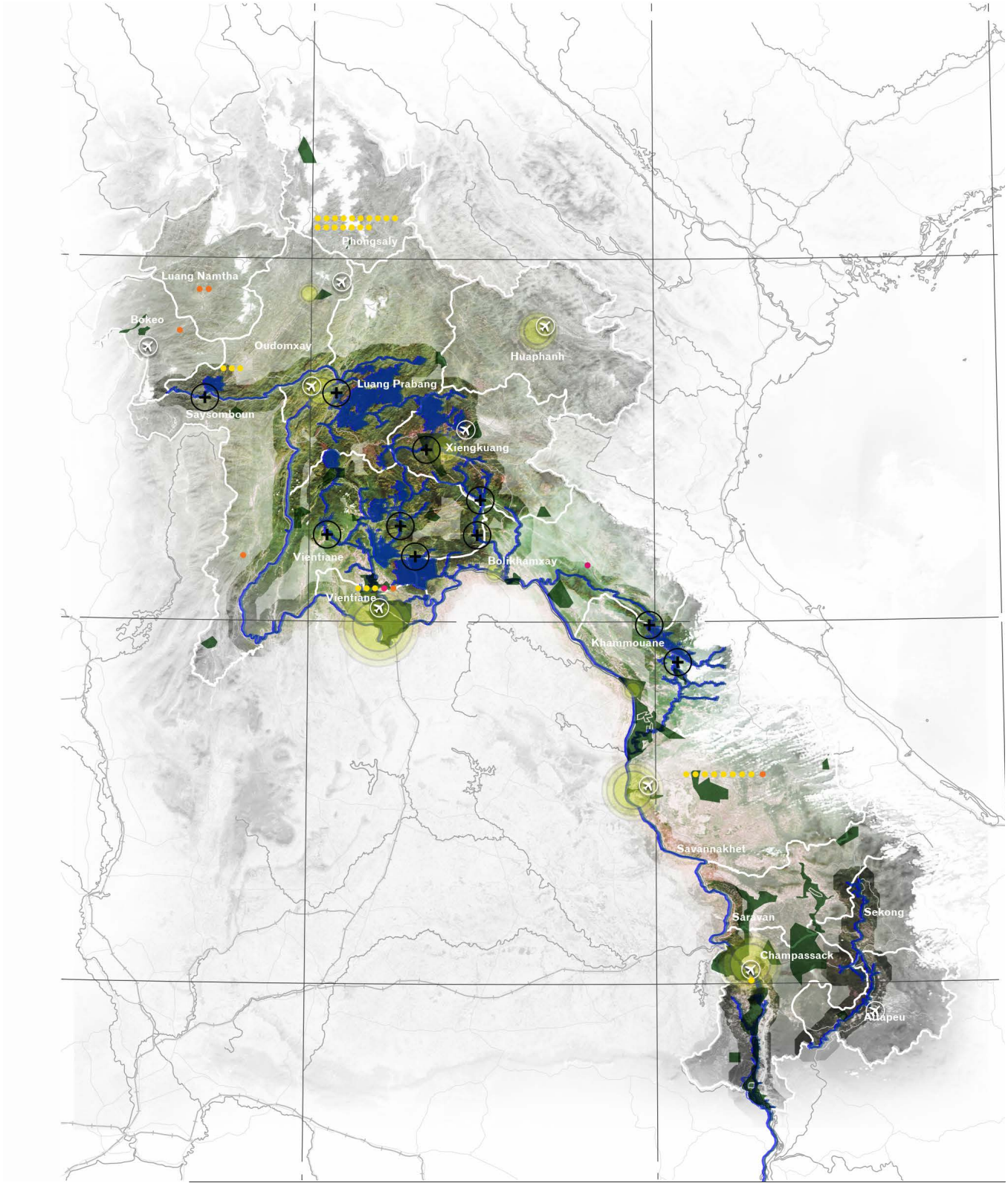
106. Wageningen University, "Sustainable aviation fuels from algae". Wageningen University, "Bonaire to have its own AlgaePARC", 20 January 2017. See also H. Hulsman and others, 2011, Algae as a source of fuel for the Dutch aviation sector - A feasibility study.

107. DSM, "DSM and Evonik establish joint venture for omega-3 fatty acids from natural marine algae for animal nutrition", 8 March 2017.

108. C.N. Mulligan and M. Kamali, Bioleaching of copper and other metals from low-grade oxidized mining ores by Aspergillus niger, Chemical Technology and Biotechnology, 2003.W. H. Dresher, "Producing Copper *Nature's* Way: Bioleaching, Copper Applications in Mining & Extraction", Innovations, May 2004.

► Figure 19: Algae farming opportunities




Phongsaly
Luang Namtha
Bokeo
Oudomxay
Huaphanh
Luang Prabang
Saysomboun
Xiengkuang
Vientiane
Bolikhamxay
Vientiane
Khammouane
Savannakhet
Sekong
Saravan
Champassack
Attapeu

▲ Figure 20: Impression of algae farming in combination with tourism

nutrients from the water to produce biomass. These structures can separate the different activities in the reservoir, like algae production, tourism, fishing or fish farming. The floating systems can also be made accessible for pedestrians, to form paths that connect shores of the lake, and turn the lake into a unique public space. The paths attract not only tourists, but also become a floating market place for local merchants and craftsmen to sell their products.

In the short term, algae from the reservoirs can replace fertilizers. Lao PDR is a net importer of fertilizers worth US$40 million in 2015. In the long run, technological advancements can make the production of biofuels from algae commercially viable. These biofuels could replace the net value of US$1.04 billion fossil fuels which Lao PDR is importing every year.[55] » p.26

More likely however is that the country will switch its car fleet to electric

109. S. Khan and others, "Remediating industrial wastewater containing potentially toxic elements with four freshwater algae, *Ecological Engineering*, Vol. 102, pp 536–541, May 2017.

110. Omega Project 2009-2012, "National Aeronautics and Space Administration", n.d.

vehicles, making optimal use of the existing hydropower capacity. In that case, biofuels can replace kerosene. This would enable Lao PDR to address one of the main environmental issues from tourism: the increasing greenhouse gas emissions from airlines. This would be a unique feature of ecotourism in Lao PDR, distinguishing it from its peers in the region.

The existing agricultural metabolic profile of the country can be a basis for the development of a **bio-based economy** with a more industrial character. Replacing synthetic materials with biotic or even biodegradable materials, is a development strategy in several industrialised countries. Lao PDR has maintained its agricultural profile and uses relatively little synthetic or inorganic materials. The agricultural and forestry foundation of its economy are a solid basis for developing a bio-based economy. Concrete examples are:

1. Using waste streams from cassava starch production as raw material for biodegradable plastics. The use of biodegradable plastics would also solve environmental problems associated with the disposal of synthetic plastics in areas without proper waste collection and disposal.[111]
2. Using organic fibres like hemp, in the textiles or motorcycle assembly industry.[112]
3. Positioning Lao PDR within the bio-based industrial ambitions in neighbouring countries, like the production of bioplastics in Thailand, based on tapioca production and starch chemistry.[113]

111. Freshplaza, "New biopolymers from cassava and banana waste developed", 4 August 2013.

112. Bio Based Press, "Biobased materials in the motor car, part 1: automotive industry's demands" 21 September 2014.

113. Bio Based Press, "The Transition", n.d. N. Waramit, "Developing a bioeconomy in Thailand", *Journal of the International Society for Southeast Asian Agricultural Sciences*, Vol. 18, No.2. 2012.

3.4 Overview of technologies and benefits per sector

The three circular economy strategies proposed involve a range of priority sectors. The strength of a systems' approach is that it reveals opportunities across, rather than within, sectors. *Table 3* summarizes by sector, the different solutions proposed and the main benefits.

3.5 Contribution to achieving SDGs

The three circular economy strategies will not only contribute to the articulated development ambitions of Lao PDR, but they will also assist with achieving the Sustainable Development Goals. *Table 4* provides an overview.

3.6 International cooperation on climate mitigation supporting circularity

Lao PDR imports several products with a relatively high carbon footprint at production. Examples are meat and dairy products, paper and paperboard, and products and materials with high iron and steel content including vehicles, plastics and plastic products, cotton and fabric.[55] » p. 26 Materials substitution for low-carbon alternatives could reduce the dependence of Lao PDR on imports, while reducing carbon emissions in the countries of origin.

For example, to support the construction boom in Vientiane, Lao PDR imports cement. Cross laminated timber is a construction material with a substantially lower carbon footprint than reinforced concrete has. Furthermore, it is produced in Lao PDR.

That Paris Agreement has moved away from the bipolar world of developed and developing countries, opening the door for all countries to take up mitigation ambitions. Within a more equal global climate regime, international cooperation along supply chains under Article 6 could be a means to create incentives for reducing the consumption and use of carbon intensive products. Prime candidates are cement and steel.[46] » p. 19 As a net importer of these two products, Lao PRD could side with other countries with negative trade balance on these materials, and promote the use of Article 6 for this purpose.

A variation on this line of thought is to encourage the production and supply of the substitutes for carbon intensive materials, with a carbon incentive. Lao PDR is uniquely positioned to do so. Substituting carbon intensive enforced concrete with cross laminated timber, would be the kind of fundamental changes in consumption habits, which really contribute to meeting the Paris targets. Some of the sustainable wood production companies in Lao PDR produce cross laminated timber.

Table 3: Overview of technologies proposed, and their benefits per sector

Sector	Technology						
	Produce and use bio-based materials like cross laminated timber, bamboo, hemp, bioplastics	Produce algae in hydropower reservoirs to produce fertiliser, protein, fish oil or biofuels	Adopt bioleaching which uses bacteria to extract metals from ores and e-waste	Recycle textiles and sort fibres with Fibresort	Remanufacturing of motorcycle components and convert to electric	use local food sources in tourism and close the minerals cycle	Use rainwater harvesting and biological waste water treatment in resorts
Forestry	Substitutes imported construction materials Develops national timber industry						
Agriculture	Substitutes imported plastics and fibres Develops national bio-based industry	Adds hydropower reservoirs to the productive agricultural area Improves river water quality	Reduces risk of pollution in irrigation water			Increases value of agricultural products	
Energy	Reduces energy consumption and greenhouse gas emissions from concrete and steel production	Substitutes imported fossil fuels Adds economic value to current and future hydropower reservoirs			Reduces the import of fossil fuels		
Mining			Substitutes hazardous chemicals Reduces risk of water pollution				
Solid waste and wastewater	Reduces plastics and synthetics fibres in solid waste and wastewater	Improves river water quality	Potentially a safer and cleaner way to process e-waste				
Manufacturing	Substitutes imported synthetic materials				Extends lifetime of motorcycles Uses low-cost reverse logistics capacity		
Textiles	Substitutes imported fibres			Substitutes imported fibres Reduces textiles waste			
Tourism	Reduces landscape impact of quarries for construction minerals	Improves river water quality	Reduces risk of water pollution			Favours community-based ecotourism	Favours community-based ecotourism

Table 4: Contribution of the circular strategies to the Sustainable Development Goals

Sustainable Development Goals and underlying targets	Relevant to		
	Recycling and remanufacturing hub	Circular resort	Algae-biofuel
SDG 1 - No poverty			
1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than US$1.25 a day: explain what share of the rural population lives under this budget.	X	X	X
1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to **economic resources**, as well as **access to basic services**, ownership and control over land and other forms of property, inheritance, **natural resources**, appropriate new technology and financial services, including microfinance	X	X	X
SDG 2 - End hunger, achieve food security and improved nutrition and promote sustainable agriculture.			
By 2030, **ensure sustainable food production systems** and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality		X	No harm
Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, **in particular least developed countries**.		X	X
SDG 6 - Ensure availability and sustainable management of water and sanitation for all			
6.1 By 2030, achieve universal and equitable **access to safe and affordable drinking water** for all		X	X
6.2 By 2030, improve water quality by **reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials**, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	X	X	X
SDG 7 - Ensure access to affordable, reliable, sustainable and modern energy for all			
7.2 By 2030, increase substantially the **share of renewable energy** in the global energy mix			X
7.3 By 2030, double the global rate of improvement in energy efficiency		X	
7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology		X	X
7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support			X
SDG 8 - Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all			
8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead	X	X	X
8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products	X	X	
SDG 9 - Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation			
9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries	X	X	X
9.5 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	X	X	X

Table 4: Contribution of the circular strategies to the Sustainable Development Goals

SDG 11 - Make cities and human settlements inclusive, safe, resilient and sustainable			
11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums		X	
SDG 12 - Ensure sustainable consumption and production patterns			
12.1 By 2030, achieve the sustainable management and efficient use of natural resources	X	X	X
12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	X	X	
SDG 13 – Take urgent action to combat climate change and its impacts			
13.2 Integrate climate change measures into national policies, strategies and planning	X	X	X

Minutes of Meeting
Stakeholder Consultation on Circular Economy Action Study for Improved Resource Efficiency in Lao PDR

Friday,4 August 2017
Lane Xang Conference Room, UNDP Office, Vientiane

1 Background

UNDP and IREP conducted the Circular Economy Action Study for Improved Resource Efficiency in Lao PDR. This meeting takes the opportunity to present the findings of the Circular Economy Study to stakeholders for feedback and comments.

2 Objectives of the meeting

To present and discuss the results of the Circular Economy Study
To discuss and consolidate comments and feedback from stakeholders
To discuss potential synergies with ongoing or proposed development projects supported by other development partners in the area of NDC implementation, rural electrification development and local livelihood development

3 Participants

About 35 people participated in the meeting, including representatives from Ministry of Planning and Investment, Ministry of Natural Resources and Environment, Ministry of Energy and Mines, National University of Laos, Ministry of Labour and Social Welfare, Ministry of Industry and Commerce, WFP, UNDP Lao PDR, UNIDO and USAID Asia.

4 Meeting proceeding

4.1 Opening remarks

The meeting was Chaired by Mr. Balasubramaniam Murali, Deputy Resident Representative and Co-chaired by Mr. Seumkham Thoummavongsa, Deputy Director General of the Institute of Renewable Energy Promotions (IREP) of Ministry of Energy and Mines (MEM). Opening Remarks of Chair and Co-Chair are attached at Annex 1 and Annex 2. The Agenda of the Meeting is given in Annex 3.

4.2 Presentation on the Circular Economy

The presentation was delivered by Dr. Margaret Jones Williams, Environment Unit Manager of UNDP. The presentation covered background, concept and objective of the circular economy, approach of the study, findings and recommendations for the way forward. The idea of the Circular Economy is for resource efficiency and economy through reducing, re-using, recycling or extending the life of products. The findings of the study show that the Circular Economy concept could be applied in Lao PDR and support Lao PDR's development agenda and also contribute to the implementation of the Paris Agreement. The study identified three sectors that could implement the CE:

First: A regional recycling and remanufacturing hub

Second: Circular construction materials from forests to advance ecotourism

Third: Algae farming to produce valuable bio-based materials and clean surface water.

.

The PPT presentation is given in Annex 5.

UNDP and IREP are working on finalization of this report and this meeting is an opportunity to share the report with stakeholders and get some feedback. A stakeholder consultation was also held in December 2016. The final report will be shared with stakeholders.

IREP commented that in discussing Circular Economy there is a focus on reuse, recycling and remanufacturing. The Circular Economy implementation is relevant to MEM mandate and to MONRE mandate. In the future MEM and MONRE should closely work together to discuss the legal framework that could be enabling the implementation of the Circular Economy in the country.

UNIDO noted that Circular Economy is not only relevant to MEM and MONRE. The MOIC has already started implementation of this idea. Thus, both ministries should coordinate with other ministries and agencies as well.

DIC/MPI noted that the implementation of Circular Economy should have a main coordination agency. DIC supports that MEM should be a lead coordination agency to develop the policy for the implementation. However, it is subject to the decision at the higher level. The idea of Circular Economy is not new and not old, the MOIC has already started implementation of this idea.

DMO/MLSW supports DIC comments that implementation of the Circular Economy should have a coordination unit to further develop policy to enable the implementation on the ground.

5 Closing remarks

Mr. Murali thanked all participants and IREP team for the preparation. Mr. Murali also noted the Circular as a fairly is a new concept. The goal of Lao PDR is to achieve graduation from LDC status and to achieve sustainable development. The implementation of CE could also contribute to the achievement of the LDC graduation and we should find a way to support the implementation of Circular Economy.

Mr. Seumkham also thanked the participants and noted his appreciation to stakeholders for providing direct comments to the presentation.

Annexes:

1. Opening Remarks from IREP
2. Opening Remarks from UNDP
3. Agenda of Meeting
4. PPT on circular Economy Study
5. Tweet https://twitter.com/MargaretJWUNDP/status/893338962483269633
6. Photos of Meeting

Photo 1: Chair and Co-Chair
Photo 2: Group of Stakeholders
Photo 3: Stakeholder asking questions

Deputy Resident Representative
United Nations Development Programme

Balasubramaniam Murali

Deputy Director General
Institute of Renewable Energy Promotion

Seumkham Thoummavongsa, PhD.

Economic growth in developing countries is often paralleled by a gradual decrease in resource and carbon efficiency. By redefining development from the perspective of the system, developing countries can grow their infrastructure and building stock, and meet the needs of its society, while moving away from the linear economic model which is putting long-term development ambitions at risk. The systems approach outlined for Lao PDR steps away from focussing on a single sector or industry. Rather, it defines collaborative strategies to develop a circular economy, in line with national objectives to reduce greenhouse gas emissions and make more efficient use of resources.

This way of thinking opens new avenues for countries to act on their climate ambitions and Paris Agreement commitments. It is also an opportunity to redefine development and growth, through the lens of metabolic efficiency.

Lao PDR is a country with abundant national resources. It is experiencing rapid economic growth, build on the export of valuable raw materials. However, large extractive industries leave their mark on the landscape, while the temporary rents from resource exports suppress the growth of non-extractive, local industries. Mapping the flows and stocks of raw materials and energy, reveals three pivotal strategies to substitute carbon-intensive materials, develop and diversity the economy, make better use of existing assets and avoid further linear lock-in. For each strategy described, artist impressions provide a preview of a circular future for Lao PDR.