

COP27 POLICY BRIEF SERIES

The economic and environmental benefits of recycling plastic waste in Lao PDR

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Summary

As the Lao People's Democratic Republic (PDR) is undergoing rapid economic development, the changed lifestyle of the population comes with an increased amount of plastic waste. Currently, it is mostly waste pickers from the informal sector that collect plastic waste at the landfills. However, there is potential to systematically separate plastics and reduce carbon emissions by either recycling the plastic or generating electricity through incineration and replacing higher-carbon power sources. In

our study we developed an optimization model maximizing the economic return of different CO₂ reduction options related to plastic waste management in Lao PDR. It chooses the best location for building new separation plants and different recycling and incineration options. The results show that building mechanical recycling plants (placed in seven of Lao PDR's 18 provinces) and establishing a recycling network across provinces would maximize both economic and environmental returns and could lead to further social benefits.

Key Policy Recommendations

- **Install new plastic waste recycling facilities to maximize economic and environmental benefits.** This would yield positive economic returns, is most effective in reducing carbon emissions, and could have social benefits. Recycling would help Lao PDR achieve strategic policy objectives in terms of socio-economic development and environmental protection, for example by reducing carbon dioxide emissions and saving resources. It offers opportunity for local investment.
- **Develop recycling strategies in close cooperation between provinces.** Upfront investment and operational cost can be saved if neighbouring provinces jointly use plants for plastic recycling.
- **Enforce plastic waste recycling at household level.** This would lead to an increased plastic recycling rate and lower separation costs.
- **Establish cross-ministerial working groups.** Optimal plastic waste recycling strategies require support from various ministries. Also, improved data collection and sharing is necessary to optimize waste management strategies.



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Introduction

Lao People’s Democratic Republic (PDR) is facing huge waste management challenges resulting from rapid economic development and a lack of infrastructure upgrading [1, 2]. Plastic constitutes 24% of waste found in Lao PDR, and 95% of that is from single-use plastics [2]. Currently, there are 17 landfills scattered across the country’s 18 provinces generating close to 40,000 tons of plastic waste per year. The breakdown of plastic landfill waste in Lao PDR is given in **Table 1**.

| Province | Landfill Location | Plastic Waste [kg/year] |
|--------------------|--------------------|-------------------------|
| Attapeu | Xaysettha | 799,877 |
| Bokeo | Houayxai | 1,026,817 |
| Borikhamxay | Pakxanh | 1,567,875 |
| Champassack | Pakse | 3,975,802 |
| Huaphanh | Xamneua | 1,657,826 |
| Khammouane | Thakhek | 2,245,922 |
| Luang Namtha | Namtha | 1,006,824 |
| Luang Prabang | Luang Prabang | 2,115,175 |
| Oudomxay | Xay | 1,762,253 |
| Phongsaly | Phongsaly | 1,019,633 |
| Xayaboury | Xayaboury | 890,600 |
| Saravan | Saravan | 2,273,935 |
| Savannakhet | Kaysone Phomvihane | 5,555,037 |
| Xekong | Lamam | 647,610 |
| Vientiane Capital | Vientiane City | 8,906,000 |
| Vientiane Province | Vangvieng | 2,400,812 |
| Xiengkhouang | Muang Pek | 1,401,705 |

Table 1. Location of landfill sites by province and annual plastic waste generated.

Note: Data collected by National University of Laos and partly extrapolated [3].

In 2018, Lao PDR introduced a Green Growth Strategy which aims to increase economic prosperity by, among other measures, reducing waste and using resources more efficiently [4]. Municipal solid waste management is

“ General and nontoxic solid waste should be segregated properly into relevant types for reuse or recycling ”



overseen by the Department of Public Work and Transportation. Each province follows their regulations and laws as well as that of the Ministry of Natural Resources and Environment [5]. The environmental protection law stipulates that general and nontoxic solid waste should be segregated properly into relevant types for reuse or recycling and must be disposed of in the areas determined in the regulations. However, there is a need for improved implementation and enforcement of regulation and the promotion of public participation, as currently only 30–40% of solid waste is collected in Lao PDR [6]. For example, in the country’s largest city and national capital, Vientiane, approximately 1,000 tonnes of general waste are generated per day, of which 38% is collected and transported to the dumping site, 54% is self-disposed (e.g., burnt or openly dumped), and only 8% is recycled (on- and off-site) [6]. Despite these low recycling rates, urban areas in general, and especially Vientiane, have better waste management than most rural areas.

It is known that recycling plastic waste avoids considerably more carbon emission than incineration for electricity generation [7]. However, a key issue with regards to planning solid waste management in Lao PDR is that, to the best of our knowledge, there is no existing least-cost planning study outlining which options for using separated plastic waste are associated with the largest economic benefits, nor how to implement them strategically. While there are some informal waste management activities taking place in Lao PDR [8], such as PET-bottle collection by waste pickers from the informal sector at the landfills, uncollected waste is most commonly burned or openly dumped (e.g., in waterways). This has huge environmental and health implications. A recent study by the World Bank found waste dumping and burning has resulted in around 10,000 yearly deaths and 100 million missed hours at work due to illness [2].

Hence, a large-scale change is needed to tackle Lao PDR's waste management problem. In line with Lao PDR's Green Growth Strategy, which mentions plans for incinerating plastic waste for electricity production, **this policy brief assesses the potential economic benefits of plastic waste recycling to study the associated green growth potential.**

Methodology and data

OPTIMIZATION MODEL

Our study develops and applies an optimization model which maximizes the economic returns of different plastic waste management options in Lao PDR (i.e., maximize revenues minus cost).¹ The optimization model finds the optimal locations, sizes, and types of new plastic waste facilities needed for separation and recycling

“ There is no existing least-cost planning study outlining which options for using separated plastic waste are associated with the largest economic benefits ”



in Lao PDR. It also identifies the optimal waste transport network between the existing landfill sites and the newly built recycling plants. The model considers the main landfill in every province. At each landfill, there is a certain amount of collected waste. This waste can either:

1. be dumped, or
2. separated at the landfill site in order to extract plastics for export or further value added.

In the case of the latter, the now separated plastic waste is transported to a recycling or incineration facility. The model assumes that these facilities are located right next to a landfill. However, the model also considers the option for waste to be transported to recycling or incineration facilities at a different landfill if this

¹ This model is a mixed-integer linear programming model developed by the authors

is more efficient. Aside from incineration, as recycling options, the model chooses between mechanical recycling or chemical recycling.

DATA GAP

Data was difficult to come by, with data gathering efforts being led by researchers from the National University of Lao PDR. Data was not publicly available for the most part, and where available there was much variation across provinces. To elaborate, there is some data availability in large cities, like Vientiane Capital, but close to no data in rural areas.

This data gap implies risks of planning inaccuracies, especially in rural areas. The

collected data like waste amounts, plastics ratio, distances, locations, costs, and revenues are given as input to the model. In the model, there are a range of decisions that are determined in the process of solving for the best solution. To deal with the uncertainty of several input parameters, the model was run repeatedly for various input scenarios. The scenario analysis included uncertainty of costs and uncertainty of (plastic) waste amounts. For tackling the data gap, simplified inputs were used; for example, plastic ratios were considered to be constant for all provinces that had missing information. Additionally, in the absence of exact coordinates of landfills, the coordinates of the cities were used as locations for landfills and demand centres.



1-2: Visited landfill
3: Visited Urban Development and Administration

Results and Discussion

The optimization model finds that mechanical recycling yields the highest positive net economic return of plastic waste management in Lao PDR. This means that recycling plastic waste and selling it is able to recover the initial investments in the infrastructure. It also means that the environmentally most beneficial option of recycling also outperforms incineration economically in Lao PDR. The economic returns increase further if waste is already separated at the household level, as it reduces the required investment and transportation cost. In the baseline scenario (which does not assume separation at the household level), the model suggests building new mechanical recycling plants in seven provinces (see Figure 1). The resulting network would allow 20,000 to 40,000 tonnes of plastic waste to be recycled each year depending on assumed plant capacity and budgetary limits.

Limitations of the model, beyond the previously discussed data availability issues, are that only annual waste streams are considered whereas operational aspects are not taken into account in detail

There are three major insights arising from the solution of our model.

First, building recycling plants has a positive net economic, environmental and social effect, serving triple bottom line sustainability purposes [9]: Given its economic potential, there are opportunities, especially for local investors, to monetize the recycling supply chain. Furthermore, developing new separation and recycling facilities generates jobs. Reducing plastic pollution will improve living standards of the population and therefore yield social benefits. Not only is landfilling clearly the least favoured option regarding plastic waste management [10], but, in comparison to both landfilling and incineration, mechanical recycling also saves carbon dioxide emissions [11]. It follows that the new solution characterized by plastic recycling has obvious environmental benefits [8]. These findings challenge the suitability and sustainability of existing incineration plants in Lao PDR.

Second, we find that transporting waste between provinces is always part of the cost-optimal solution. In scenarios where we assume very high fuel prices, the optimal solution would still only build the same seven new mechanical recycling plants, meaning that it is still optimal to transport significant shares of waste between districts.

Third, improved waste separation at the household level would improve the business case for large-scale recycling. Currently, the model considers all waste to be separated at landfill sites first before transportation to the recycling plant can happen. If plastic waste would instead be separated on a household level, plastic waste could be directly transported to the recycling location, implying an increase in recycling rates because the capacity would not be restricted by the landfill separation plants.

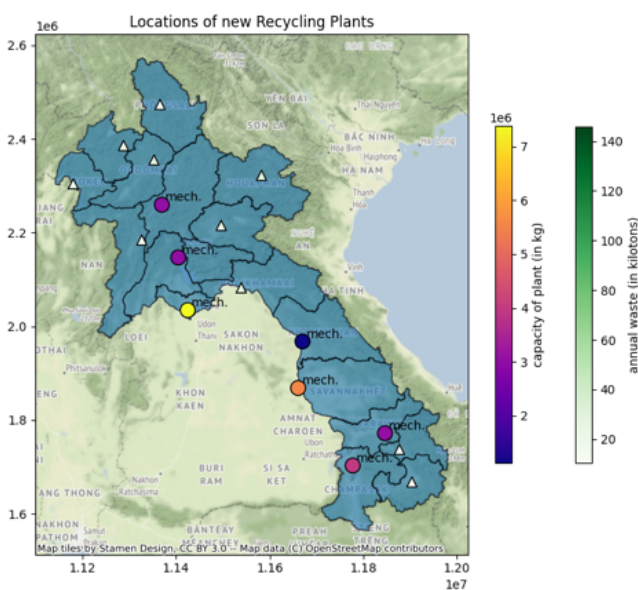


Figure 1: Optimal plastic waste recycling plants in Lao PDR. Circles represent landfills, where recycling plants are also located in the optimal solution.



Policy Recommendations

We propose a number of solutions to overcoming Lao PDR plastic waste problem:

- **Install new plastic waste recycling facilities.** This yields positive economic returns, helps tackle pollution, and thus offers social benefits. Specifically, mechanical recycling outperforms incineration economically and environmentally, and therefore would help Lao PDR achieve strategic policy objectives in terms of socio-economic development. It could generate income, secure jobs, and investment opportunities for local businesses, as well as environmental protection and increased quality of life.
- **Develop recycling strategies in close cooperation between provinces.** Upfront investment and operational costs can be saved if neighbouring provinces jointly use plants for plastic recycling. The additional transport costs are lower compared to high fixed costs for machinery and operational costs.
- **Enforce or encourage plastic waste recycling at the household level.** This would lead to an increased plastic recycling rate and lower separation costs. By separating plastic waste at the household level, a saving can be achieved.
- **Establish cross-ministerial working groups** to fully realize the country's economic, environmental, and social potential. Optimal plastic waste recycling strategies require support from various ministries. Also, improved data collection and sharing at the sub-national and cross-ministerial level would help to design more cost-efficient and sustainable waste management approaches in Lao PDR.

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ACKNOWLEDGEMENTS:

Dr Stephanie Hirmer (Oxford University) and Prof. Jim Watson (University College London) have led the curation of this policy brief series. The policy briefs underwent an anonymous (double blind) peer-review process. They were edited by Simon Patterson (Loughborough University) and designed by Sarel Greyling (Sarel Greyling Creative).

This material has been produced under the Climate Compatible Growth (CCG) programme, which brings together leading research organizations and is led out of the STEER centre, Loughborough University. CCG is funded by UK Aid from the UK government. However, the views expressed herein do not necessarily reflect the UK government's official policies.



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CITATION: Finkbeiner, L., Khounvilay, K., Phohalath, K., Nanthavong, K., Hirmer, S.A., and Trotter, P.A.(2022). The economic and environmental benefits of recycling plastic waste in Lao PDR. Climate Compatible Growth Programme COP27 Policy Brief Series (Version 1). Available at: <https://doi.org/10.5281/zenodo.7107895>.