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Assessment and prioritisation of low-carbon technology for the waste sector in Vietnam

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Abstract:

This paper presents a multi-criteria assessment approach for the prioritisation of low-carbon technologies for the waste sector in order to enable the implementation of Vietnam's nationally determined contributions (NDCs) in terms of the Paris Agreement. A four-step approach is developed for assessing and prioritising low-carbon technologies for the waste sector using this approach. A set of five criteria and indicators are defined for multi-criteria assessment. Based on mitigation options defined in the NDCs, a shortlist of 26 technological options are defined. The multi-criteria assessment and prioritisation is conducted based on the shortlist. The assessment results in eight prioritised low-carbon technologies. Of the eight technologies prioritised, semi-aerobic landfill, which is a low cost and relatively simpler technology than the other technologies evaluated and can contribute to greenhouse gas emission reduction, is given the highest priority. The technical, financial, and social and environmental feasibility of each of the technologies evaluated is presented.

Keywords: **emission reduction, GHG waste sector, low-carbon technology, multi-criteria assessment and prioritisation, NDCs.**

Classification number: **5.1**

Introduction

In September 2015, the Government of Vietnam submitted its intended nationally determined contribution (INDC), in which the national greenhouse gas (GHG) emission reduction target for the period 2020-2030 is defined, to the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) [1]. This endeavour was undertaken as part of the global, collective effort to reach a comprehensive, fair, and effective agreement on the post-2020 climate regime.

Following the submissions of country INDCs, the Conference of the Parties (COP21) to the UNFCCC adopted the Paris Agreement in December 2015 to provide an overarching framework and a series of requirements for the post-2020 regime. With the necessary number of instruments for ratification having been submitted, the Paris Agreement successfully entered into force in November 2016 [2]. Subsequently, country INDCs have transformed into nationally determined contributions (NDCs) in anticipation of the submitting countries duly implementing these, starting from 2021. For its part, in October 2016, the Government of Vietnam approved the Paris Agreement implementation plan in which key climate-change mitigation tasks are identified [3].

To implement the plan and especially to meet the mitigation targets, it is crucial to elaborate the NDC into implementable actions in order to achieve the aggregate amount of GHG emission reductions. Such elaboration requires an in-depth technical and realistic assessment of the implementation method for each mitigation option.

Four sectors (Energy/transport; Land use, Land-use Change and Forestry; Waste; and Agriculture) with 45 mitigation options are included in Vietnam's NDC [1]. This paper presents a multi-criteria assessment approach for prioritising low-carbon technologies for enabling mitigation options in the waste sector.

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Methods

Definitions

In this paper, low-carbon technologies for the waste sector are defined as both hardware (e.g. waste collection and transportation infrastructure) and software (e.g. waste management systems) that can contribute to climate change mitigation goals through GHG emission reduction efforts, and that encourage Vietnam to embark on a sustainable and low-carbon development pathway. Not only are hardware, devices, machines, and facilities, which are commonly regarded technological elements considered; techniques, practices, and management tools attached to some of the mitigation options and sectoral attributes are also included in this assessment.

Approach for multi-criteria assessment

A four-step approach is developed in order to conduct a multi-criteria assessment and prioritisation of low-carbon technologies for the waste sector [4]. Details of the steps are shown below.

Step 1: confirmation of progress regarding climate change measures.

Stakeholder interviews and consultations with experts at the Ministry of Construction were conducted to identify suitable technologies to enable four mitigation options for the waste sector. In addition, the need for legislation and standards to enable some of the options were reviewed to capture the enabling conditions and current levels of political appetite for policy reforms.

Step 2: development of low-carbon technologies based on the INDC technology report.

With the current situation and the direction of the climate change measures in Vietnam in mind, technologies applicable to Vietnam's context have been selected from existing technology lists.

Step 3: definition of criteria for evaluation and prioritisation.

Five assessment criteria and indicators are defined for assessing and prioritising low-carbon technology for the waste sector. Consensus on these criteria was reached through consultation with experts at the Ministry of Construction and at a consultation workshop in which multiple stakeholders participated. Details of the defined criteria and indicators are shown in Table 1.

Table 1. Criteria and indicators defined for the prioritisation of low-carbon technologies for the waste sector.

Criteria	Indicators	Evaluation	
Compatibility with policy priorities	Presence of supporting policies and policy tools/measures	High	Presence of supporting policies and policy tools/measures
		Medium	Presence of supporting policies
		Low	No relevant policy
Economic efficiency	Cost of waste handling/treatment per ton of waste	The estimated unit cost in US$ per ton of waste	
GHG emission reduction effect	GHG emission reduction per ton of waste	The estimated unit of GHG emission reduction as ton of CO_2eq/ton of waste	
Versatility	Simplicity/ease of application of the technology	High	Already applied or conventional technology in the country
		Medium	Training or technical transfer is required for a certain period
		Low	Regular monitoring and supervision by a technical expert is required
	Limitation of application of the technology in terms of waste amount and/or composition	High	No limitation
		Medium	Limitation in terms of amount of waste or composition
		Low	Limitation in terms of amount of waste and composition
Social and environment impacts	Social impacts	Identify and describe positive and negative impacts on society (qualitatively)	
	Environmental impacts	Identify and describe positive and negative environmental impacts (qualitatively)	
Overall assessment	Identify and describe the extent and conditions of the application of the technology with its priority evaluation.		

Source: [1].

Evaluation was undertaken qualitatively as either high, middle, or low (A, B, or C grading, respectively) for each criterion [5]. What follows is the annotation of the grading letters.

- A: the technology is of relatively higher priority and early deployment is recommended.

- B: the technology can be deployed when barriers are removed by improving the enabling conditions and environment to some extent.

- C: a long lead time for the deployment of the technology in order to arrange an appropriate enabling environment is anticipated; the result is used for the final evaluation.

For the criteria of economic efficiency and GHG reduction effect, the prioritisation of technology is undertaken comparatively based on the available numerical data.

Step 4: selection of the technologies with high priority

Technologies graded with higher priority for selection are selected based on the results of the evaluation in Step 3 and on Vietnam's context, as reflected in the opinions obtained from experts in the waste sector [1].

The sources of GHG emissions in the waste sector mainly comprise:

+ Energy-related CO_2 emissions from waste collection and haulage vehicles [6].

+ CH_4 emissions from organic components in waste arising during the process of their decomposition in an anaerobic condition in the final disposal landfill [7].

+ CO_2 emissions from intermediate waste treatment, such as waste incineration.

Incineration of organic waste before its decomposition may reduce net GHG emissions by the conversion of CH_4 to CO_2 as well as by energy recovery from its thermal treatment. Incineration of plastic waste (fossil fuel-based plastic) can be regarded as a net GHG emission even with heat/energy recovery; however, this is advantageous when its high incineration heat can be utilised effectively [8].

The climate change mitigation technologies in the sector mainly address methane emissions from the decomposition of organic components in municipal solid waste (agricultural waste is not discussed in this chapter but in the agriculture sector), though they also tackle the possible reduction of CO_2 emissions arising from waste collection and haulage vehicles [9].

All the technologies identified are evaluated in terms of their feasible application potential based on five criteria: compatibility with policy priorities; economic efficiency; GHG-emission reduction effect; flexibility; and social and environmental impacts (positive and negative).

Table 2. Results of the multi-criteria assessment of low-carbon technologies for the waste sector.

No.	INDC #	Technology options	Rate*	Evaluation (inc. the extent of and conditions for the application of the technology)
1	W1	Production of organic fertilisers from organic waste (composting)	B	▪ Conventional technologies in Vietnam ▪ Strict control of waste composition is required to produce good quality compost to compete with chemical fertilisers ▪ A certain area of land is required to handle large amounts of waste (40,000 m^2/daily handling of 100 tons)
2	W2	Landfill gas capture/recovery and energy utilisation	B	▪ To effectively introduce the target technology, establishing the appropriate conditions, such as the amount and quality of waste (i.e. sufficient amount of organic waste), and the conditions at the final disposal facility (anaerobic treatment) are vital. The technology is not applicable to facilities that do not meet these conditions. The technology is only applicable if the above conditions are met and if a sufficient amount of methane gas is estimated to be recoverable; hence the opportunity for its application is extremely limited
3	W3	Recycling of solid waste	C	▪ Although recycling is the win-win technology for both GHG emissions and for the reduction of waste itself, the recyclable and salable materials in the waste have already been collected and recycled using the current market mechanism ▪ Recycling of the remaining materials in the waste is mostly not technologically or financially feasible due to the types of materials or their contamination by or mixture with strange materials ▪ The potential for GHG emissions by recycling is very limited
4	W4	Anaerobic treatment of organic waste with methane recovery for power and heat generation	B	▪ There is an example of the application of this technology in Ho Chi Minh City ▪ Suitable for areas where a certain amount (50 to 100 tons daily) of food waste is stably generated, such as the wet market (fish meat and vegetable market), hotels, and restaurants ▪ If the above amount of food waste can be regularly obtained, this technology is worth applying for food waste management
5	W5	Semi-aerobic landfill operations	A	▪ Semi-aerobic landfills are a low cost and simpler technology of sanitary landfills and contribute to GHG emission reduction. As a standard for the construction and operation of a sanitary landfill, a semi-aerobic landfill is technologically and economically suitable in Vietnam if proper technological transfer is undertaken
6	W6	Waste to energy (WTE)	B	▪ There is no full-scale application of WTE technology, though there are some existing waste incineration facilities in operation with no energy recovery ▪ Treatment cost is the highest, though the waste reduction ratio is also the highest ▪ A certain amount of waste is required to reach an economy of scale when applying this technology ▪ A certain heat value is required in waste to maintain its self-sustaining combustion with minimal input of supplementary fuel (The higher the heat value of the waste, the higher the potential for energy recovery from the waste)
7	W7	Conversion to low-carbon fuel trucks for waste collection and haulage vehicles	B	▪ No application in Vietnam ▪ Low-carbon trucks can contribute to both climate change mitigation and to improving air quality (vehicle-related air pollution) ▪ A supply infrastructure and network needs to be built for low-carbon fuels ▪ The cost of trucks and fuel may increase
8	W8	Construction of a waste transfer station	B	▪ There are several waste transfer stations that have been built and are currently in operation in Vietnam ▪ It can also mitigate traffic congestion and improve transportation efficiency in waste collection and haulage ▪ The impact of a transfer station upon transportation efficiency depends on the distance between the waste-generation sources and final destination (landfill) and on traffic conditions (traffic volume, road conditions, etc.)

*A: the technology is of relatively higher priority and early deployment is recommended; B: the technology can be deployed when barriers are removed by arranging the deployment environment to some extent; C: long time may be required for technology deployment in order to arrange appropriate environment.

Results and discussion

Results

The qualitative multi-criteria assessment results of each climate change technology in the waste sector are summarised in Table 2. A total of eight low-carbon technologies for waste management and treatment are identified and assessed. The assessment results indicate that semi-aerobic landfill operations are graded highest, with an A grade, the highest priority.

Discussion

In this section, the potential for the deployment of the above-identified technologies, with a focus on three dimensions, namely the technical, financial, and social/environmental aspects, is discussed.

First, as concerns the technical aspect, all of the technologies evaluated and listed above were originally defined to serve different waste management purposes, such as waste treatment to produce reusable products (e.g. composting to produce organic fertiliser), to reduce the amount of waste finally disposed of in landfills, and to prevent environmental pollution arising from the improper management and treatment of waste. Although none of the technologies evaluated were designed to reduce GHG emissions in the waste sector, some of them can significantly reduce the amount of waste and GHG emissions from the anaerobic decomposition of organic waste, such as the composting and incineration of waste to produce electricity. Technically, all of the above technologies are applicable in Vietnam.

Second, initial investment and operation and maintenance costs are the first financial and economic aspects that are taken into consideration when a technology is applied. Some technologies need a large amount of initial investment and have high operation costs even though they have larger positive impacts on waste management, such as waste volume reduction and GHG emission reduction. In this regard, WTE is a typical example of such technology. With WTE, GHG emissions from waste treatment are almost zero, and the amount of waste to be finally disposed of is significantly reduced. However, the initial investment and operation and maintenance costs for this technology are much higher.

Finally, the social and environmental aspect involves public acceptance of the technology and its environmental impacts. Some of the technologies evaluated above have already been used, such as composting and recycling. Other technologies are new to the Vietnamese market, for example, WTE, and have not been used in Vietnam. There has not been any public protest against the technologies that have been used which indicates that they are accepted by society. As concerns the environmental impacts, it can be said that all of the technologies evaluated that have been designed to treat waste properly do not cause any significant negative impacts.

Conclusions

With the multi-criteria assessment, and based on technology options identified in the NDC, eight low-carbon technologies for the waste sector were evaluated and prioritised. Local contexts have been taken into consideration in the prioritisation of the identified technologies. The semi-aerobic landfill technology option was given the highest priority. This is a low cost and relatively simpler than other technologies and it contributes to GHG emission reduction. As the standard for the construction and operation of sanitary landfills, a semi-aerobic landfill is technologically and economically suitable in Vietnam if proper technological transfer is undertaken.

The authors declare that there is no conflict of interest regarding the publication of this article.

REFERENCES

[1] N.K. Hieu, et al. (2015), *Technical report Vietnam's intended nationally determined contribution*, https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf.

[2] United Nations Framework Convention on Climate Change (2015), *Adoption of the Paris agreement*.

[3] Government of Vietnam (2016), *Plan for implementation of the Paris agreement*, https://auschamvn.org/wp-content/uploads/2016/10/Plan-for-implementation-of-Paris-Agreement-in-Vietnam-Eng.pdf.

[4] J.F. Gerber, et al. (2012), *Guide to multicriteria evaluation for environmental justice organisations*, EJOLT Report No. 8, 45pp.

[5] G. Munda (2008), *Social multi-criteria evaluation for a sustainable economy*, Berlin Heidelberg: Springer-Verlag.

[6] Ichikawa Kankyo Engineering CO., Ltd. (2016), *Project formulation study on development of waste transfer station in the city of Hanoi, Vietnam*.

[7] Hitachi Zosen Corporation and K.K. Satisfactory International (2013), *Anaerobic digestion of organic waste for cogeneration at market (Vietnam),* Reports of MOEJ/GEC JCM Project Planning Study.

[8] Hitachi Zosen Corporation (2014), *Introduction of energy from waste project in Ho Chi Minh city*, MOEJ/GEC JCM Project Planning Study.

[9] EX Research Institute Ltd. (2012), *Introduction of mechanical biological treatment (MBT) of municipal solid waste and landfill gas capture, flaring and utilization (Lao PDR)*, Reports of JCM/BOCM Feasibility Study.