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CONTENTS

Investigation of the adsorption potential of green coffee husks biochar activated with K_2CO_3 for caffeine removal from water

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Abstract

The abundant coffee by-products in Vietnam have great potential for producing environmentally friendly adsorbent materials, increasing the value of processed coffee products, contributing to climate change mitigation. The objective of this study is to evaluate the microstructure of coffee husk biochar (BC) and potassium carbonate-activated biochar (BC-K_2CO_3) revealed the material has rough surface with numerous pores ranging from 100 nm to 300 nm. When used at a dosage of 0.1 g/mL with an adsorption time of 120 minutes and an initial caffeine concentration below 0.025 g/mL, it achieved an adsorption efficiency of over 89.75%. The kinetic caffeine adsorption of BC-K_2CO_3 aligns well with the Freundlich adsorption isotherm model (R^2 >0.992). BC-K_2CO_3 exhibited a maximum adsorption capacity (Q_m = 33.74 mg/g), significantly higher than the control sample biochar BC (Q_m= 13.99 mg/g), which was produced under the same pyrolysis conditions without K_2CO_3 activation.

JEL Classification: *Q56, Q57, Y10, O13, R11.*

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1. INTRODUCTION

Vietnam is the world's leading exporter of Robusta coffee, significantly contributing to the national economy. The coffee processing industry generates coffee husks at a rate of 0.6–0.78 kg of husk per 1 kg of green coffee beans. This husk can be converted into valuable materials, such as ammonium adsorbents, nutrients, fertilizers, cyclic chemicals, inks, aromatic substances, pharmaceuticals (notably caffeine), and adsorbents for caffeine removal from aqueous environments, caffeine-containing extracts, or wastewater. Additionally, there is an increasing demand for safe and effective caffeine adsorbents to produce caffeine-free coffee products, especially for individuals sensitive to caffeine[1-18].

The use of water and activated carbon adsorbents for caffeine removal in decaffeinated coffee production (decaf coffee beans) provides an alternative to traditional methods that rely on environmentally harmful organic solvents. While activated carbon has been widely used for this purpose, the activation of biochar derived from coffee husks in this study presents an opportunity to develop caffeine adsorbents for water treatment as well as for producing high-value caffeine-free coffee extracts. Replacing conventional caffeine removal methods which often use hazardous chemical solvents such as methylene chloride, chloroform, or the less toxic ethyl acetate helps address environmental concerns, chemical residues, and cost issues[1].

Supercritical CO_2 extraction, proposed by Zosel[2], is a more environmentally friendly approach but requires high equipment costs due to the need for high pressure. The use of biochar has emerged as a sustainable and promising solution[3]. Studies such as those by Elvio et al. (2021) have demonstrated the significant caffeine adsorption capacity of activated carbon derived from coconut leaves[4]. Similarly, Keerthanan et al. (2020) highlighted the advantages of biochar derived from pyrolyzed tea plant residues[5].

Our research focuses on utilizing biochar derived from coffee husks activated with K_2CO_3 (BC-K_2CO_3) and comparing it with non-activated biochar (BC). The objective is to develop an environmentally friendly and cost-effective caffeine removal material and method that promotes waste recycling without the use of harmful chemicals[3]. This approach aims to repurpose coffee husks for the selective adsorption of caffeine, contributing to the production of value-added materials from coffee by-products and high-value decaffeinated coffee products. The outcome of this study is the development of a novel, eco-friendly biochar material for caffeine adsorption, offering environmental, economic, and public health benefits while supporting the production of decaffeinated coffee beans.

2. MATERIALS AND METHODS

2.1. Materials

Coffee husk and green coffee bean were collected from Cư M'gar - Dak Lak (Dak Lak – Vietnam).

2.2. Experiments

Preparation of biochar samples

Method 1: Making biochar of coffee husks (BC)

3 grams of green coffee husks were tightly packed into a cup with a lid. Slow pyrolysis was conducted under anaerobic conditions within the cup. The temperature was gradually increased to 400 degrees Celsius and maintained for 30 minutes. This process resulted in the production of BC biochar.

Method 2: Making biochar activated with K_2CO_3 (BC- K_2CO_3)

BC and K_2CO_3 were mixed at a 1:3 mass ratio and allowed to react for 2 hours. Afterward, the reacted sample was tightly packed into a cup with a lid. Slow pyrolysis was then conducted under anaerobic conditions. The temperature was gradually increased at a rate of 10 degrees Celsius per minute until it reached 400 degrees Celsius. This temperature was maintained for 30 minutes. This process resulted in the production of BC-K_2CO_3 biochar.

Method 3: Making caffeine extraction of green coffee beans

The coffee bean was grounded and impregnated with deion water at the rate of 10 mL.g^{-1} with a heating of 80^{o}C for 3 hours. Coffee bean extract was determined at pH = 6.7 and stored at -4^{o}C for further experiments.

Setting up experiments

The influence of contacting time (10-180 minutes) on the treatment efficiency was carried out at the pH of 6.7; biochar dose of 0.05 g.mL^{-1}, agitation of 100 rpm. The influence of the biochar dose (0.01 - 0.15 g.mL^{-1}) on the caffeine removal capacity was carried out at pH of6.7, agitation of 100 rpm for 120 minutes. The influence of initial caffeine concentration on treatment efficiency was carried out at pH of6.7, biochar dose was 0.15 g.mL^{-1}, agitation of 100 rpm for 120 minutes.

Analysis methods: The biochar microstructure was analyzed by SEM technique, The FTIR was done by Bruker Tensor 27 IR (USA) in spectral range from 400 cm^{-1} to 4000 cm^{-1}.[6]

Adsorption isotherm and kinetic model

The caffeine adsorption isotherm of biochar was evaluated by Langmuir (1) and Freundlich (2) models.[7]

$$\frac{C_e}{Q_e} = \frac{1}{Q_m}C_e + \frac{1}{bQ_m} \quad (1) \qquad q_e = K_F C_e^{\frac{1}{n}} \quad (2)$$

where:q_e (mg.g^{-1}) and C_e (mg.l^{-1}) are equilibrium ammonium ion concentrations in solid phase and liquid phase, respectively; Q_m (mg.g^{-1}) is the maximum adsorption capacity of the material and b(kl.g^{-1}) is the equilibrium constant related to the adsorption energy; K_F and n are Freundlich constants. The adsorption rate is either first-order (3), or second-order (4), dependent on the capacity of the adsorbent.[8]

$$\log(q_e - q_t) = \log(q_e) - \frac{k_1}{2.303}t \quad (3)$$

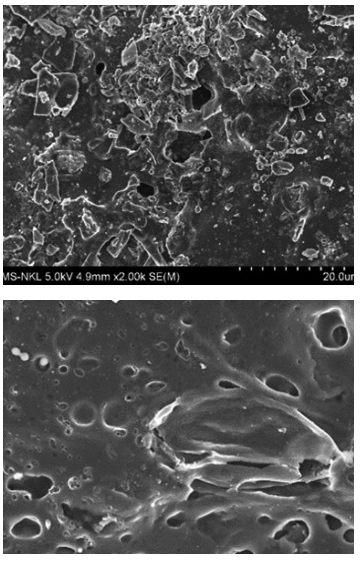
$$\frac{1}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e}(t) \quad (4)$$

where: Q_t (mg.g^{-1}) is adsorption capacity at time t (min), Q_e (mg.g^{-1}) is adsorption capacity at equilibrium time, k_1 (min^{-1}) and k_2 (g.mg^{-1}.min^{-1}) are rate constants.

3. RESULTS AND DISCUSSION

3.1. Characteristics of biochar

The SEM imaging presented in Figure 1 and 2 show that the material has a rough surface, many pores with pore size in the range of 100 nm to 300 nm (BC-K_2CO_3). This feature contributes to the material's good adsorption and retention capacity for pollutants. Thermal treatment at elevated temperatures can induce the decomposition of constituent components such as cellulose and lignin within the material, concurrently leading to an expansion of its pore structure. This phenomenon is associated with an enhanced adsorption efficiency.[8,9,10]



▲ *Figure1: SEM images of BC*

The FTIR spectra (Figure 3 and 4) showed that the functional groups on the surface of the biochars are in the range of 500-4000 cm^{-1}.The wide spectral band in the range of 3500-3000 cm^{-1} of both biochar due to the OH group being stretched and the OH group present in cellulose, lignin, water or can also correspond to the N-H valence oscillation in the amine (first-order and second-order) and carbohydrate groups in macromolecular compounds; the spectral band near the 1500 cm^{-1} value indicates that the C=C bond is stretched in the structure of both biochars; spectral in the range of 1300-1000 cm^{-1} shows the appearance of C-O bond.[11]

3.2 Effect of contacting time on the adsorption

The effect of contacting time on caffeine treatment efficiency was carried out in the time from 10 to 180 min at initial pH 6.7. The Figure 5 resulted that after the first 30 minutes, the adsorption rate increased slowly. Between 30 and 120 min, the adsorption rate continued to increase, then gradually stabilized and reached equilibrium after 120 min in both BC and BC-K_2CO_3, with the treatment efficiency reaching 39.48% and 62.01%. This trend could be explained as follows: the initial rapid adsorption is due to the caffeine replacing the positive ion on the material's surface. In the first time of contact, the biochar has a lot of vacant adsorption sites, the caffeine concentration in the water is the highest, so the adsorption process is high and leads to a rapid increase in the process efficiency. The next slower rising phase represents physical adsorption deterioration with ionic equilibrium. The slow increase is due to chemisorption and diffusion of caffeine inside the material, then reaches saturation of the active sites.[12]

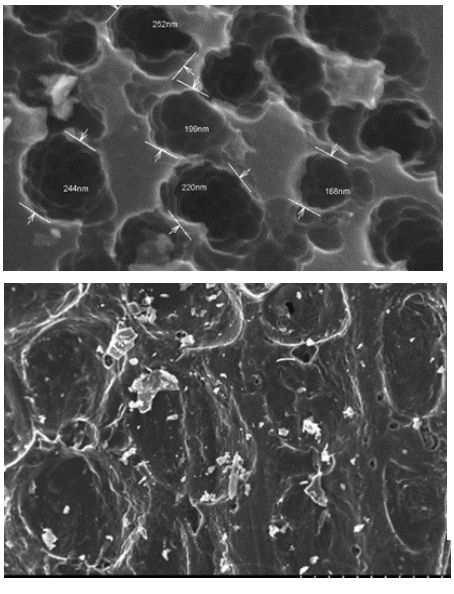
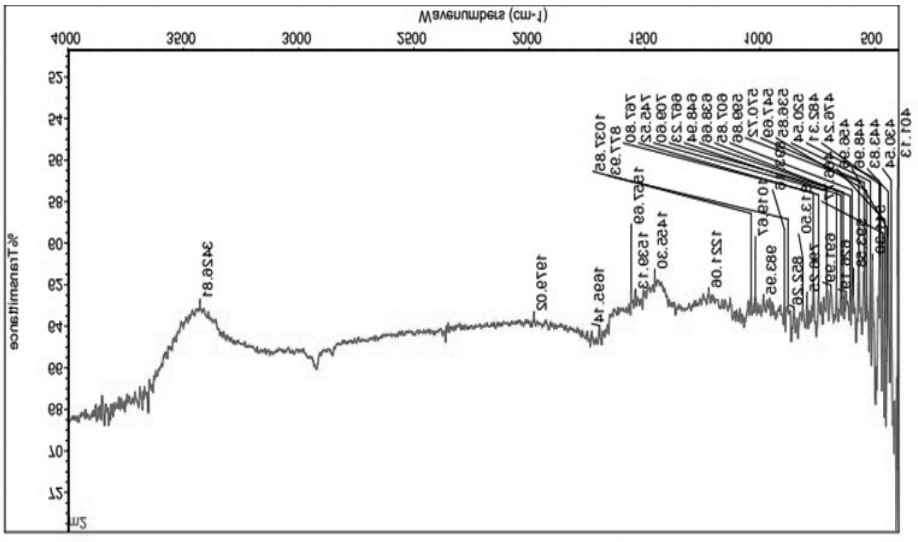
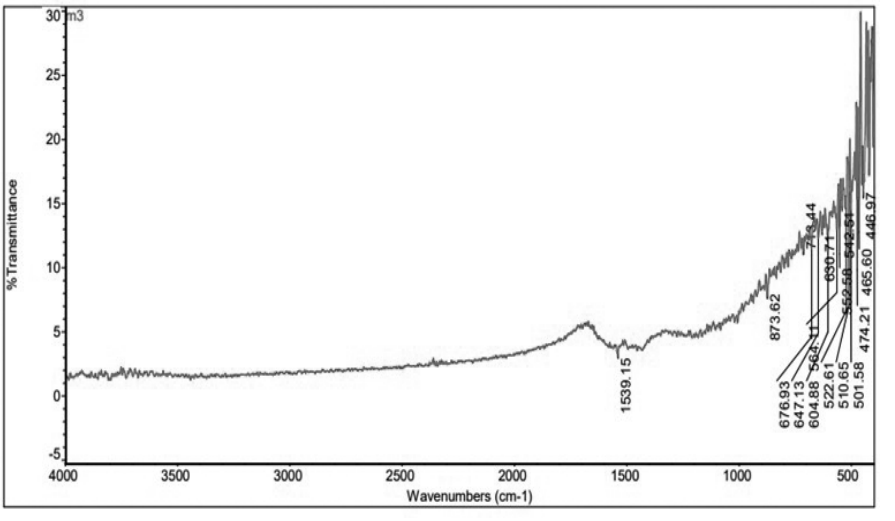


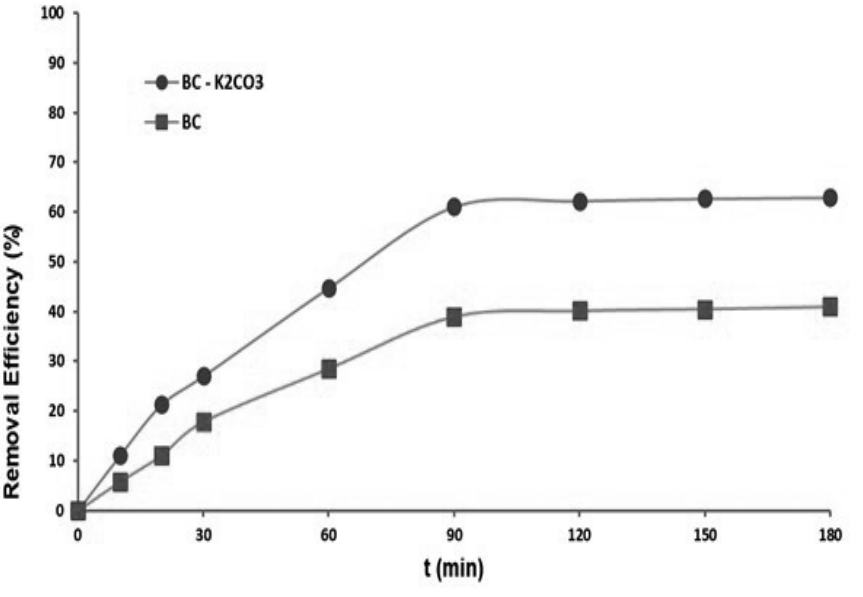
Figure2: SEM images of BC- K_2CO_3



▲ *Figure 3. FTIR spectra of BC-K_2CO_3*



▲ *Figure 4. FTIR spectra of BC-K_2CO_3after caffeine adsorption*

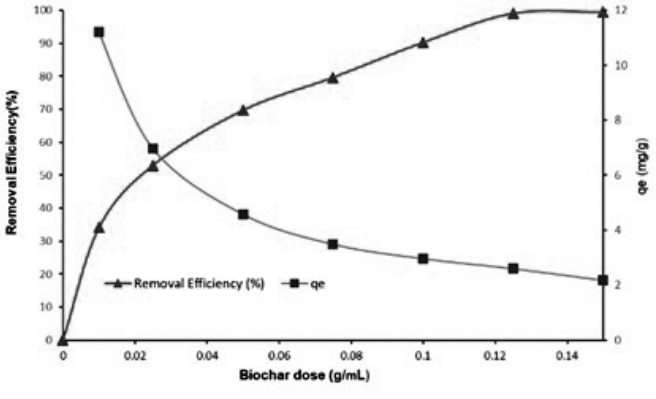


▲ *Figure 5. Effect of contact time on caffeine removal efficiency byBC and BC-K_2CO_3*

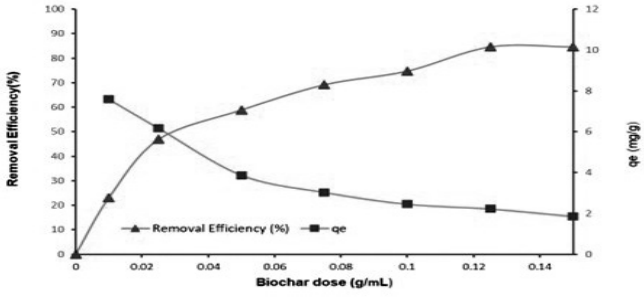
3.3. Effect of biochar on the adsorption capacity

The biochar dosage (g.mL^{-1}) was carried out at pH6.7, contact time was 120 min, there was a change in the ratio between the mass of the material and the volume of the solution in the range from 0.01 to 0.15 g.mL^{-1}. Figure 6a and 6b showed that the caffeine adsorption efficiency increased rapidly from 22.89% to 44.55% for BC and from 31.29% to 53.36% for BC-K_2CO_3 when the biochar dosage was in the range from 0.01 to 0.1 g.mL^{-1}.

For both BC and BC-K_2CO_3, when the biochar dosage increased to 0.15 g.mL^{-1}, the treatment efficiency did not increase too much and the biochar dosage for the highest adsorption efficiency is 0.15g.mL^{-1}. When the material dosage is higher, the contact surface will be larger and more caffeine will be adsorbed on the surface. However, when the biochar dosage was increased to a certain value, the caffeine adsorption was not significantly increased because the overlap of adsorbent layers could obscure the active sites.



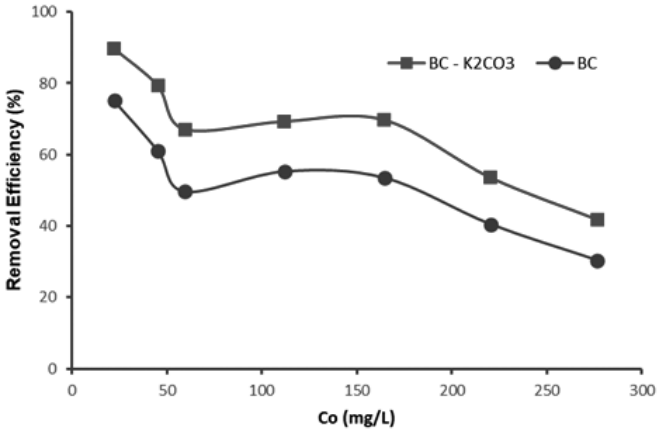
▲ *Figure 6a. Effect of biochar dosage on caffeine removal efficiency and amount of caffeine adsorbed on the surface of materials BC-K_2CO_3*



▲ *Figure 6b. Effect of biochar dosage on caffeine removal efficiency and amount of caffeine adsorbed on the surface of materials BC*

3.4. Effect of initial caffeine concentration on the adsorption capacity

To investigate the influence of initial caffeine concentration, experiments were carried out with BC and BC-K_2CO_3 materials at biochar dosage of 0.05 g.mL^{-1}, agitation of 100 rpm for 120 min. The initial caffeine concentration was investigated ranging from 0.02 to 0.27 mg.mL^{-1}. Figure 7 showed that the initial caffeine concentration was 0.02 mg.mL^{-1}, the treatment efficiencies of BC and BC-K_2CO_3 were 75.1% and 89.7%, respectively. With an increase in initial caffeine concentration from 0.02 to 0.27 mg.mL^{-1}, the efficiency decreased from 75.1% to 30.3% with BC and from 89.7% to 41.6% with BC- K_2CO_3. This reduction can be attributed to the limited maximum adsorption capacity of the materials.[13] When the material surface does not have enough adsorbent sites to adsorb caffeine, increasing the concentration of caffeine solution while keeping the same dose of material will cause the amount of free caffeine to increase while the adsorbed caffeine remains unchanged, leading to the adsorption efficiency was gradually reduced.



▲ *Figure 7. Effect of initial caffeine concentration on caffeine adsorption efficiency by BC and BC-K_2CO_3*

Caffeine adsorption isotherm: The studies of equilibrium in adsorption indicate the biochar adsorption capacity by Langmuir and Freundlich models that have been widely used. The experimental results are shown in Figure 8 and 9, and the constants are shown in Table 1. The suitability between the model and experimental data is shown by the correlation coefficient R^2. The correlation coefficient R^2 in Table 1 shown that caffeine treatment with biochar is more consistent with Freundlich adsorption theory for both materials BC and BC-K_2CO_3 ($R^2$of 0.992 and 0.963).

For the Langmuir theory, the R^2 values of the two materials are both in the range of 0.8 to 0.9. It could be seen that the adsorption of biochar can not only describe the linear or saturation region and the working concentration range. The caffeine adsorbant follows both monolayer and multilayer mechanisms. The caffeine extraction process may not follow a

Table 1: Parameters of Langmuir and Freundlich isotherms and coefficient of determination (R^2) for model

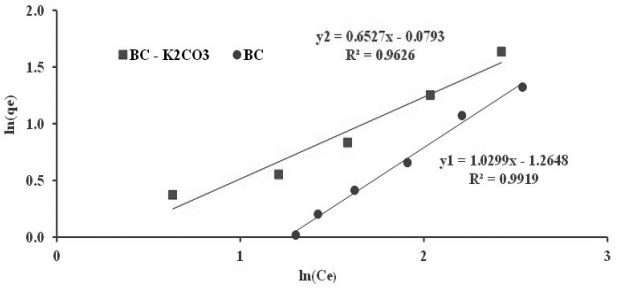
	Parameter values		R^2	
	BC	BC-K_2CO_3	BC	BC-K_2CO_3
Langmuir				
b (L.mg^{-1})		0.015		0.806
Q_m *(mg.g^{-1})*		33.74		
Freundlich				
K (mg.g^{-1})		1.197		0.963
n		0.692		

Table 2. Kinetic models applied and parameters and coefficient of determinations (R^2) obtained from the model fits

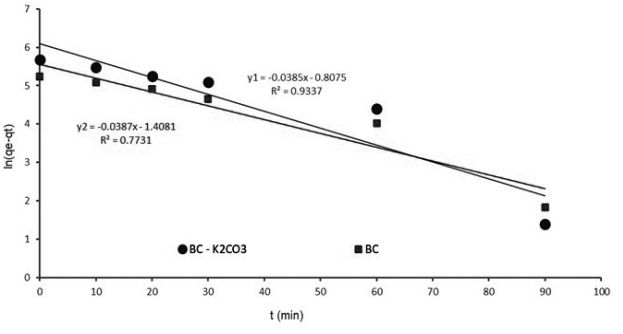
Parameters	Parameters		R^2	
	BC	BC-	BC	
Pseudo-first order				
k_1 *(1.min^{-1})*		0.040		
q_{e1} *(mg.g^{-1})*		1.94		
Pseudo-second order				
k_2 *(g.(mg. min^{-1})*		1.758		1
q_{e2} *(mg.g^{-1})*		1.94		

single adsorption mechanism, but rather multiple mechanisms (ion exchange, chemisorption, complexation...). Therefore, the use of the Langmuir or Freundlich adsorption theory to describe the adsorption process by the experimental material can only provide an approximate description.

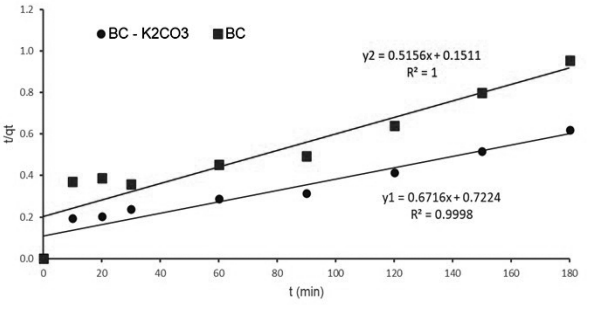
***Caffeine adsorption kinetic*:** Results have been shown in Table 2 and Figure 10 and 11. Table 2 showed that the correlation coefficient R^2 for each material in both pseudo-second-order kinetic models is very high (greater than 0.999). For the BC-K_2CO_3 material, the R^2 value for the second-order model reaches a value of 1. However, the experimental q_e value also needs to be compared with the q_e value calculated from the two models. The second-order model gives q_e value closer to the experimental value. Therefore, it can be concluded that the caffeine treatment process fits the pseudo-second-order kinetic model.



▲ *Figure 9. Freundlich model*



▲ *Figure 10. Pseudo-first-order model prediction of the kinetics of caffeine removal*



▲ *Figure 11. Pseudo-second-order model prediction of the kinetics of caffeine removal*

3.5. Comparison of caffeine adsorption by various adsorbents

Previous studies have investigated the adsorption of caffeine by various adsorbents, including activated carbon, carbon xerogel, and biochars. Activated carbon and carbon xerogel exhibited high caffeine adsorption capacities due to their extensive surface areas. [14,15] However, their production often involves significant use of chemicals and high energy consumption, leading to increased costs. Consequently, there is growing interest in utilizing environmentally friendly waste materials as low-cost alternatives for contaminant remediation.While fique bagasse biochar displayed a caffeine adsorption capacity of 3.52 – 9.13 mg.g^{-1},[16] and woodchip biochar a capacity of 13.2 mg.L^{-1},[17] this study presents a novel approachof using coffee husk activated by K_2CO_3 at suitable temparature 400^{0}C that could be easily made by local biochar maker equipment at local site. We engineered BC-$K_2CO_3$and make the comparison with previously reported, our BC-K_2CO_3 coffee husk biochar activated by K_2CO_3adsorbents caffein with high adsorptioncapacity Q_m = 33.74 mg.g^{-1}.

4. CONCLUSION

In this study, we investigated the adsorption potential of biochar derived from pyrolyzing waste green coffee for caffeine removal. BC-K_2CO_3 exhibited a rough surface and abundant pores with sizes ranging from 100 nm to 300 nm. At 37°C, BC-K_2CO_3 biochar was suitable for the time to equilibrium is 120 minutes, the optimal solid/liquid ratio was 0.5 g/mL, the input caffeine concentration less than 0.06 $mg.mL^{-1}$, the caffeine removal efficiency was 89.75 %. The caffeine adsorption of BC-K_2CO_3 biochar was consistent with Freundlich adsorption theory with high correlation coefficients R^2 (>0.992). Significantly, BC-K_2CO_3 exhibited a higher maximum adsorption capacity (Q_m = 33.74 $mg.g^{-1}$) compared to the control BC biochar (Q_m = 13.99 $mg.g^{-1}$), which was pyrolyzed without bioactive compound extraction. The effectiveness of BC-K_2CO_3 biochar as an efficient and environmentally friendly adsorbent for caffeine removal from water. The utilization of waste green coffee for biochar production offers a sustainable approach to address caffeine while adding value to the coffee industry's by-products.

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Organic pollution (pH and TOC) in sediments at tidal sluice gates in the Saigon river basin

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Abstract
The Saigon river plays a crucial role in the ecosystem and socio-economic development of Ho Chi Minh City but is affected by industrial activities, urbanization, and domestic wastewater, particularly in river branches with tidal sluices. This study assesses organic pollution in sediment through pH and total organic carbon (TOC) during the period 2022 – 2024. Monitoring results from 2022 to 2024 indicate that pH values remained stable and within the permissible limits set by QCVN 07:2009/BTNMT. Meanwhile, TOC exhibited an increasing trend along the sampling locations, with significant fluctuations during the rainy season, particularly at certain sites with sudden high values, such as B3 (2.15%), B5 (2.36%), B6 (2.36%), and B7 (2.15%). In contrast, TOC levels during the dry season showed a more stable increase, with higher concentrations observed at locations B5 (2.14%), B7 (2.24%), B8 (2.24%), and B9 (1.92%). These seasonal variations reflect the influence of rainfall and surface runoff. The study provides a scientific basis for pollution management and proposes effective solutions for sediment environment protection. [1]; [2];[4];[5];[6];[7]

Keywords: *Total Organic Carbon (TOC) in sediments, tidal sluice gate, Saigon river basin.*
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1. INTRODUCTION

The Saigon River basin is a region experiencing rapid urbanization and industrialization, which exerts significant pressure on the water and sediment environments. Notably, the tidal sluice system on the river branches not only serves to control tidal flooding and saltwater intrusion but also alters hydrodynamic conditions, thereby influencing the accumulation of pollutants in sediments. Among these, organic pollution—represented by indicators such as pH and total organic carbon (TOC) - is a critical concern in environmental studies. Assessing the level of organic pollution at tidal sluice points provides essential scientific data for environmental quality management and supports sustainable development efforts.

This study focuses on the level of organic pollution in sediments at tidal sluice points located along the tributaries of the Saigon river basin. Previous studies have mainly concentrated on water quality or heavy metal contamination in sediments, while organic indicators such as TOC and pH have received limited attention [3]; [4]; [5]. The novelty of this research lies in its evaluation of organic pollution within tidal sluice systems and its analysis of how these systems affect pollutant accumulation processes. By utilizing pH and TOC indices, the study aims to determine the extent of organic pollution in sediments and propose effective management solutions to mitigate the impact of organic contaminants on the sedimentary environment and aquatic ecosystems.[7]

2. DATA AND RESEARCH METHODOLOGY

2.1. The data

The database in the study of assessing organic pollution in sediments at tidal sluice points in the Saigon river basin includes information collected from the field and laboratory analysis results. The data is recorded at various observation points, including location coordinates, sample collection time, sediment depth, along with important environmental parameters such as pH, total organic carbon (TOC) content, and concentrations of organic pollutants.

2.2. Research methodology

The research methodology includes collecting sediment samples at tidal sluice gates, analyzing pH and TOC indices in the laboratory, and using Excel software for data statistics and processing to assess the level and trends of pollution in space and time.

2.3. Sampling and Sample Analysis Methods

All samples were collected according to the appropriate sampling and sample preservation procedures in accordance with the Vietnamese Standards TCVN 6663-13: 2015 and TCVN 6663-15: 2004. Sampling was conducted during both the dry and rainy seasons. In the laboratory, the samples were analyzed following approved procedures to determine the presence and concentration of pollutants or to assess

their impacts under various conditions. These analytical methods adhere to the standards set by the United States Environmental Protection Agency (EPA) [8] and are in compliance with current Vietnamese standards. Samples were collected during the dry season (March, April) and the rainy season (October, November) at 9 sampling sites in the Saigon river basin from 2022 to 2024. The sampling locations were chosen in areas affected by discharge sources from domestic waste, industrial zones, and waterway traffic, among others. The sampling locations are presented in Table1.

3. RESULTS

The survey results indicate that the pH values during the rainy season range from 5.18 to 7.28, with many points exhibiting pH values above 7, reflecting a mildly alkaline environment. However, some locations, such as B3, B4, and B5, have relatively low pH values (pH < 6), suggesting a slightly acidic environment. The variation between survey points is relatively large, which may be due to the influence of flow, pollution sources, or other environmental factors during the rainy season. In contrast, during the dry season, the pH values range from 5.33 to 7.28. Compared to the rainy season, pH at some points shows a slight decrease, particularly at locations B3, B6, B7, and B9, where pH values are lower than 5.5. Overall, the average pH values in both seasons are mostly within the permissible limits according to QCVN 07:2009/BTNMT (pH: 2.0 – 12.5). However, the pH variation between locations during the dry season is somewhat smaller than during the rainy season, indicating greater stability. [5]; [7]; [8]; [9]

When comparing the two seasons, the pH variation range generally does not show significant differences, but there are variations at specific locations. Some points, such as B3, B6, and B7, have lower pH during the dry season compared to the rainy season. Notably, the dry season shows higher pH stability due to less influence from rainwater and water dilution. In the rainy season, rainwater may alter the characteristics of the water environment, leading to larger pH fluctuations. On the other hand, during the dry season, evaporation and reduced water flow can increase the concentration of acidic or alkaline substances in the water, leading to pH fluctuations at certain points. [7]; [8]; [9]

In general, the pH values at the surveyed locations range from neutral to slightly acidic. The pH fluctuations during the rainy season are greater due to the influence of flow and rainfall, while the dry season tends to be more stable. However, some locations still show low pH values, possibly due to the accumulation of pollutants or the impact of organic decomposition processes. To obtain a more accurate assessment, continued monitoring and further research on the factors affecting pH, particularly at points with low values, are needed. [5]; [7]

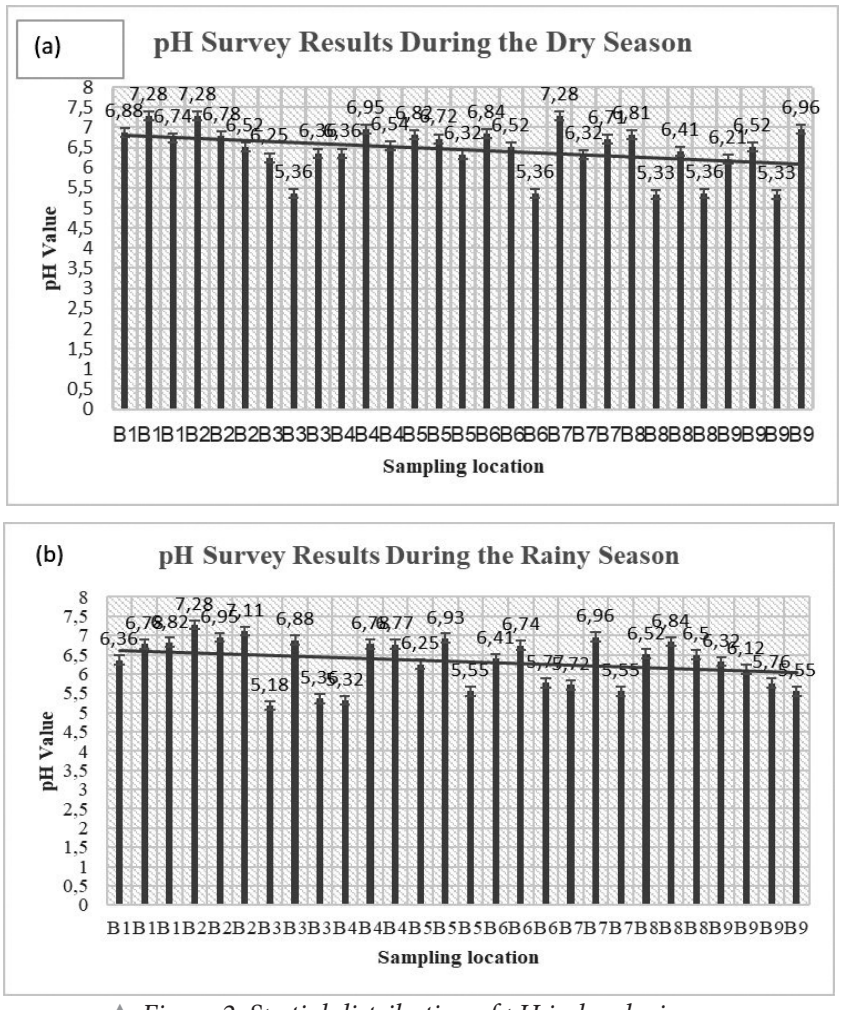
The fluctuation of total organic carbon (TOC) between the two seasons demonstrates a clear difference in accumulation dynamics and distribution in the sediment environment. During the rainy season, TOC concentrations exhibit strong variability across the monitoring sites, with some locations recording sharp spikes, reaching a maximum of 2.36% (B5 and B7). In contrast, during the dry season, TOC also tends to increase with sampling location; however, the degree of fluctuation is lower, and there is less seasonal variation between sampling points during the 2022–2024 period.

Regarding the spatial distribution trend of TOC, both seasons show an increase in TOC concentrations along the flow path, clearly reflected by the trendline. However, in the dry season, this trend is more stable, indicating a more uniform accumulation of organic matter compared to the rainy season, when hydrodynamic factors strongly influence the distribution of organic material. [7]

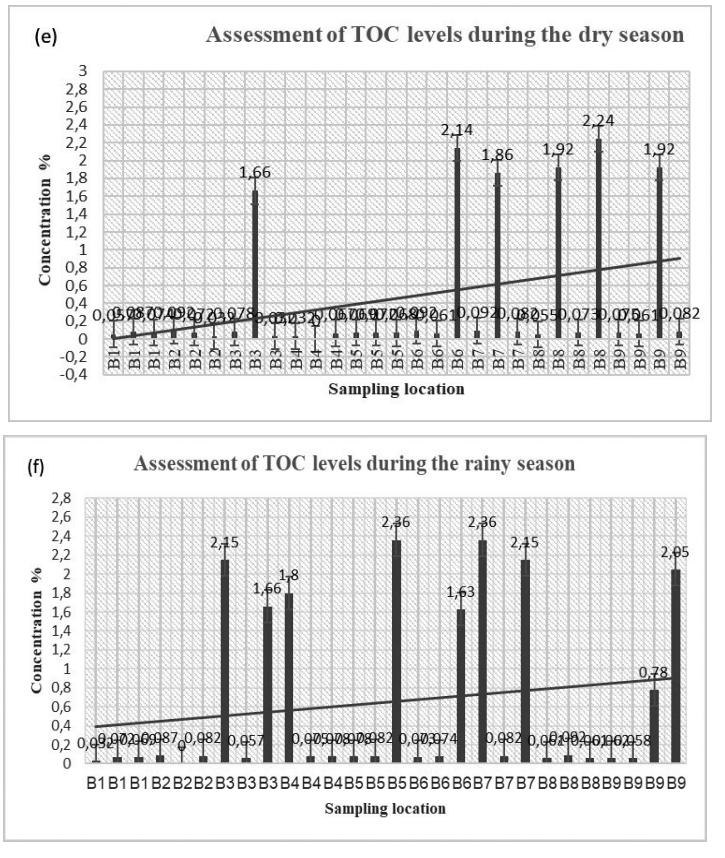
In terms of average values, during the rainy season, many locations have high TOC

Table 1: Sediment Sampling Locations

No.	Location	Code	VN 2000 Coordinates	
			X (m)	Y (m)
1	Ben Nghe	B1	1189604	606003
2	Kenh Te	B2	1189604	606003
3	Phu Xuan	B3	1183917	608181
4	Muong Chuoi	B4	1190231	605662
5	Can Giuoc river	B5	1184661	595261
6	Ba Buom creek	B6	1190975	604053
7	Cay Kho	B7	1180485	601280
8	Cau Kinh creek	B8	1166885	612214
9	Drainage Outlet of Hiep Phuoc Industrial Park	B9	1183510	608462



▲ *Figure 2. Spatial distribution of pH index during the dry season (a) and the rainy season (b)*



▲ *Figure 3. Spatial distribution of TOC concentrations in the dry season (e) and rainy season (f).*

concentrations, with some points exceeding the 2% threshold, such as B3 (2.15%), B5 (2.36%), B6 (2.36%), and B7 (2.15%), reflecting uneven accumulation of organic material. Meanwhile, the dry season records high TOC values but fewer extreme points. This may be related to the impact of surface flow and flooding during the rainy season, altering the processes of transport, deposition, or washout of organic compounds in various areas of the hydrological system. [1]; [2]; [5]; [7]

The effect of seasonal factors on TOC is clearly reflected in the fluctuation of organic content concentration. During the rainy season, strong flows may disturb sediments, causing suspended matter and re-deposition of organic material in low-lying areas, leading to uneven distribution of TOC. Conversely, in the dry season, due to less influence from strong flows, organic matter tends to accumulate more consistently in sediments, contributing to a more uniform distribution trend.

The results show that TOC concentrations in sediments tend to increase with sampling location in both seasons. However, during the rainy season, the fluctuations are stronger, with some points exhibiting sharp increases in TOC values, while the dry season shows a more stable increase. This difference may stem from the influence of hydrodynamic processes during the rainy season and the organic accumulation mechanism in the dry season, affecting TOC distribution in the riverbank sediment ecosystem. [5]; [7]

4. CONCLUSION

The research results indicate that the total organic carbon (TOC) content in sediments varies between the two seasons, with higher TOC values during the rainy season compared to the dry season. This may be due to increased flow and the transportation of organic matter from upstream. Additionally, the pH index fluctuates seasonally, with pH values during the rainy season tending to be lower at some sampling sites, possibly due to dilution and the influence of other environmental factors. The variations in TOC and pH at the sampling locations reflect the impact of tidal sluice gates in accumulating and dispersing organic pollution within the Saigon river basin.

The current study primarily focuses on TOC and pH indices, without fully assessing other factors such as heavy metals, persistent organic pollutants (POPs), or nutrients that may affect sediment environmental quality. Moreover, the sample collection period was limited to a specific timeframe, not fully reflecting the long-term fluctuations of the river ecosystem. The study's scope is also confined to a few sampling points in the tidal sluice system and has not been extended to cover the entire basin for a more comprehensive overview.

In the future, the research could be expanded to assess the impact of other environmental factors, such as metals, nutrients, microorganisms, and more complex organic pollutants. Additionally, the use of remote sensing technology and hydrological modeling to predict the distribution and accumulation of pollution in the context of climate change is an important direction. Furthermore, studying the mechanisms of pollution spread based on the operation of tidal sluice systems could help clarify the role of water control structures in managing sediment environmental quality.

Based on the research results, environmental managers and businesses could consider the following measures: controlling organic waste sources by tightening the management of emissions from industrial, agricultural, and residential activities to reduce organic pollution in river sediments; improving the operation of tidal sluice gates by developing flow control procedures to limit pollution accumulation at tidal discharge points; continuously monitoring the environment with automated monitoring systems to track sediment environmental quality in real time, helping to detect early signs of pollution; and developing pollution treatment technologies such as biological traps, adsorbent materials, or sediment restoration techniques to minimize negative impacts on river ecosystems. These solutions will contribute to more effective management of sediment environmental quality in the Saigon river area, protect ecosystems, and reduce adverse effects on socio-economic activities.

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Evaluating the role of community awareness on ecosystem services at Tao Dan park

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Abstract

Amidst increasing urbanization and climate change, the conservation and expansion of urban green spaces pose significant challenges for cities like Ho Chi Minh City. This study assesses the potential for ecosystem service development at Tao Dan park using direct surveys and statistical analysis to examine public awareness and engagement. The findings indicate that the park plays a crucial role in microclimate regulation (reducing temperatures by 1-2°C), mitigating the urban heat island effect, and serving as an essential communal space, benefiting over 60% of local residents. However, 69% of respondents lack a clear understanding of the concept of ecosystem services, underscoring the need for enhanced awareness campaigns. Notably, 56% of surveyed individuals expressed willingness to contribute financially (20,000-30,000VND per month) for park maintenance, provided that a transparent fee collection mechanism is implemented. This research highlights the park's significance in promoting sustainable urban development and proposes strategies to enhance public awareness, improve management efficiency and implement appropriate policies to safeguard and maximize the benefits of green spaces.

Keywords: *Urban parks; ecosystem services; green spaces; community awareness; Tao Dan.*
JEL Classification: *Q56, Q57, P18.*
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1. INTRODUCTION

Amidst the rapid progression of urbanization and climate change, the conservation and expansion of urban green spaces present significant challenges for cities worldwide, particularly in large metropolitan areas such as Ho Chi Minh City. Urban parks, with Tao Dan park as a prime example, function as the city's "green lungs", enhancing air quality, absorbing CO_2 emissions, mitigating the urban heat island effect, and regulating the microclimate. Additionally, these parks serve as vital community spaces, accommodating cultural, social, and recreational needs of urban residents (Jones, 2022).

Nevertheless, Tao Dan park is currently facing various challenges, including high population density pressures, a shrinking green space area, and inefficient management strategies (Semeraro et al., 2021). These issues not only impact the park's capacity to provide ecosystem services but also diminish its ecological, social, and cultural values within the context of sustainable urban development. The ecosystem services provided by the park are closely aligned with multiple Sustainable Development Goals (SDGs) (Liu et al., 2023). Specifically, Tao Dan park contributes to Goal 11 (Sustainable Cities and Communities) by maintaining and expanding green spaces (Devisscher et al., 2019), Goal 13 (Climate Action) by mitigating the urban heat island effect and absorbing carbon emissions (Pandey & Ghosh, 2023), and Goal 15 (Life on Land) by promoting the conservation and sustainable management of urban ecosystems (Monaco, 2024).

Urban parks provide valuable ecosystem services that enhance urban living conditions and are increasingly recognized as nature-based solutions to address environmental challenges in urban areas (Mexia et al., 2018). Among various urban ecosystems, parks contribute essential services such as air and water purification, noise and wind reduction, carbon sequestration, microclimate regulation, wildlife habitat preservation, and enhancement of psychological and social well-being (Chiesura & planning, 2004). Theoretically, this study contributes to a deeper understanding of the concept and role of ecosystem services in the context of urbanization in developing countries, particularly regarding livability and environmental conservation. Practically, this research provides a scientific foundation for the formulation of sustainable urban park management strategies, catering to the increasing demand for green spaces and their associated benefits (Yoong et al., 2017). Thus, the investigation and enhancement of ecosystem services at Tao Dan park are not only scientifically significant but also serve as a basis for policy recommendations aimed at preserving and promoting the park's long-term sustainability. The novelty of this research lies

in its comprehensive assessment of existing ecosystem services at Tao Dan park, alongside an analysis of public willingness to contribute and the proposal of sustainable utilization models based on current socio-economic and environmental trends.

This study focuses on key research objectives, including evaluating community awareness of ecosystem services in urban parks (Stępniewska, 2021), identifying challenges in maintaining and developing these services, and proposing sustainable strategies to enhance the ecological and economic value of the park. According to (Zhang et al., 2021), a clear understanding of public perceptions regarding ecosystem services is crucial not only for improving urban planning and conservation efforts but also for fostering community engagement in ecological preservation. Moreover, this study employs empirical data analysis to investigate interactions between the community and the park (Zhang et al., 2021). Zhang et al. (2021) highlighted that landscape design elements, such as greenery, water features, and recreational areas, significantly impact psychological and social well-being, emphasizing the importance of optimizing park designs to better accommodate community needs. By referencing these studies, this paper establishes a scientific foundation for formulating specific recommendations on the management and development of ecosystem services.

The primary objective of this research is to examine and evaluate public awareness and satisfaction regarding ecosystem services at Tao Dan park. The study aims to identify factors influencing public perception and satisfaction levels, while also analyzing barriers and opportunities for enhancing the park's ecological, social, and cultural significance. The findings of this study not only offer empirical insights into the relationship between the community and urban green spaces but also contribute to the development of effective management strategies for fostering sustainable urban park development. These insights will provide a scientific foundation to support urban planners and policymakers in designing strategies for the conservation and expansion of sustainable green spaces in Ho Chi Minh City and comparable urban environments.

2. RESEARCH APPROACH AND METHODOLOGY

Study subjects and research location

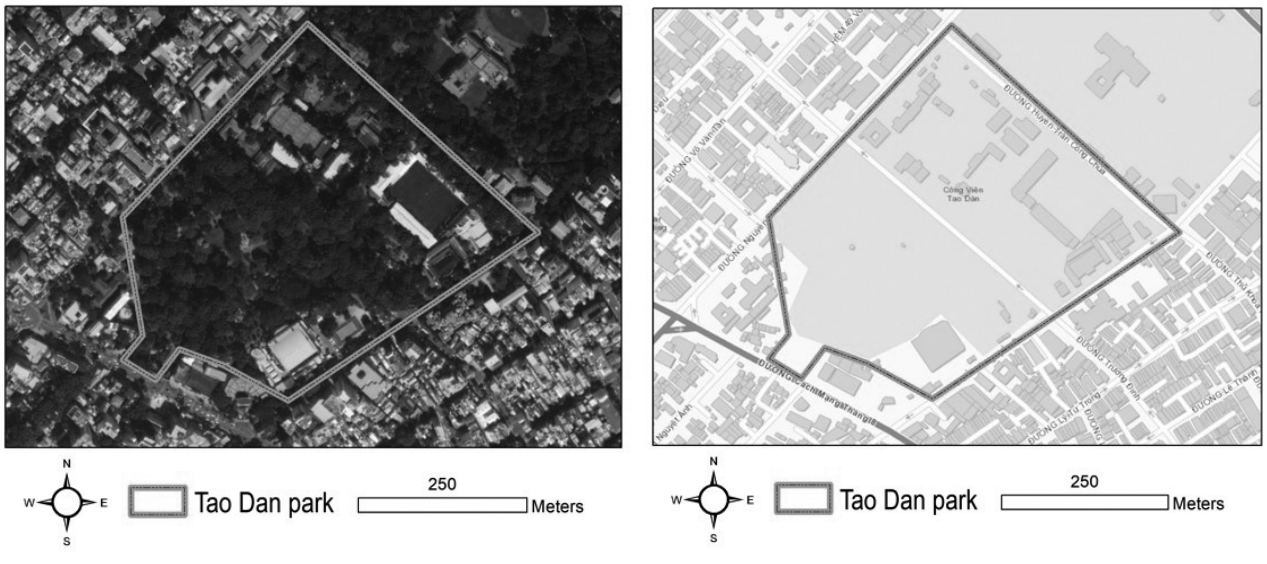
Survey participants: The target respondents of this study are individuals engaging in activities within the park.

Research location: The study was conducted at Tao Dan park, one of the largest and most significant urban parks in District 1, Ho Chi Minh City. The park serves as a key green space, spanning 10 hectares, with over 1,000 trees and a high vegetation density (Tran et al., 2024).

3. RESEARCH METHODOLOGY

Survey on ecosystem services of the park

The questionnaire was structured into four sections: (1) an introductory section outlining the survey objectives and inviting participant engagement, (2) a screening section utilizing a 5-point Likert scale (Tran et al., 2023), (3) a specific question section collecting data on park visit purposes, awareness of ecosystem services, and interest in green spaces, and (4) a concluding section gathering basic demographic information. The survey was conducted in the morning at various locations within Tao Dan park, targeting peak exercise hours to optimize respondent accessibility. Based on the sample size estimation method commonly applied in survey research, with a minimum sample size determined as the number of questions ×5 (Tran et al., 2023), the study successfully collected 240 survey responses, with data recorded through direct interviews.



▲ *Figure 1. Location of Tao Dan park in Ho Chi Minh City.*

Method for assessing public interest in ecosystem services

Descriptive statistics were employed to analyze the collected data, including sample classification based on survey criteria, as well as calculations of mean values, maximum values, and minimum values for responses to the survey questions. The research hypotheses were tested using data obtained from the constructed regression model. The significance of the tests was evaluated through t-statistics and p-value (Sig.), with a confidence level of 95%. The p-value was directly compared to 0.05 to determine whether to accept or reject the research hypotheses (Maneejuk & Yamaka, 2021). To examine differences between subpopulations within the study, T-tests and analysis of variance (ANOVA) were conducted. These statistical tests also relied on the direct comparison of p-values (MacFarland et al., 2016; Mishra et al., 2019).

4. RESULTS AND DISCUSSIONS

Frequency and habits of park visitors at Tao Dan park

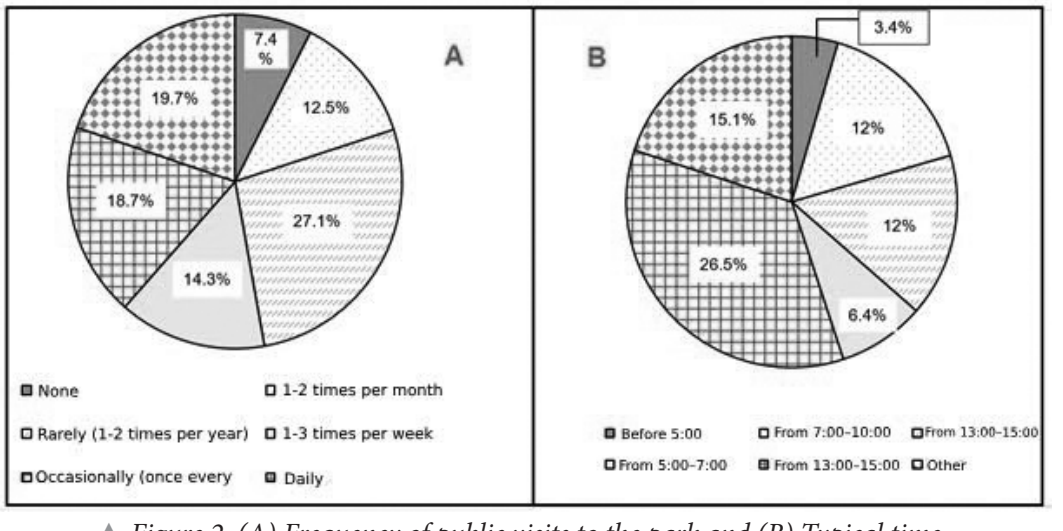
Based on the survey findings presented in Figure 2, the frequency and time frame of visits to Tao Dan park clearly reflect public space utilization patterns. Regarding park visit timing, the majority of respondents preferred the afternoon period from 15:00 to 17:00, likely because this timeframe is suitable for outdoor activities such as exercise, relaxation, or social interactions. While early morning and late morning hours also attracted some visitors, the number of participants was lower. In contrast, noon and pre-5:00 AM periods were the least preferred time slots. These results suggest that the time of day significantly influences park usage, offering insights into optimal survey timing for reaching target respondents.

The survey results indicate that Tao Dan park is a highly accessible public space, catering to the diverse needs of local residents. The majority of respondents reside near the park, with an average travel time ranging from 10 to 20 minutes. This finding underscores the park's significance as a familiar and convenient destination for the surrounding community. Private vehicles, particularly motorcycles, were the most commonly used mode of transportation, while walking and cycling also accounted for a substantial proportion, reflecting the flexibility in park accessibility. In contrast, the use of public transportation was minimal, suggesting the need for improved public transit connectivity to the park.

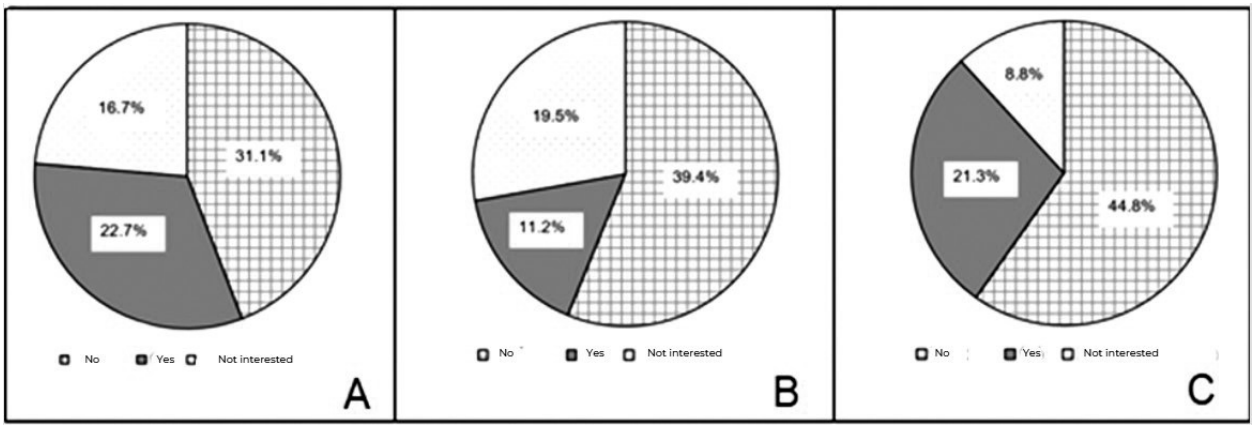
Regarding length of stay, most visitors remained in the park for an extended duration, typically one hour or more, indicating that the park serves not only as a short-term stopover but also as an ideal space for activities such as relaxation, exercise, social interactions and recreation. A small proportion of visitors stayed for less than 30 minutes, potentially due to time constraints or lower park usage needs. The longer stay duration observed among most respondents highlights the park's significant role in enhancing both mental and physical well-being within the community.

Figure 3 illustrates the public's sensitivity to air quality in the park, highlighting the strong correlation between environmental conditions and the frequency of park usage. The results indicate that when the park experiences mild air pollution, the proportion of individuals choosing not to visit exceeds those who continue to use the park, while a small group remains indifferent to the issue. As pollution levels increase to a moderate level, the percentage of non-visitors rises significantly, whereas the number of individuals willing to visit declines sharply. Notably, when air pollution reaches a severe level, the proportion of individuals avoiding the park peaks, underscoring thecommunity's deep concern regarding environmental quality. Simultaneously, the proportion of indifferent individuals decreases to its lowest point, demonstrating widespread public awareness of the critical role of clean air in both recreational experiences and overall health.

These findings are consistent with the study conducted by (Chang & Lee, 2016), in which the authors emphasize that large urban parks not only enhance air quality but also serve as essential habitats for various plant and animal species.



▲ *Figure 2. (A) Frequency of public visits to the park and (B) Typical time periods during which visitors frequent the park*



▲ *Figure 3. Public visitation under different air pollution levels: (A) Mild air pollution, (B) Moderate air pollution, and (C) Severe air pollution*

This further reinforces the notion that green spaces, particularly large parks, contribute not only to microclimate regulation but also to the provision of essential ecosystem services that support and regulate urban life quality. Furthermore, these results align with the conclusions of (Chang & Lee, 2016), who recommend that the design and management of green spaces should incorporate considerations of air quality and public accessibility to maximize the benefits derived from ecosystem services.

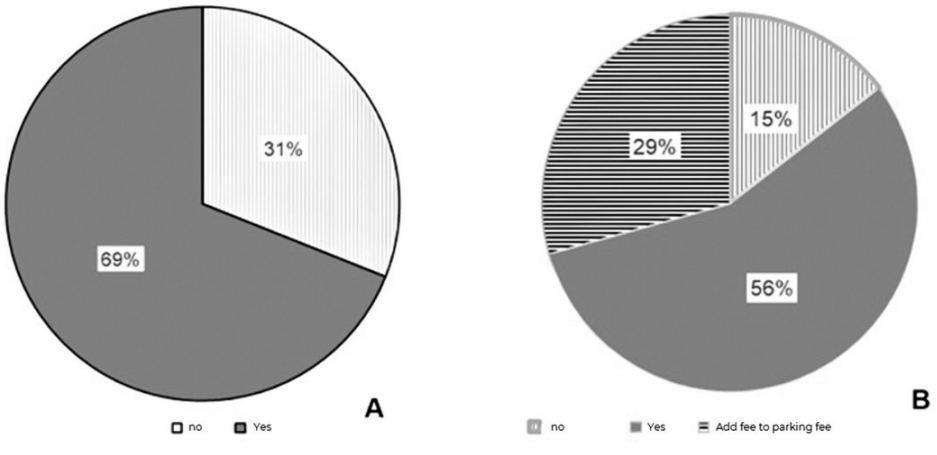
The collected data indicate that air quality is a primary determinant influencing individuals' decisions regarding park usage. This underscores the urgent need to maintain and improve environmental quality within Tao Dan park. The survey results not only provide a comprehensive perspective on how the public interacts with and evaluates the park, but also establish a scientific foundation for formulating sustainable strategies to enhance the value of ecosystem services, ensuring that the park continues to function as a vital "green lung" for the city.

Potential and development orientation of ecosystem services

The data presented in Figure 4 illustrate the current state of public awareness and perspectives on ecosystem services, as well as the willingness to contribute financially to the maintenance and improvement of the park.

The results from Figure 4A indicate that public awareness of ecosystem services at Tao Dan park remains limited. Although 31% of respondents, primarily young individuals, have some understanding of this concept, the majority (69%) still lack a clear perception of the role and significance of ecosystem services. This finding suggests that, despite the increasing availability of information on environmental issues in modern society, the concept of ecosystem services has not yet gained widespread recognition. This reality underscores the necessity of public awareness campaigns, which should not only emphasize environmental aspects but also clarify the social and cultural value of ecosystem services within public spaces such as urban parks.

Additionally, Figure 4B illustrates the public's strong consensus on financial contributions to support the preservation and enhancement of the park. Specifically, 56% of respondents expressed willingness to pay additional fees to support initiatives such as tree maintenance, equipment upgrades, and overall park improvements. This finding reflects the community's sense of responsibility in safeguarding urban green spaces. However, 29% of respondents suggested integrating these fees into parking charges to ensure transparency and convenience, whereas 15% opposed any additional charges, arguing that public funds should be allocated for park maintenance. These diverse perspectives highlight the urgent need for a transparent, rational, and equitable



▲ *Figure 4. (A) Public awareness of ecosystem services; (B) Public agreement on the willingness to pay additional service fees for the park*

management strategy. A well-structured financial policy would not only mobilize community contributions but also enhance public trust, ensuring the efficient allocation of resources for the sustainable development of urban green spaces (Rigolon et al., 2024).

Public satisfaction with the services provided by the park is also evident in Figure 5. The park is highly regarded for its expansive green spaces, which facilitate various outdoor activities, including walking, sports, and relaxation. Notably, its capacity to provide shade, lower ambient temperatures, and improve the microclimate is widely recognized, highlighting its critical role in mitigating the urban heat island effect. The study conducted by (Sarı & Bayraktar, 2023) further emphasizes the significance of park size in influencing the "park cooling island" (PCI) effect, where larger parks with higher vegetation density exhibit superior temperature regulation capabilities.

Beyond its environmental benefits, the park also functions as a dynamic social hub, supporting a wide range of recreational and community activities, from picnics and group gatherings to family interactions, thereby enriching residents' social lives. Additionally, the park serves as an outdoor educational center, fostering greater awareness among younger generations about historical, cultural, and environmental values. These potentials not only reinforce the park's ecological significance but also position it as a key cultural and educational landmark within the urban landscape. Similar findings from (Sarı & Bayraktar, 2023) and (Annerstedt Van Den Bosch et al., 2016) emphasize that large urban parks contribute to increased physical activity and improved psychological and physical well-being.

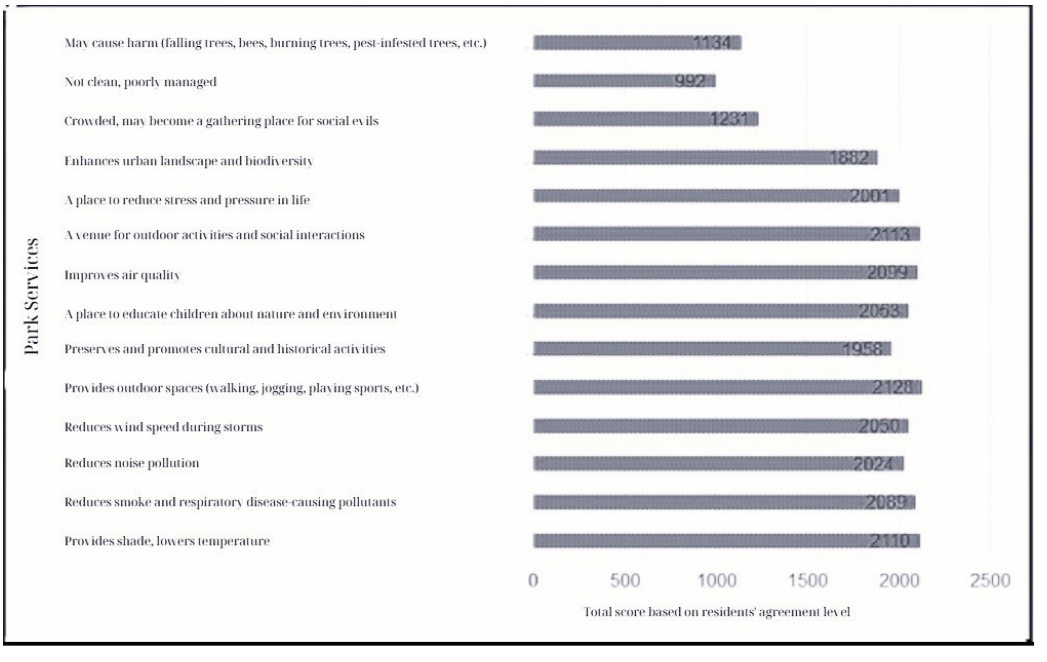
Nevertheless, despite these advantages, the park faces certain risks that require attention. Some residents have reported concerns regarding incidents such as falling trees, bee stings, and the potential for illicit activities in the absence of proper park management. Although these concerns were raised by a relatively small proportion of respondents (approximately 4%–5%), they remain critical issues that must be addressed to ensure that the park remains a safe and sustainable urban space.

The data from Figures 4A, 4B, and 5 provide a comprehensive overview of the current state and potential of the park in delivering ecosystem services. By enhancing public awareness, improving management practices, and promoting its cultural, educational, and social values, the park can continue to serve as a key asset within the urban green space network, provided that existing challenges are addressed through systematic and sustainable solutions.

Challenges and constraints in the development of ecosystem services at Tao Dan park

Tao Dan park is recognized as one of the most significant urban green spaces, playing a crucial role in delivering ecological, social, and cultural benefits. The findings from Figure 6A indicate that the public clearly acknowledges the park's role, considering it the top-priority green space compared to other alternatives, such as residential greenery or zoos. This highlights the park's dual function, not only as a "green lung" that regulates climate and enhances air quality, but also as a provider of essential ecosystem services, including urban cooling, carbon sequestration, and overall improvement of urban community well-being.

However, these ecosystem services are facing major challenges. According to Figure 6B, residents identified environmental pollution (286 responses) and shrinking living spaces (278 responses) due to urbanization as the primary barriers, alongside other factors such as climate change (256 responses). These challenges emphasize the need for more effective management and conservation measures to maintain and enhance the park's essential ecosystem services.



▲ *Figure 5. Public satisfaction with park services.*

The community has also demonstrated a strong sense of responsibility and proposed practical solutions to address these issues. As shown in Figure 6C, a majority of respondents suggested expanding green areas by utilizing rooftop spaces (237 responses) and identifying vacant areas for additional tree planting (311 responses). This underscores the pressing need for increasing green space, not only from a management perspective but also through strong community support. These solutions hold both ecological and social value, reflecting the active role of the public in contributing to sustainable urban development.

Notably, Figure 6D shows that 61% of respondents are willing to pay additional costs to own a home near the park, indicating that ecosystem services provided by the park hold not only environmental value but also economic significance, enhancing real estate value through clean air and health benefits. However, 32% of respondents stated that they would consider additional factors, such as surrounding amenities and transportation connectivity, before making a decision. This underscores that the full value of the park can be optimized when integrated into a comprehensive urban planning strategy.

These findings clearly demonstrate that Tao Dan park is not only crucial in providing ecosystem services but also serves as a core element of sustainable development solutions. However, to fully leverage this potential, more effective management policies and active community participation are required to ensure a balance between urban development and environmental conservation.

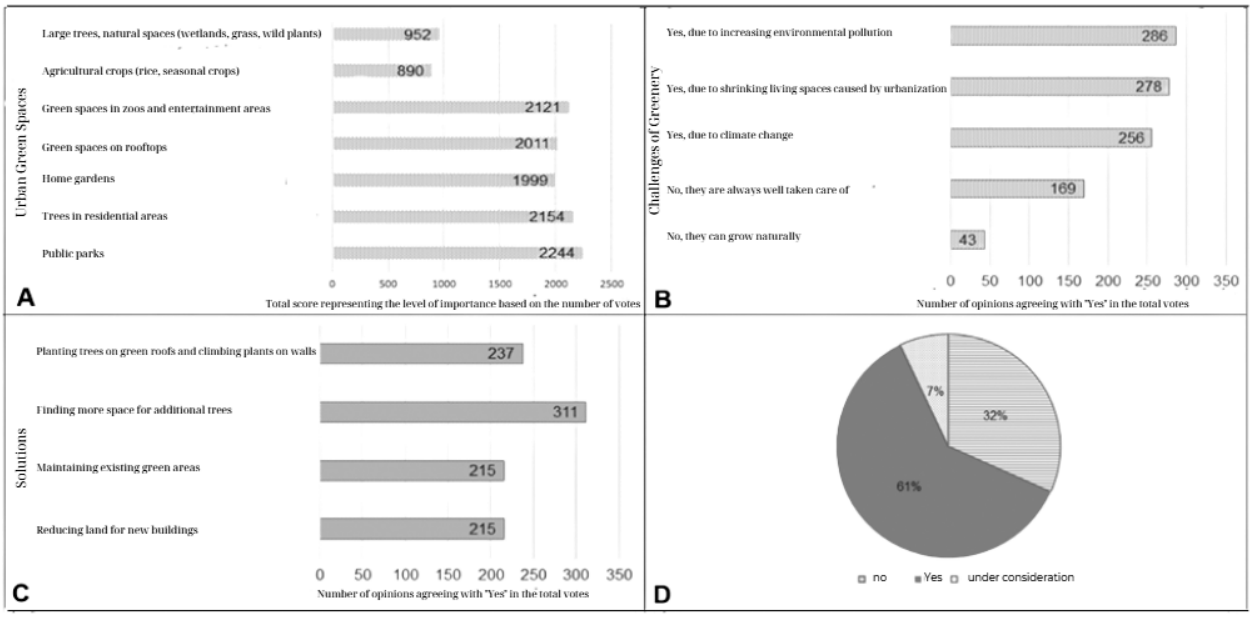
5. CONCLUSION

This study provides a comprehensive analysis of the potential for ecosystem service development at Tao Dan park, encompassing community awareness assessment, impact factor analysis, and the proposal of sustainable solutions. The findings indicate that Tao Dan park serves not only as a critical "green lung" that contributes to air quality improvement, urban temperature reduction, and microclimate regulation, but also as a cultural and social hub, addressing recreational, social, and communal needs. However, public awareness of ecosystem services remains limited, with 69% of surveyed respondents lacking a clear understanding of the concept. This highlights the need for public awareness campaigns and community education programs to enhance understanding of the role and value of ecosystem services.

The existing legal framework, including Decree No. 64/2010/ND-CP on urban green space management and Decision No. 199/2004/QD-UBND issued by the People's Committee of Ho Chi Minh City regarding urban park and tree management, provides a regulatory foundation for the protection and expansion of urban greenery. However, the study reveals that current regulations require modifications and further clarification to better align with practical implementation. Additionally, the Ho Chi Minh City Public Park and Green Space Development Plan (2021-2030) outlines objectives for increasing park areas and urban greenery, but challenges remain in execution, particularly in attracting investment and managing resources effectively.

Based on the findings, the study proposes several key recommendations:

Enhancing public education and communication on ecosystem services through media campaigns,



▲ *Figure 6. Public perspectives on: (A) Awareness of the importance of urban green spaces; (B) Public perception of the relationship between greenery and the environment; (C) Public proposals for urban spaces in response to global climate change; (D) Willingness to pay additional costs for housing near parks.*

workshops, and practical engagement activities, integrating these efforts into the city's green planning strategy.

Developing a transparent, fair, and reasonable fee mechanism, such as incorporating green space usage fees into other service charges (e.g., parking fees or event participation tickets) while ensuring that these revenues are allocated toward park maintenance and quality improvements.

Updating and refining management policies, including establishing clearer urban tree standards within Decree No. 64/2010/ND-CP and Decision No. 199/2004/QD-UBND, to promote effective urban green space planning and conservation.

Encouraging collaboration among government agencies, businesses, and communities to implement smart green park models, integrating urban greenery with public amenities to optimize ecological, economic, and social benefits.

Additionally, this study suggests future research directions focusing on the impact of climate change and environmental pollution on urban ecosystems, leading to the development of integrated models that combine green space planning with smart urban solutions. Such advancements will contribute to the sustainable development goals of Ho Chi Minh City, ensuring not only the protection of Tao Dan park but also the enhancement of urban livability for the entire community.

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Current situation, challenges and community perception for water security of Ben Tre provice

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Abstract

This study analyzes the current status of surface water resources in Ben Tre province in the context of climate change and upstream exploitation of the Mekong River. Findings indicate that Ben Tre faces major challenges, including deep and prolonged saltwater intrusion, increasing surface water pollution due to domestic, agricultural, and aquaculture wastewater; freshwater shortages during the dry season; strong impacts from climate change (sea level rise, reduced river flow); and pressure from urbanization and population growth. The research employs document review, field surveys, GIS applications, and SWOT analysis to assess risks and propose sustainable management strategies. Sociological surveys reveal that the community is aware of pollution and saltwater intrusion issues and is willing to engage in water protection measures, though limited by skills and resources. SWOT analysis highlights strengths such as water resource potential and policy support, but also points out weaknesses in management capacity and threats from climate change and upstream water exploitation. The paper proposes key solutions including integrated water resource management based on ecological zones, investment in climate-adaptive irrigation infrastructure, community awareness enhancement, and the development of multi-stakeholder water governance models to ensure long-term water security for Ben Tre province.

Keywords: *Surface water resources; saltwater intrusion; water security; Ben Tre province; community perception; climate adaptation.*

JEL Classification: *Q50, Q56, Q57.*

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1. INTRODUCTION

Surface water resources play a central role in ensuring water security, supporting socio-economic development, and maintaining the stability of ecosystems in coastal delta regions. Amid global challenges such as climate change, sea-level rise, and environmental degradation, provinces in the Mekong Delta - particularly Ben Tre province are facing mounting pressures on surface water resources [1].

Ben Tre is a coastal province located in the lower Mekong River system, with a dense network of rivers and canals directly influenced by tidal regimes and upstream water exploitation. In recent years, the quantity and quality of surface water in the province have been seriously threatened. One of the most significant challenges is the increasingly complex saltwater intrusion, which now occurs earlier, lasts longer, and reaches salinity levels well above the multi-year average. Severe saline droughts in 2015–2016 and 2019–2020 caused extensive damage to agriculture, aquaculture, domestic water supply, and public health [2][3]. Climate projections indicate that saltwater intrusion will intensify in both scale and severity in the coming decades, particularly during the dry season [2].

Simultaneously, surface water quality has declined significantly in many areas of the province, especially in rapidly urbanizing zones, industrial parks, aquaculture regions, and intensive agricultural areas. Surface water is increasingly impacted by untreated wastewater, agricultural chemical residues, and organic pollutants. Environmental monitoring results show that many river and canal sections fail to meet national surface water quality standards (QCVN 08-MT:2015/BTNMT), especially for domestic water use purposes [4].

In addition, population growth, urbanization, and the rapid development of economic sectors such as agriculture, industry, and tourism services have increased water demand, while surface water supply has become increasingly unstable and seasonal. During the dry season, many areas - particularly coastal districts like Ba Tri, Binh Dai, and Thanh Phu district regularly suffer from severe freshwater shortages, seriously affecting livelihoods and local living conditions [1][3].

These realities underscore the urgent need for a comprehensive assessment of the current status of surface water resources and the identification of critical challenges. This paper is highlights key issues requiring attention in order to formulate effective solutions and ensure water security for Ben Tre province in the future.

2. THEORETICAL FRAMEWORK AND METHODS

2.1. Sampling area

This study focuses on the surface water resource system of Ben Tre province, including natural and artificial rivers, canals, reservoirs, ponds, and irrigation structures used for domestic and production purposes. Ben Tre, a coastal province in the lower Mekong River basin, has low-lying terrain and a dense river network influenced by tides, saltwater intrusion, and climate change. The study categorizes the area into three main aquatic ecological zones:

a. *Freshwater zone:* Mainly located in the upper reaches of major rivers, supplying water for domestic use and production. The study evaluates water quality, discharge, and the risk of reduced storage during the dry season.

b. *Brackish water zone:* A transitional area between freshwater and saltwater, highly sensitive to tidal fluctuations and upstream flows. The study focuses on salinity-freshwater dynamics and the adaptability of aquatic ecosystems.

c. *Saltwater zone:* Concentrated in coastal districts, affected by saltwater intrusion. The study assesses the effectiveness of salinity control infrastructure and freshwater storage solutions.

The research also examines risk factors such as saltwater intrusion, pollution, dry season water shortages, and climate change impacts, while investigating community awareness regarding water resource protection.

2.2. Research methods

The study combines document review, field surveys, and data analysis to evaluate the current state of surface water resources in Ben Tre province. Specific methods include:

Collection and analysis of secondary data: Data was sourced from reports by the Department of Natural Resources and Environment, Department of Agriculture, Statistical Office, and academic studies to establish a basis for analyzing the status and challenges related to water resources.

Field surveys: Conducted in freshwater, brackish, and saltwater areas to observe water flow, levels, salinity, pollution, and irrigation infrastructure, as well as to interview local residents and officials. This information validates the data and reflects issues such as saltwater intrusion and freshwater scarcity.

GIS application: Geographic Information Systems (GIS) were used for spatial analysis and thematic mapping of aquatic zones, salinity fluctuations, and pollution risk areas to support effective water resource management.

SWOT analysis: Used to assess strengths, weaknesses, opportunities, and threats in water resource management, helping to identify barriers and potential improvements for enhancing water security.

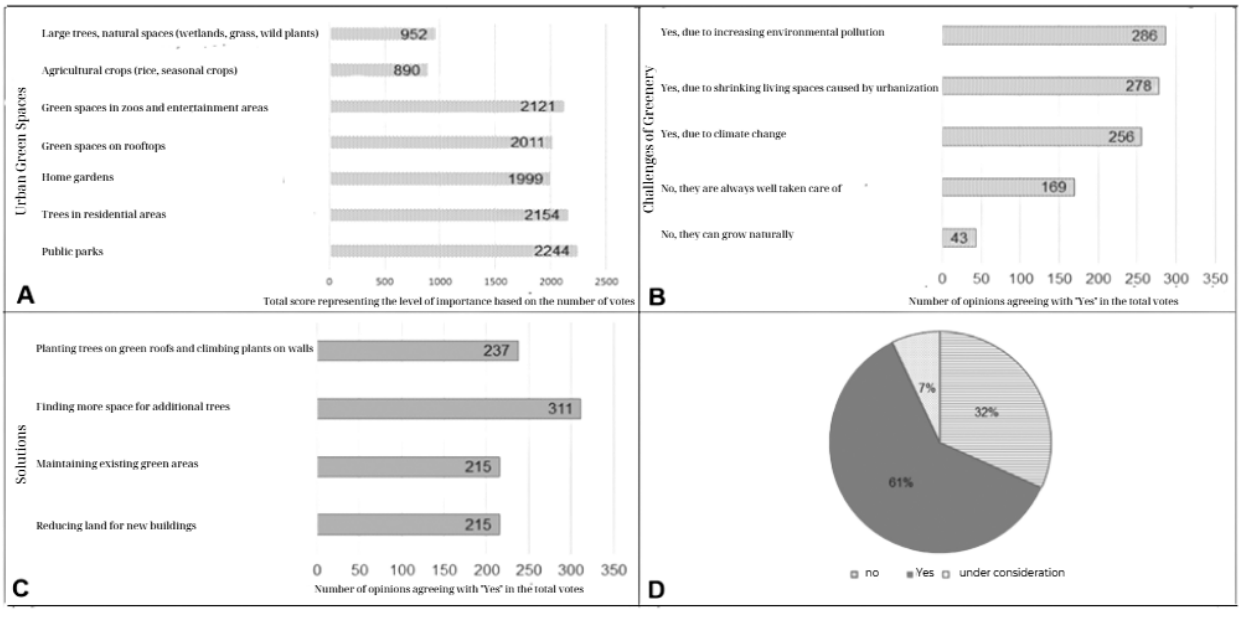
Sociological surveys: Conducted with 200 residents from saltwater intrusion-affected districts to assess community awareness of water resources, impacts of salinity, and current mitigation measures, thereby supporting decision-making and sustainable development.

3. RESULTS AND DISCUSSION

3.1. Surface water status

Ben Tre province possesses a diverse hydrological system with major rivers such as the Tien, Ham Luong, and Co Chien river. These rivers are crucial for agriculture, domestic use, and aquaculture but face challenges including saltwater intrusion and water pollution. Covering an area of approximately 2,400 km² with a population of over 1.2 million, the province's dense river network helps regulate the climate and supports ecotourism development.

Figure 1. Map showing Ben Tre's location within the Mekong Delta region



However, it is also highly vulnerable to saline intrusion from the East Sea, particularly during the dry season [5].

Surface water reserves in Ben Tre province mainly depend on the upstream flow of the Mekong River, with an average annual volume ranging from 12.5 to 15 billion m^3. The rainy season (June - November) accounts for about 80% of the water supply, while the dry season (December - May) often experiences water shortages and saline intrusion, affecting over 200,000 households, especially in coastal areas [6].

Surface water in Ben Tre is categorized into three zones: freshwater, brackish, and saline. Freshwater zones are primarily used for domestic and production purposes, but during the dry season, reduced flows can lead to saline intrusion. Brackish zones mainly serve aquaculture but face difficulties in salinity control [7]. Saline zones, especially in coastal districts such as Thanh Phu and Ba Tri district, support shrimp farming but are severely affected by saline intrusion, hindering domestic water supply and agriculture [8].

Saline intrusion is a major challenge, particularly during extreme events like the 2015–2016 drought. The province has invested in hydraulic works such as the Ba Lai sluice to prevent salinity and protect freshwater sources, but their effectiveness still needs improvement, especially in water monitoring and coordination [9][10].

Surface water quality in Ben Tre is seriously polluted, mainly due to domestic and aquacultural wastewater. Organic and microbial pollution reduces water quality, affecting livelihoods and production [6]. Water demand is increasing sharply and is projected to exceed 1.6 million m^3/day by 2030. However, current water exploitation lacks proper planning and data infrastructure, leading to overexploitation and reduced water replenishment capacity [10].

3.2. Challenges to water security in Ben Tre

a. Surface water quality

Ben Tre currently has 20 monitoring stations for salinity and water quality (WQ) along major rivers such as Ham Luong, Co Chien, Ba Lai, and Tien river, along with hydrological stations and 3 automatic wastewater monitoring stations. In 2021, three more wastewater monitoring stations were added in industrial zones, and the province conducted periodic monitoring at 53 points with a frequency of once per year.

For domestic water supply, surface water is the main source. There are 67 plants with a total capacity of 240,000 m^3/day-night, meeting 72% of the demand. Groundwater is used less, with four plants; the largest, Son Dong, provides 31,900 m^3/day from the Ham Luong river. The rate of households using hygienic water reaches 99.8%, with 78.4% using standard clean water. The rate of households with clean water access varies from 42.3% (Thanh Phu district) to 99.3% (Ben Tre city).

Table 1. Percentage of households supplied with clean water in Ben Tre

No.	Administrative unit	Rate (%)
1	Ben Tre city	99,3
2	Chau Thanh district	90,9
3	Cho Lach district	76,6
4	Binh Dai district	74,0
5	Ba Tri district	70,6
6	Mo Cay Bac district	66,8
7	Mo Cay Nam district	65,8
8	Giong Trom district	57,4
9	Thanh Phu district	42,3

However, surface water quality (SWQ) is being affected by industrialization and urbanization, with multiple sources of pollution. While indicators such as pH, $N\text{-}NO_3^-$, and $P\text{-}PO_4^{3-}$ meet the standards, others like Fe, BOD5, COD, and TSS exceed limits, and some areas show DO, NH_4^+-N, and Coliform levels above permissible thresholds [11]. Compared to the 2011–2015 period, pollution indicators have increased [12].

In agriculture, the province has an irrigation system with 68 main canals totaling 363.52 km and 1,537 sluices, serving irrigation for 181,821 ha of farmland. In 2021, total freshwater usage for agriculture was approximately 500.3 million m^3, with aquaculture consuming about 83.5 million m^3 annually [13][14].

b.Saltwater intrusion

According to the Southern Institute of Water Resources Research, Mekong upstream flows to the delta have declined from 2000 to 2020, with major floods becoming rare and potentially absent by 2050. Severe saline intrusion has occurred earlier in the dry season (December–January), penetrating 60–70 km inland, causing freshwater shortages in coastal regions [15]. Ben Tre is heavily affected due to reduced rainfall and upstream inflow. From 2015 to 2024, 4‰ salinity has intruded 50–143 km inland depending on the area, severely damaging fruit trees and aquaculture [16].

The historic 2015–2016 drought led to 160,000 ha of land being salinized, causing losses of over VND 5,500 billion. In 2020, drought and saline intrusion lasted over six months, damaging 43,000 ha of rice and affecting 80,000 households, with losses nearing VND 11,800 billion [16]. Currently, saltwater has intruded 70 km inland, affecting 4,000 ha of seedlings and fruit trees, threatening drinking water sources for around 25,000 households. The anti-salinity irrigation system remains incomplete, limiting control effectiveness and increasing the risk of erosion and freshwater shortages during the dry season [16].

c.Climate change

Climate change (CC) severely affects water resources (WR) in Ben Tre province, especially in coastal areas that suffer from extreme freshwater shortages during the dry season. Saltwater intrusion (SWI) in major rivers such as the Tien, Ba Lai, Ham Luong, and Co Chien river is increasing due to climate change and excessive upstream water exploitation, significantly impacting domestic water supply.

During the dry season, saline water from the East Sea intrudes deep inland, causing over two-thirds of the province to experience salinization. River and canal water sources become heavily polluted, significantly affecting residents' lives. Although groundwater is available, it often does not meet the Ministry of Health's standards for domestic use due to high salinity levels (0.35–0.8‰ compared to the 0.3‰ standard). The incomplete irrigation canal system further aggravates SWI into the interior fields [17].

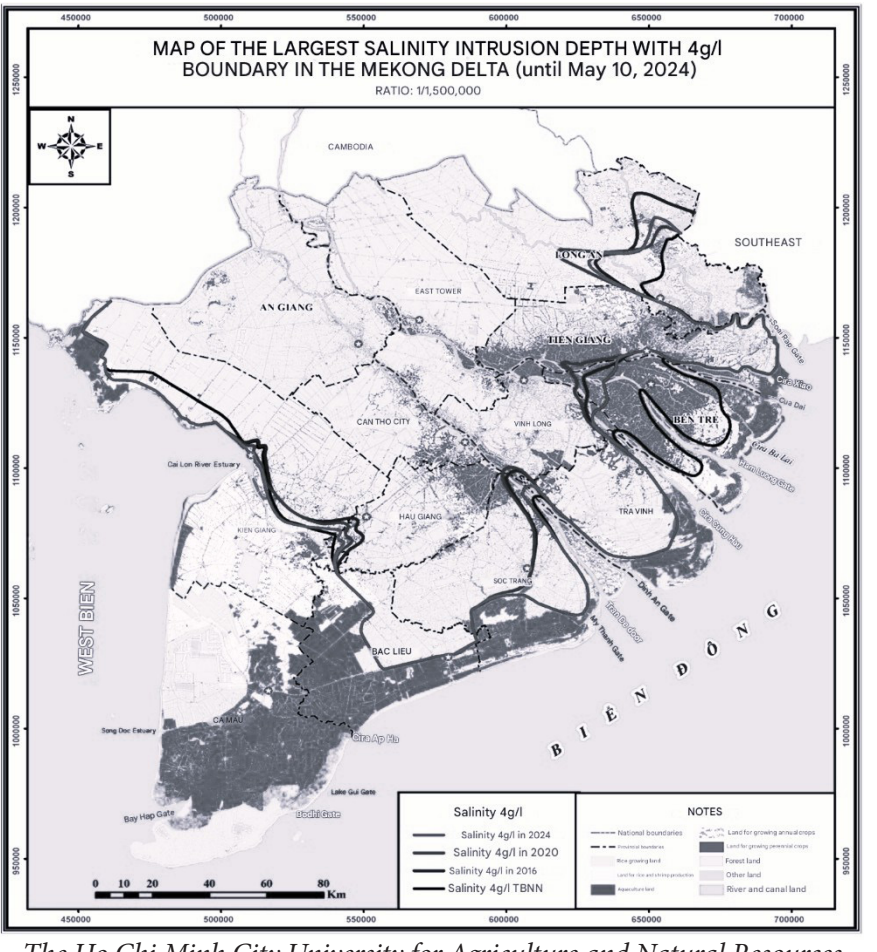
Salinity boundary calculations based on climate change scenarios indicate that SWI intensifies in brackish areas, especially during the dry months (February–May), with April being the most severe. The saltwater penetrates 23–35 km inland, primarily through the Ham Luong and Co Chien river mouths. The extent of SWI depends on tidal levels and upstream flow rates [17]. Specifically, maximum salinity during the dry season is measured at 29.1‰ at the Tien River estuary, 33.3‰ at Ham Luong River (An Thuan station), and 32.1‰ at Co Chien River (Ben Trai station) [18].

Under the RCP4.5 scenario, rainfall is projected to increase by 17.1% by 2030, with significant rises during the dry season (30.8%) and the rainy season (16.6%). Sea level is expected to rise by 12.1 cm in 2030 and 22.3 cm by 2050, increasing the risk of flooding. The districts expected to experience the most inundation by 2030 include Cho Lach (18%), Mo Cay Nam (12%), and Thanh Phu district (10%) [18].

Table 2. Saline intrusion patterns in recent years (4g/l salinity front distance in km)

River mouth	2013–2019	2015–2016	2019–2020	2023–2024
Vam Co Dong	74	111	91	100
Vam Co Tay	74	123	143	130
Cua Tieu	39	48	91	55
Cua Dai	40	50	91	55
Ham Luong	50	73	78	65
Co Chien	45	65	68	58
Hau River	45	60	62	54
Cai Lon	55	68	62	61

Figure 2. Land use and saline intrusion boundary map in the Mekong Delta Region [16]



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d.Impact of population growth

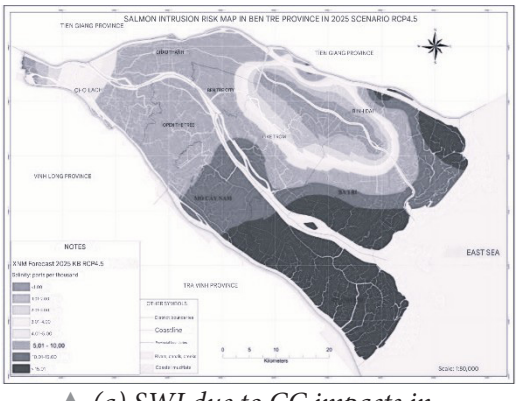
Population growth increases the demand for water for domestic use, sanitation, and agriculture. Agriculture requires large amounts of water to meet food needs, which can lead to resource depletion. Rapid urbanization also puts pressure on infrastructure and water supply systems; if not properly planned, this may cause shortages. High population density leads to competition among water users, exacerbating water scarcity. In many

areas, water infrastructure lags behind population growth and climate change, making problems like drought and irregular rainfall even more severe.

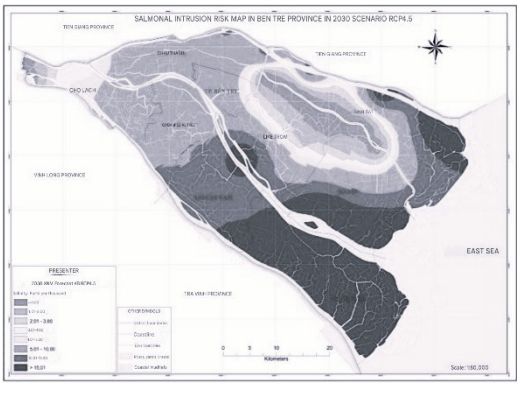
By 2030, 90% of Ben Tre city's population is expected to live in urban areas, requiring high-quality surface water to meet residential and service needs. Urbanization reduces vegetative cover, affecting groundwater recharge and ecosystems. The growing population also increases solid waste; if improperly collected, it can contaminate surface water. A key challenge lies in raising awareness about waste sorting, water conservation, and protecting water resources from domestic pollution.

Figure 3. Dry season and annual salinity boundaries under climate change scenarios [17]

Figure 4. Saltwater intrusion due to climate change impacts in 2025 and projected to 2030 under RCP4.5 [18]



▲ *(a) SWI due to CC impacts in 2025 under RCP4.5*



▲ *(b) SWI due to CC impacts by 2030 under RCP4.5*

e.Impact of pesticides

Residues of pesticides on agricultural products and in the environment (soil, water, air) can enter the food chain and cause both acute and chronic poisoning, such as birth defects and cancer. The main exposure route is ingestion (97.3%), with lesser contributions from skin contact (1.9%) and inhalation (1.8%) [19]. Common toxic pesticides include Volfatoc (77.3%), 66 (14.7%), and DDT (8%) [20].

Pesticides disperse into the environment, polluting soil and water, killing beneficial organisms, and persisting for long periods. Chemicals may flow into water sources due to runoff, erosion, or uncontrolled disposal. Water pollution occurs from field runoff, equipment washing, and stormwater carrying chemicals from storage sites [19]. Pesticide management in remote areas remains inadequate, with users failing to comply with regulations on dosage and pre-harvest intervals, increasing environmental risks and reducing agricultural product quality. The collection and treatment of pesticide containers is also ineffective, causing serious pollution in provinces like Ben Tre [20].

f. Assessment of overall challenges

Despite having a legal framework in place at both the national and provincial levels for water resource management in general, and surface water management in particular, Ben Tre still faces many challenges. These are analyzed using the SWOT (Strengths – Weaknesses – Opportunities – Threats) model, as presented in Table 3.

Table 3. Harmful effects of pesticides on human health

HEALTH EFFECTS OF PESTICIDES ON HUMANS AND ANIMALS								
Toxicity			**Genetic Effects**			**Allergic Reactions**		**Premature Birth**
Chronic	Subacute	Acute	Embryotoxicity	Biotoxicity	Mutagenicity	Benign Tumor	Malignant Tumor	

Table 4. Assessment of surface water management challenges in Ben Tre province using the SWOT model

1. S - Strength	2. W - Weakness
Abundant water resources from both surface and groundwater sources, especially large groundwater reserves in coastal sand dunes. A relatively comprehensive legal framework for surface water management at both central and local levels, with clear guidelines and directives.	Limited resources for water resource management and environmental protection, especially human resources, due to recent restructuring of management agencies. Weak inter-sectoral coordination among management agencies and lack of synchrony. Limited budget for surface water protection, insufficient for meeting socio-economic development needs.
3. O - Opportunity	**4. T - Threat**
The Government's sustainable development policy for the Mekong Delta has been established, fostering more effective water management. Ben Tre receives support from many international cooperation projects such as those by the World Bank, JICA, GIZ, and others, enhancing resources and infrastructure development.	Surface water is frequently threatened by pollution and increasing saltwater intrusion. Climate change and sea level rise pose serious risks to water quality and quantity. The decline in flow from the Tien and Hau rivers driven by climate change - further complicates water resource management.

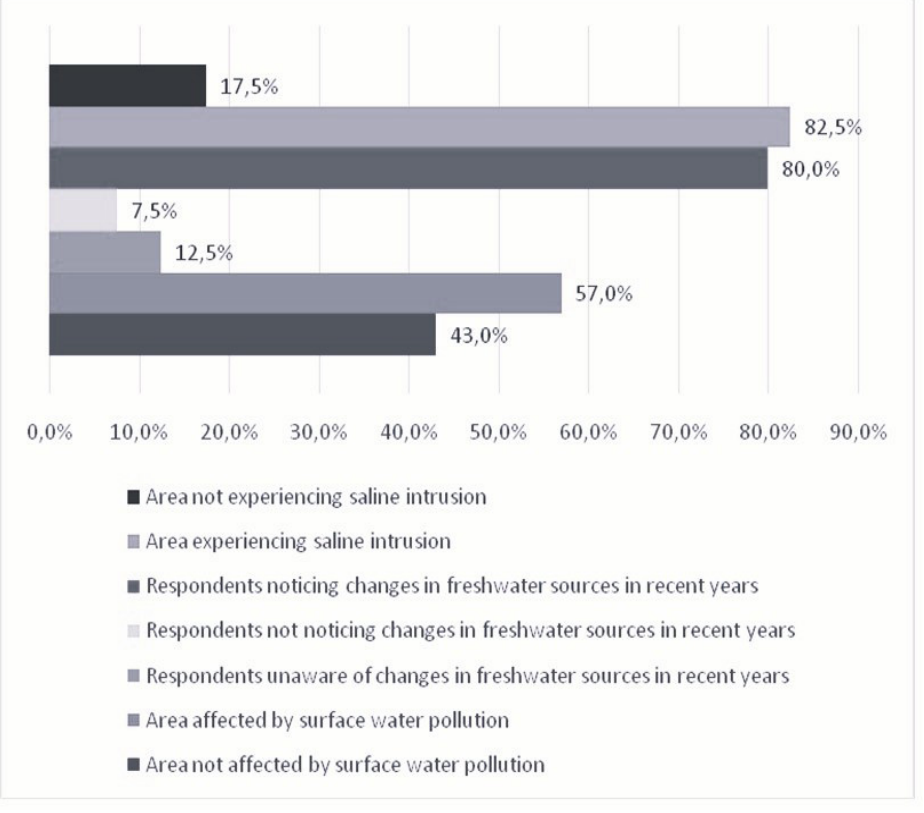
The key challenges in surface water management in Ben Tre stem from both internal factors (e.g., human and financial resources) and external ones (e.g., climate change, saltwater intrusion, and upstream activities in the Mekong River basin). Addressing these issues requires improving coordination, enhancing resources, and implementing climate adaptation measures.

3.3. Community awareness and willingness to participate

a. Community awareness

A survey of 200 questionnaires on public awareness in Ben Tre province revealed that 57% of respondents believed that surface water sources in their area were polluted. Residents reported that the water was often turbid, had an unpleasant odor, and caused itching when used for bathing. The causes were identified as indiscriminate littering, untreated wastewater discharge from livestock farms, and the dumping of animal carcasses into rivers. However, thanks to training sessions and awareness campaigns, public consciousness regarding environmental protection has somewhat improved.

Figure 6. Public awareness of pollution and saltwater intrusion in Ben Tre



In addition to pollution, residents also reported difficulties in accessing and using water resources due to saltwater intrusion and freshwater shortages during the dry season. This situation has seriously affected daily life and production, particularly in urban and densely populated areas. Nevertheless, local authorities have made efforts to raise community awareness through various communication channels, including mass media and social networks, helping residents stay informed and develop better environmental protection habits.

b. Community readiness

According to the survey, residents noted that local authorities had launched strong campaigns to address serious environmental issues. Communication activities, guidance on protecting water resources, prohibiting untreated wastewater discharge, and enforcement of penalties have been intensified. In addition, campaigns such as building embankments to prevent saltwater intrusion, cleaning up waste, unclogging waterways, and constructing drainage systems have also been implemented. These measures to protect surface water in Ben Tre are illustrated below.

Regarding the adaptability of local people, the campaigns have helped raise awareness and foster responsible behavior toward protecting surface water. Residents are applying context-specific environmental practices depending on their living conditions, such as refraining from littering, not discharging untreated wastewater, conserving water, and sorting household waste. A portion of the population also participates in environmental protection activities with the support of local authorities. These practices are reflected in the following statistical illustrations.

Figure 7. Community perception of water pollution, treatment methods and local authority guidance

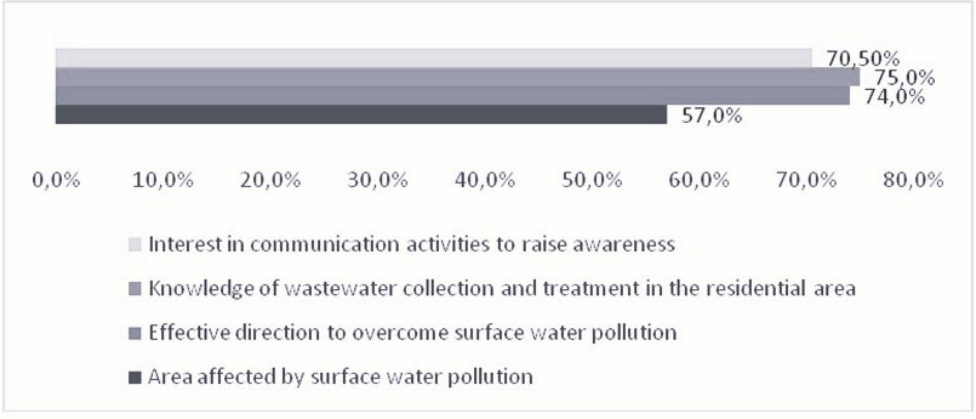


Figure 8. Preferred communication channels for receiving information

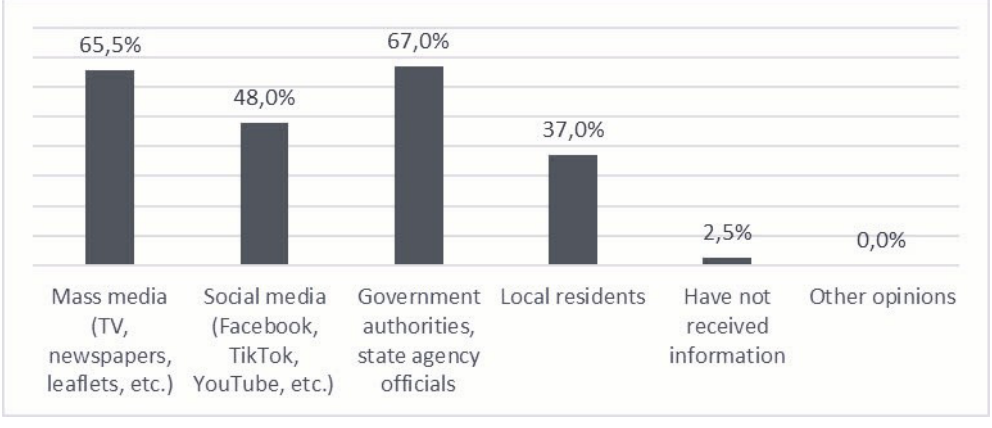
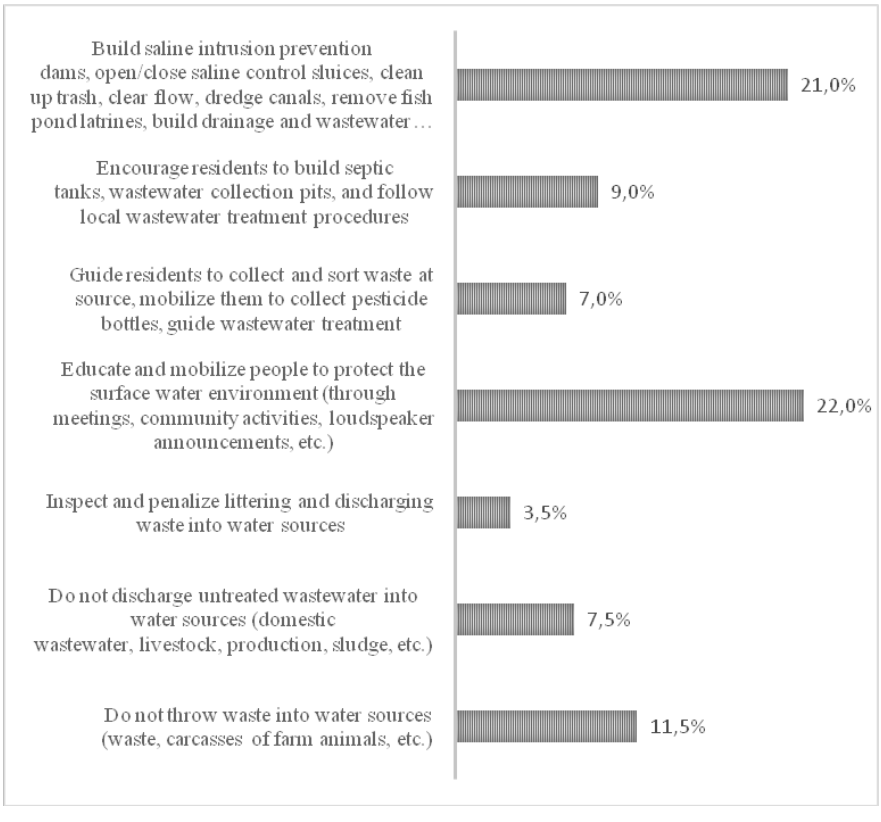


Figure 9. Measures to protect surface water resources in Ben Tre



Residents are highly willing to participate in efforts to protect water sources in their local areas, especially in Ben Tre, where a dense network of rivers exists. As people rely on water sources for daily living and production, they are proactive in safeguarding these resources. The primary purpose of water use is to meet essential needs, as shown in the figure below.

Figure 10. Community-level surface water protection practices

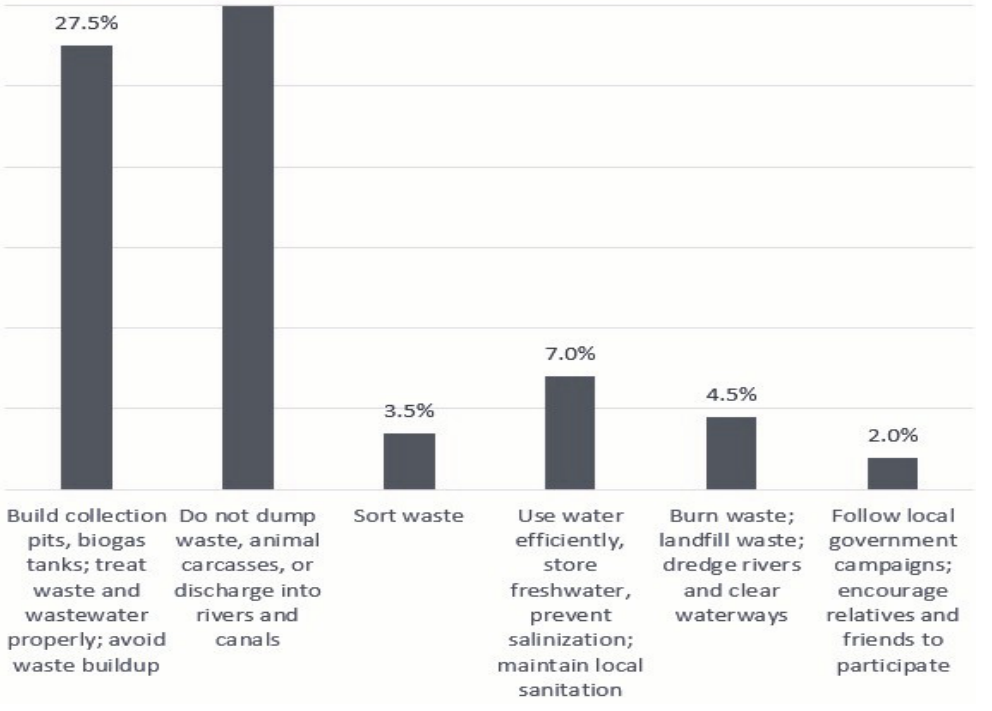
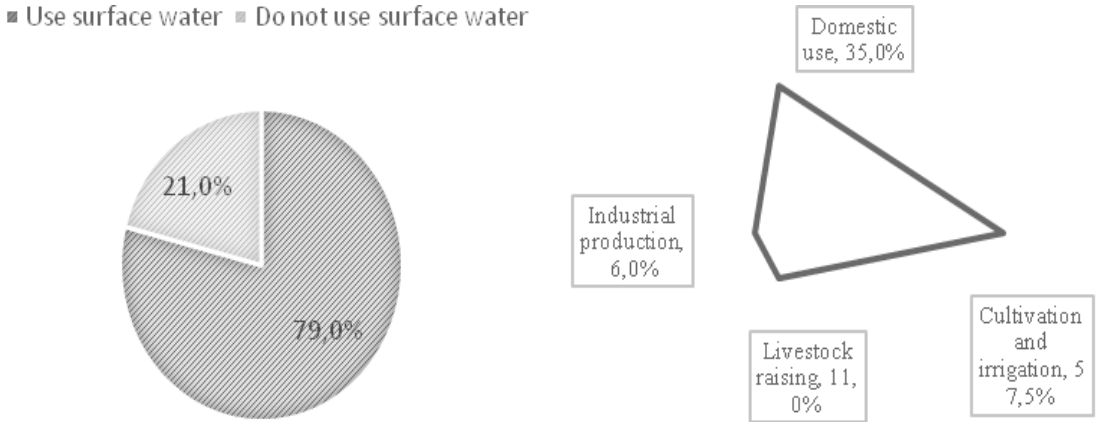


Figure 11. Purpose of surface water use by residents in Ben Tre province



5. CONCLUSION

This study provides a comprehensive overview of the current status of surface water resources in Ben Tre province, highlighting critical challenges to water security. These include prolonged and deep saltwater intrusion, increasing surface water pollution, freshwater shortages during the dry season, impacts of climate change, population growth pressure, and contamination from agricultural pesticides. In addition, sociological surveys reveal that local communities are increasingly aware of water-related issues and are willing to participate in protection efforts when properly supported. The SWOT analysis indicates that while Ben Tre has hydrological potential and policy backing, limitations persist in terms of resource capacity and water governance.

Due to constraints in time and resources, the study mainly focuses on identifying current conditions and key risks without quantitatively assessing the extent to which each factor impacts water security. Some data relies on secondary sources and qualitative community surveys, which may lack temporal updates or fail to capture the full diversity of community awareness and practices across different regions.

This research opens several pathways for further exploration, including quantitative assessment of climate change impacts on water balance, modeling water allocation across sectors, examining the effects of microplastics and emerging pollutants, and piloting community-based water governance models - especially under increasing urbanization and the rise of high-tech agriculture.

Based on the findings, the study recommends integrated water resource management by ecological zones and the inclusion of climate change considerations in long-term planning. Investments in adaptive hydraulic infrastructure and the enhancement of monitoring and early warning systems for saltwater intrusion are essential. Simultaneously, communication and capacity-building for local communities should be strengthened to foster grassroots engagement in water conservation. Policy makers should establish effective cross-sectoral coordination mechanisms and promote multi-stakeholder water governance models with the support of information technology for monitoring and decision-making. Lastly, it is critical to formulate and enforce policies that encourage water saving, wastewater treatment, and pollution control in agricultural production to ensure long-term water security amid increasingly complex climate dynamics.

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The fourth Partnership for Green Growth and the Global Goals 2030 (P4G) Summit: Sustainable green transformation, people-centered

The 2025 P4G Vietnam Summit will bring together global leaders, experts and influential stakeholders from businesses and civil society to share insights, showcase innovations and develop actionable strategies that support innovation and entrepreneurship, accelerate global climate finance and deliver country level climate transitions. The P4G Vietnam Summit is tentatively scheduled for April 14th – 17th in Hanoi, Vietnam.

▲ *Vietnam General Secretary To Lam delivered a keynote speech at the P4G Summit, Ha Noi, April 16th, 2025*

THE P4G VIETNAM SUMMIT - THE CATALYST FOR ENVIRONMENTAL AND ECONOMIC PROGRESS

Positioned strategically between COP29 – 'The Finance COP' and COP30 in Belem, the P4G Vietnam Summit will provide global leaders with the latest insights from the entrepreneurs and investors who are driving global financial commitments into real investments in nationally aligned and locally based climate ventures. With a focus on practical solutions and transformative partnerships, P4G's fourth biennial summit will serve as a catalyst for environmental and economic progress.

Gathering the world's leaders in innovative finance and featuring P4G climate startup companies and global climate businesses, the Vietnam Summit will create opportunities to rapidly advance and scale financeable models for on-the-ground climate solutions.

P4G Forum comprises 12 member countries: Denmark, Chile, Mexico, Vietnam, South Korea, Ethiopia, Kenya, Colombia, the Netherlands, Bangladesh, Indonesia, and South Africa. It also engages over 90 nations, international organizations, and businesses.

P4G is recognized as a leading global forum promoting public-private partnerships. It connects governments, businesses, and socio-political organizations to develop groundbreaking solutions for green growth and contribute to the realization of the 2030 Sustainable Development Goals (SDGs). P4G primarily supports partner countries through public-private partnerships, offering financial and technical assistance to small and micro enterprises in implementing climate change mitigation initiatives.

The most significant activity of P4G is its biennial summit. So far, three summits have taken place: in Denmark (2018), virtually in South Korea (2021), and in Colombia (2023). Vietnam, a founding member and official partner of P4G, will host the 4th P4G Summit from April 16–17, 2025.

The Government of Vietnam views this event as an opportunity to strengthen relations with partners, attract resources for socio-economic development, address climate change, and promote sustainable development. In addition to the multilateral conference, Vietnam plans to organize numerous bilateral activities with high-level delegations and meetings among senior leaders.

Vietnam will mobilize the participation of domestic and international business communities within the P4G framework, especially key enterprises driving green transformation, climate change adaptation, and sustainable development.

FOURTH P4G SUMMIT FOCUS ON GREEN GROWTH, GREEN TRANSITION

The fourth Partnership for Green Growth and the Global Goals 2030 (P4G) Summit focuses on green growth, green transition and sustainable development. Event targets to concretize the policies and viewpoints of the Vietnamese

▲ *Vietnamese Prime Minister Pham Minh Chinh handed over a symbolic statue to his Ethiopian counterpart Abiy Ahmed Ali, passing the responsibility of hosting the next forum, at the closing ceremony of the fourth edition of P4G in Ha Noi*

Party and State regarding foreign relations, deepen relationships with partners, and enhance Vietnam's position and role in multilateral mechanisms. It also seeks to leverage international resources for development, particularly in addressing climate change, advancing the green transition, digital transformation, science and technology, and innovation.

As Vietnam enters a new era of the nation's rise, this is also an opportunity to affirm the Vietnamese Party and State's commitment to a sustainable development path. Vietnam will not sacrifice social progress, equity, or the environment in pursuit of mere economic growth. Green growth must contribute to economic restructuring and the transformation of the growth model, aiming for economic prosperity, environmental sustainability, and social equity.

Through this summit, Vietnam wishes to convey to the international community a message of determination to transform its growth model, promote rapid and sustainable development, and highlight its economic achievements and potential, rich cultural heritage, and the hospitality, friendliness, and resilience of its people.

The delegates include P4G member countries and partners, investment funds, research institutes, scholars, businesses, and diplomatic missions have registered to participate in the event, both in-person and online. The summit is expected to adopt the Ha Noi Declaration, strongly affirming commitments to green and sustainable growth with people at the center, and a shared determination to collaborate responsibly in tackling global challenges.

VIETNAM PROMOTES INSTITUTIONAL REFORM AND SCIENCE AND TECHNOLOGY, INNOVATION, AND DIGITAL TRANSFORMATION

"The Party leader highlighted Vietnam's goals of becoming a developing country status with modern industry and upper-middle income by 2030, and a developed socialist nation with high income by 2045. Building on the achievements gained over the past four decades of Doi Moi (renewal), Vietnam's development path ahead will adhere to the principles of sustainability, inclusiveness, and harmony," The General Secretary To Lam said.

He said that rapid growth must align with sustainability, balancing economic progress with cultural preservation, social equity, environmental protection, and climate adaptation. National development must contribute to global peace, stability, and prosperity, with people at the core of all policies as both drivers and beneficiaries.

The General Secretary said Vietnam is ramping up efforts to promote institutional reform and science and technology, innovation, and digital transformation.

Regarding green growth, Vietnam stands out as an ASEAN leader in renewable energy, accounting for two-thirds of the bloc's wind and solar power capacity. The country has also emerged as a model for sustainable green agriculture, notably one-million-hectare quality, low-emission rice cultivation project drawing attention and interest from international partners and organizations.

Vietnam is an active and responsible member of all major multilateral mechanisms and global initiatives on green growth and energy transition. The country has essentially established the necessary frameworks and mechanisms to support green growth, including national and energy master plans, sectoral development strategies, lists of key projects, and other documents to remove related obstacles. As a developing nation with a transitioning economy, Vietnam faces significant challenges in financial resources, technology, human capital, climate resilience, and navigating global geopolitical changes. Vietnam's development cannot be separated from global trends and human progress. The nation will continue with openness as well as proactive, comprehensive, and effective international integration.

Hosting the 4th P4G Summit reinforces the country's role as a good friend, reliable partner, and responsible member of the international community and the P4G initiative. It also reaffirms Vietnam's commitment to sustainable development, energy transition, and its 2050 net-zero carbon emissions target. The summit serves to raise awareness of international cooperation and amplify the voice of developing countries in promoting green growth and sustainability.

The leader expressed confidence that the summit will generate fresh momentum to boost cooperation between P4G and its partners, foster collaboration between the Global North and Global South and between the public and private sectors in advancing green transition and green finance.

VIETNAM COMMITMENT TO ACHIEVE NET-ZERO EMISSIONS BY 2050

The P4G Summit has demonstrated the far-reaching impact of a world leading forum for promoting public-private partnerships, connecting governments, businesses and social organizations to jointly come up with breakthrough solutions for green growth, contributing to the implementation of the United Nations Sustainable Development Goals to 2030.

The world is facing unprecedented challenges such as natural disasters, climate change, pandemics, environmental pollution, resource depletion, and an aging population, green transition and sustainable development are inevitable trends, top priorities, and strategic choices for nations and people globally.

The 4th P4G Summit reflects a shared desire for a bright, green, clean, and beautiful world emphasizing that the human factor is the centre, the subject, the goal, the driving force, and the resources for the greening process and sustainable development in the world.

According to the Prime Minister (PM) Pham Minh Chinh, facing difficulties and challenges also presents opportunities for countries to develop together, overcoming headwinds for the enduring development of nations, and for the happiness of all people worldwide.

The green transition in the world has not been easy with both successes and failures, but it has left important lessons, which are valuable guides as the world is entering a new phase of development that is greener, more inclusive, and more sustainable, adding these include ensuring an inclusive, comprehensive, global approach that leaves no one behind, especially vulnerable and disadvantaged groups during the green transition process.

"A green economy requires green businesses. A green society requires green citizens. A green world requires green nations. The participation, contribution, and enjoyment of the benefits from the green transition are both responsibility and interest of all nations and peoples, in the spirit of 'working together, winning together, benefiting together, and developing together. Science and technology, innovation, and digital transformation also play a key role, while markets lead the way and social awareness serves as a foundation in promoting green transition, upholding the principles of equality, fairness, and responsibility in this process." the Government leader emphasized.

For Vietnam, PM Pham Minh Chinh said that together with digital transformation, Vietnam identifies green transition as an objective necessity, a key factor, and a breakthrough driving force to promote rapid growth and sustainable development. This aligns with the strategic goal of becoming a developing country with modern industry and upper-middle income by 2030, and a developed, high-income country by 2045, while also contributing to the gradual realization of Vietnam's commitment at COP26 to achieve net-zero emissions by 2050. Vietnam also continues its steadfast commitment to achieving carbon neutrality by 2050, contributing to a comprehensive and inclusive green transition for the current and future generations.

The host of the fourth P4G Summit, Vietnam has three suggestions for discussions which pave the way for further cooperation in the coming time.

First, Vietnam recommends to perfect green mindset, focusing on the development of science and technology, innovation, and digital transformation linked to green growth. This includes recognizing that green resources stem from green thinking, green growth is driven by green transition, and green resources arises from the green awareness of people and businesses across nations and regions.

Second, it is necessary to build a responsible green community, in which, the government plays a guiding role, encouraging and ensuring a stable and favorable institutional environment for green growth; the private sector serves as a core in technology investment and the dissemination of green standards; the scientific community leads in developing green technologies and training green human resources; and citizens continuously enhance their green awareness, truly becoming beneficiaries of the outcomes of green transformation.

Third, international cooperation and robust multilateral green cooperation models need to be promoted, particularly public-private partnerships (PPP), South-South cooperation, North-South cooperation, and multilateral cooperation frameworks. This aims to eliminate institutional barriers, enhance access, and accelerate the flow of green capital, green technology, and green governance.

The success of the fourth Partnership for Green Growth and the Global Goals 2030 (P4G) Summit demonstrated the value of multilateral cooperation in advancing green transformation and sustainable development, said Prime Minister Pham Minh Chinh.

Developed countries should take the lead in fulfilling commitments to provide financial, technological, and institutional reform support, while developing countries need to leverage their internal strengths and effectively utilize external resources ▪

NHÂM HIỀN

Resolution No. 57-NQ/TW - A breakthrough in the development of science, technology, innovation and national digital transformation

In the context of increasingly deep globalization, the Fourth Industrial Revolution taking place strongly, and increasingly fierce international competition, on 22nd December 2024 General Secretary To Lam signed and issued Resolution No. 57-NQ/TW of the Politburo on breakthroughs in the development of science, technology, innovation and national digital transformation. This is a document of strategic significance, marking an important turning point for the country in the fields of science, technology, innovation and digital transformation. The Resolution also has special significance, being a guiding principle for the development of wealth, civilization and prosperity; a call to action for the entire Party, people and army to make joint efforts to turn Vietnam into a developed, high-income country with global competitiveness, entering a new era, an era of nation's rise. The Journal of Environment introduces some contents on the Party's strategic tasks, solutions and vision in the Resolution.

BREAKTHROUGHS OF RESOLUTION NO.57-NQ/TW

The first breakthrough of Resolution No.57-NQ/TW is that the Party has set specific high-level goals by 2030, with a vision to 2045 to turn Vietnam into a developed, high-income country, emphasizing that science, technology and innovation are key drivers to promote economic growth, increase labour productivity and improve national competitiveness. The Resolution proposes many breakthrough mechanisms and policies, prioritizing and encouraging the development of science, technology and innovation such as: Financial investment, development of high-quality human resources, administrative reform, encouragement of public-private partnership... towards removing barriers in the system, thereby facilitating enterprises and individuals to develop more strongly. Accordingly, by 2030, the potential and level of science, technology and innovation will reach advanced levels in many important fields, among the leading groups in upper-middle-income countries; the level, capacity of technology and innovation of enterprises will be above the world average; a number of science & technology fields will reach international levels. Vietnam is in the top 3 countries in Southeast Asia, the top 50 countries in the world in terms of digital competitiveness and e-Government development index; the top 3 countries in Southeast Asia in research and development of artificial intelligence, the center for developing a number of digital technology industries and fields in which Vietnam has advantages; at least 5 digital technology enterprises are on par with advanced countries. Vision to 2045, science, technology, innovation and digital transformation will develop steadily, contributing to making Vietnam a developed, high-income country; the digital economy will reach at least 50% of GDP; be one of the digital technology industrial centers of the region and the world; be among the top 30 countries in the world in innovation and digital transformation. The rate of digital technology enterprises will be equivalent to developed countries; at least 10 digital technology enterprises will be on par with advanced countries; attract at least 5 more leading technology organizations and enterprises in the world to set up headquarters, invest in research and production in Vietnam.

The Resolution identifies the need to increase investment in science, technology, innovation and digital transformation. Specifically, by 2030, the budget for research and development will reach 2% of GDP, of which the budget from social investment accounts for more than 60%; allocate at least 3% of the total annual budget for the development of science, technology, innovation and digital transformation at the national level and gradually increase according to development requirements. The increase in investment according to Resolution No.57-NQ/TW will approach the investment level of developed countries, thereby creating motivation for the Vietnamese scientific community; enhancing the national science, technology potential. However, to achieve the proposed investment level, it is necessary to have mechanisms, measures to support enterprises, even removing the ceiling of 10% of taxable income and regulating the fund management mechanism of enterprises more openly, because Vietnamese enterprises are mostly small and micro enterprises, needing large financial resources for digital transformation and technological innovation.

In addition, Resolution No.57-NQ/TW has made a breakthrough in thinking in managing state budget investment for research and development activities. Accordingly, the budget for research and development of science & technology is prioritized to be implemented according to the fund mechanism, through science & technology development funds. The fund mechanism is an international practice, meaning that the state budget funding for science & technology tasks (science & technology subjects, schemes, projects, programs, etc.) will be allocated directly to science & technology development funds according to the charter capital level and the ability to arrange

annual budget sources. Budget from funds will be provided promptly according to the progress of task approval, transferred automatically and settled once at the end of the research contract. This approach meets the timeliness of research activities, creates favourable conditions for scientists and is consistent with international practice.

Resolution No.57-NQ/TW also identifies "accepting risks, risky investments and delays in scientific research, technological development and innovation". Previously, management agencies and public opinion believed that all research tasks funded by the State must be 100% successful, and failure would be considered a waste, causing loss of state budget. But in reality, doing research means finding something new, there is always the potential for failure. Even in developed countries, the rate of successful subjects applied in practice is only about 20 - 30%. That is also the reason why developed countries have a system of venture capital funds and a culture of accepting failures in research, thanks to which they have unicorn startups, technology corporations with many high-tech products. Obviously, this innovative regulation of the Resolution will encourage scientists to dare to think, dare to do, dare to take on tasks when accessing state budget investment sources for science, technology and innovation.

The final breakthrough of the Resolution is the feasibility of the organization for implementation. For the first time, the Head of the Party directly serves as the Head of the Steering Committee for the implementation of the Resolution, and in addition there is also an Advisory Council consisting of qualified and prestigious managers and scientists. This approach is considered a solution to overcome shortcomings of previous stages, when the Steering Committees often only included representatives of state management agencies, did not have enough power in the political system and were heavily term-based.

7 GROUPS OF KEY TASKS AND SOLUTIONS

In order to achieve the goals set out in Resolution No.57-NQ/TW, the Government requires that in the coming time, in addition to regular tasks, ministries, ministerial-level agencies, government agencies, People's Committees of provinces and centrally run cities need to specify and organize the implementation of the following 7 tasks and solutions:

First, raise awareness, make breakthroughs in innovative thinking and strong political determination, resolutely lead and direct, and create new momentum and new spirit in the whole society for the development of science, technology, innovation and national digital transformation

The Government requires ministries, sectors and local authorities to develop and promulgate regulations on the responsibilities of heads of state agencies directly responsible for and directing the implementation of tasks of development of science, technology, innovation and digital transformation of agencies, organizations; regulations on the responsibilities of cadres, civil servants, public employees in implementing annual action plans on the development of science, technology, innovation and digital transformation; and development of digital platforms, digital tools to conduct online measurement of the level of completion of digital transformation tasks.Build and upgrade an online training platform to provide free knowledge of science, technology, innovation, basic digital skills and technology to people, enterprises; launch a nationwide emulation movement to promote the combined strength of the entire political system, the active participation of entrepreneurs, enterprises and people to successfully carry out the digital transformation revolution; commend, honour, reward and promptly encourage scientists, inventors, enterprises, organizations, individuals with achievements in digital transformation; respect each technical invention, initiative, improvement to enhance work efficiency and performance...

Second, urgently and resolutely improve the institutions; eliminate all thoughts, concepts, barriers that are hindering development; turn institutions into a competitive advantage in the development of science, technology, innovation and digital transformation

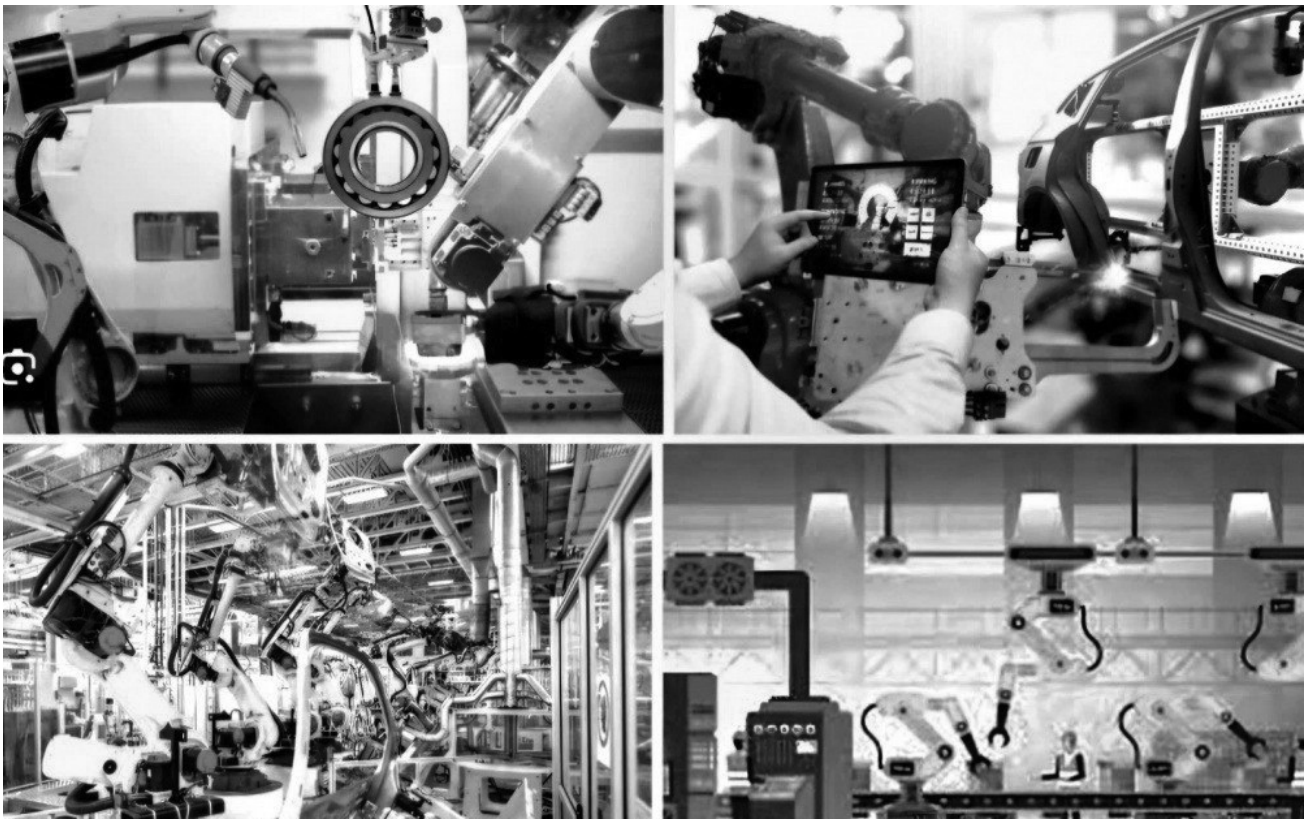
The Government requires ministries, sectors and local authorities to review, remove all institutional and policy bottlenecks, barriers in the development of science, technology, innovation, digital transformation and high-quality human resources; improve legal regulations to ensure a legal corridor for the operations of all sectors, fields in the digital environment; develop, promulgate specific mechanisms on investment, public investment, public procurement of products that are the results of scientific research and technological development, digital products and services to accelerate national digital transformation. In addition, amend legal regulations to remove bottlenecks in science, technology and innovation activities in the direction of accepting risks, risky investments and delays in scientific research, technological development and innovation. Amend the Law on Science and Technology 2013 and related laws in the project to develop the Law on Science, Technology and Innovation to: (i) Remove difficulties and obstacles, create a favourable legal corridor to promote science, technology and innovation; (ii) Simplify administrative procedures, promote decentralization and delegation of power in state management; (iii) Focus on investment resources from the state budget, attract non-budgetary investment for science, technology and innovation. Supplement policies to remove bottlenecks and improve the Law on Digital Technology Industry; develop incentive mechanisms and policies, simplify administrative procedures on investment in the fields of science, technology, innovation and digital transformation to attract, use all investment resources effectively...

Third, increase investment and improve infrastructure for science, technology, innovation and national digital transformation

Develop a network connecting innovation, creative startupcenters, focusing on strategic technology and digital transformation; implement programs, projects to promote the key technology and innovation fields of the Vietnam National Innovation Center. Strive to have at least 5 projects, programs in the fields of semiconductors, artificial intelligence, digital technology, smart factories, smart cities, etc. implemented by 2030. Develop incentive tax policies for investment, purchase and lease of digital products and services; develop mechanisms, policies to support, encourage organizations, individuals and enterprises to invest in and build laboratories, centers for the research and development of science and technology. Develop the Internet of Things (IoT) industry and a number of specialized industrial parks developing IoT; digitalize industrial parks, industrial clusters in the direction of enhancing IoT applications to become smart industrial parks, industrial clusters; promote, develop a number of sectors and fields applying IoT industry such as manufacturing, trade, energy, agriculture, transportation, healthcare, etc. Complete the legal corridor to promote AI application in solutions for developing digital technology applications in sectors, fields and local authorities, associated with state management in each field, ensuring shortcuts and anticipation.

Fourth, develop, make use of high-quality human resources, talents to meet the requirements for development of science, technology, innovation and national digital transformation

Increase investment in, innovation and improvement of the quality of education and training, ensure high-quality human resources, meet the requirements for development of science, technology, innovation and national digital transformation. Have attractive mechanisms and policies on credits, scholarships and tuition fees to attract excellent students to study in the fields of mathematics, physics, biology, chemistry, key engineering and technology, especially at the postgraduate level. Issue special mechanisms to attract highly qualified overseas Vietnamese and foreigners to work and live in Vietnam. Have special mechanisms for naturalization, house and land ownership, income, and working environment to attract, employ, and retain leading scientists, experts, and "chief engineers" at home and abroad who are capable of organizing, operating, commanding and implementing key national tasks on science, technology, innovation, digital transformation, developing artificial intelligence technology, and training human resources. Build, connect, develop a network of domestic



▲ *Resolution No. 57-NQ/TW is a clear demonstration of the Party's strategic vision and political determination in development of science, technology, innovation and national digital transformation*

and international experts and scientists; build a number of advanced schools and training centers specializing in artificial intelligence; have special mechanisms for public-private partnership in training digital technology human resources; build an online education and training platform, a digital university education model, and improve digital capacity in society.

In addition, develop a team of lecturers and scientists with sufficient capacity and qualifications to meet the requirements of teaching in the fields of basic science, semiconductor chip technology, microcircuits, key engineering and technology; promote cooperation with prestigious foreign universities; strongly innovate training programs according to international standards, modernize training methods and apply advanced technology, especially artificial intelligence.

Fifth, promote digital transformation, application of science, technology and innovation in the operations of agencies in the political system; improve the efficiency of national governance, the effectiveness of state management in all fields, ensure national defence and security

Promote the application of science & technology to build scientific foundations to support decision-making in the operations of state management agencies; build a model of a smart monitoring and control center to strengthen public management, improve governance effectiveness and operational efficiency of all levels of government; implement direction and operation of state agencies online, based on data; enhance interaction between the government and the people to help reduce bureaucracy of the state apparatus; monitor online, comprehensively and promptly warn and early detect to prevent corruption, negativity and waste. Improve the quality of online public service provision throughout the process; provide new personalized, data-based digital services for people and enterprises; provide public services regardless of administrative boundaries. Along with that, develop and master the technology of domestic digital platforms, ensure safety and many utilities for people; quickly popularize essential digital services for people; develop a plan for each person to have a digital identity, digital means, digital skills and digital accounts, forming digital citizens. Develop AI applications to support analysis, warning of natural disasters, responding to climate change and protecting the environment; support analysis, warning of risks to national defence - security, social order and safety...

Sixth, strongly promote science, technology, innovation and digital transformation activities in enterprises

Review, develop incentive policies to encourage enterprises, especially small and medium enterprises, cooperatives, and business households to invest in digital transformation, research, application of science, innovation of technology to improve production and business efficiency and enterprise governance; develop regulations to establish research foundations for digital technology and digital transformation policies in enterprises to research, apply and cooperate in transferring modern digital technology achievements from abroad to the country. Develop mechanisms, policies to support digital technology enterprises, organizations and individuals with capacity to carry out key tasks on digital transformation; policies to support, develop digital technology enterprises to well exploit the domestic digital transformation market for reaching out globally; promote the development of small and medium enterprises. In addition, develop mechanisms to attract the world's leading technology enterprises to set up headquarters, invest in research and production in Vietnam according to the following principles: Production and business in the fields that Vietnam is prioritizing; development of supporting industries in Vietnam; investment in research and development centers in Vietnam at a rate of 1% - 3% of revenue. On the other hand, create favourable conditions to support and develop digital technology enterprises to well exploit the domestic digital transformation market, as a basis for reaching out globally; develop strong enough policies to encourage the spirit of entrepreneurship in science, technology, innovation, digital transformation along with policies to support startups and attract domestic and foreign enterprises to start up in Vietnam.

Seventh, strengthen international cooperation in development of science, technology, innovation and digital transformation

Focus on promoting cooperation in scientific research and technological development with countries having advanced level of science, technology and digital transformation, especially in the fields of artificial intelligence, biotechnology, quantum technology, semiconductors, nuclear energy and other strategic technologies. In addition, have policies to purchase, transfer advanced technologies suitable to Vietnam's conditions; proactively, actively participate in developing international rules and standards on new technologies to ensure safety and mutual benefit; promote capacity building and technology transfer in international agreements and treaties to which Vietnam is a member.

THE PARTY'S STRATEGIC VISION IN THE RESOLUTION

The issuance of Resolution No.57-NQ/TW by the Politburo is a clear demonstration of the Party's strategic vision and political determination in developing science, technology, innovation and national digital transformation, because this is both a prerequisite and an opportunity, as well as a requirement of reality not only for Vietnam, but also has impacts and influences on a global scale. In the context of increasingly deep globalization, the Fourth Industrial Revolution taking place strongly, and increasingly fierce international competition, Resolution No.57-NQ/TW has a particularly important significance, a historic turning point in promoting socio-economic development, creating favourable conditions and a solid foundation for the country to enter a new era, an era of nation's rise.

The Resolution emphasizes the role of science, technology and innovation as the key driver to promote economic growth, improve labour productivity, improve production relations, innovate national governance methods, develop the socio-economy, prevent the risk of falling behind, etc. In addition, it clearly defines the goals and orientations for developing science, technology, innovation and national digital transformation in a systematic, breakthrough manner and points out the path, solutions to achieve those goals. Reality shows that the history of development and revolutionary leadership of the Party has always been closely linked to science and technology. From the first faltering steps, the Party soon realized the importance of modernizing the country through innovation, creativity and application of advanced technology. Resolutions, directives of the Party over the years have clearly demonstrated this, from the focus on building a heavy industrial foundation during the period of centralized planning, to the orientation of comprehensive innovation and deep international economic integration during the period of renovation. The issuance of each resolution marks an important turning point, demonstrating the Party's high political determination in moving the country forward, constantly reaching for the goal of being rich and powerful. This shows that the Party's strategic vision in the Resolution is consistent with the global trend, as advanced countries consider this a decisive factor to overcome all difficulties and challenges to achieve sustainable and comprehensive development. In addition, the emphasis on national digital transformation shows that the Party is clearly aware of the need for Vietnam to take advantage of opportunities from digital technology to develop faster and narrow the gap with developed countries.

The Party's strategic vision in the Resolution focuses on developing high-quality human resources, especially in the fields of science, technology and digitalization; emphasizing that building an innovation ecosystem is a necessary factor to promote the spirit of entrepreneurship and creativity in society. Above all, the Resolution demonstrates timely grasp of global trends, such as globalization, supply chain shifts and increased technological competition among countries, demonstrating forecasting as well as adaptation to global trends and international integration.

With new perspective and approach, the 7 groups of tasks and solutions proposed by the Resolution have a dialectical and unified relationship with each other in the implementation process. Each task, solution has a different position, role, and organization method, but in the implementation process, it is necessary to be deployed synchronously with high political determination, drastic and thorough measures. This is the combination of fundamental factors and breakthrough factors, in which the breakthrough idea of innovation in thinking, identification of strong political determination, drastic leadership and direction is emphasized right from the beginning in the tasks and solutions section as the decisive factor for the success of the Resolution. The group of tasks on institutional improvement, granting autonomy and self-responsibility for organization, staff, finance and expertise to public science and technology research organizations, using the state budget to hire experts, using tangible and intellectual assets to link and cooperate with organizations and enterprises... will truly be the driver for development of science and technology, soon bringing research results into practice for socio-economic development. The groups of tasks on increasing investment, improving infrastructure, developing and employing human resources and talents, and international cooperation have followed the development trend of science and technology in advanced countries in the world.

Obviously, Resolution No. 57-NQ/TW is a breakthrough strategy, laying the foundation for the country's sustainable and prosperous development, aiming to achieve the goal of Vietnam becoming a developed country with modern industry and high average income by 2030; and becoming a developed country with high income by 2045. The Resolution has removed barriers, overcome bottlenecks and created a breakthrough mechanism to unleash creativity, resources, promote the development of science, technology, innovation and national digital transformation. Therefore, to effectively implement the Resolution, it requires great efforts and political determination from the entire Party, people and army. Only with unity and drastic actions, we can turn ambitious goals into reality, making Vietnam a rich and strong country with sustainable development in the future ■

EDITORIAL BOARD

Innovation and breakthroughs in the natural resources and environment sector for sustainable development in Vietnam

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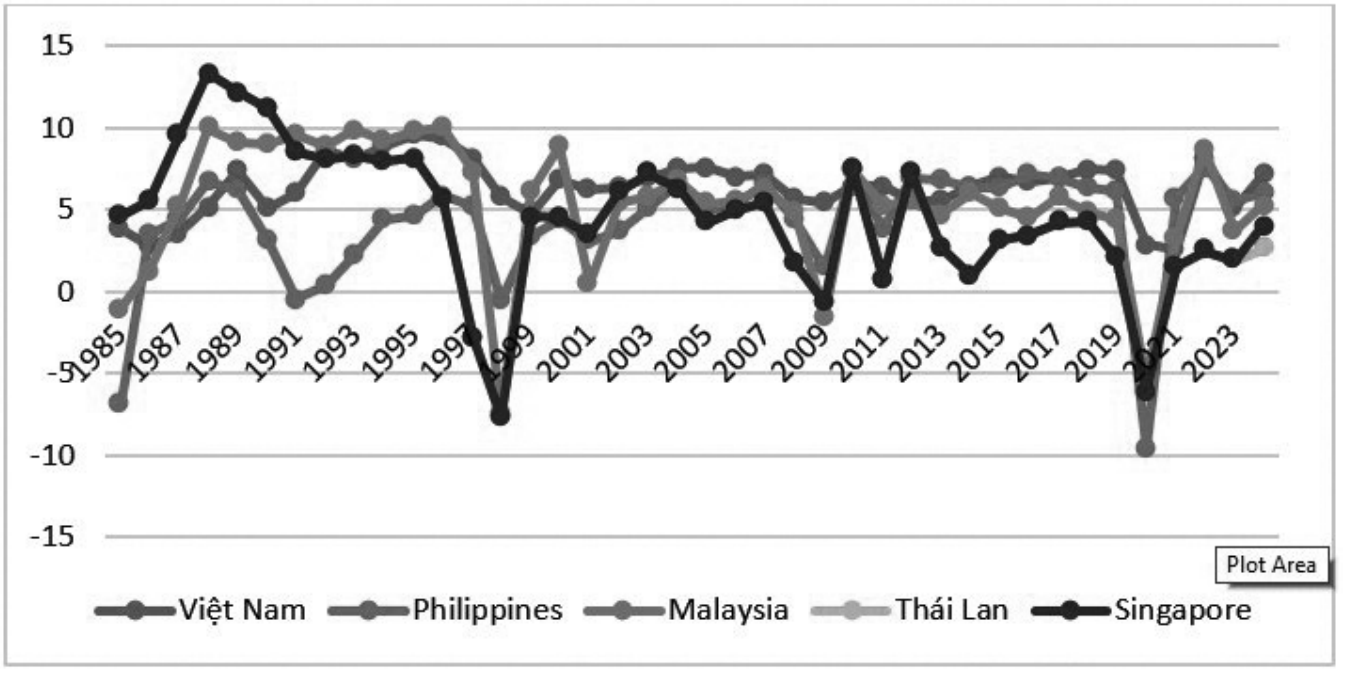
1. ECONOMIC INNOVATION AND VIETNAM'S GROWTH AND DEVELOPMENT OVER 40 YEARS

Over the past 40 years, Vietnam has maintained an impressive GDP growth rate, averaging 6.37% per year, the highest in ASEAN compared to the Philippines (4.17%), Malaysia (5.34%), Thailand (4.48%), and Singapore (4.51%). This achievement reflects Vietnam's stability and adaptability, especially in the face of regional fluctuations. From 1985-1990, the Doi Moi (Renovation) policy helped Vietnam's GDP grow from 3.81% (1985) to 7.36% (1989) due to extensive economic reforms. Meanwhile, the Philippines faced a recession (-6.86% in 1985), while Thailand and Malaysia experienced high but unstable growth rates. From 1990-1997, Vietnam experienced rapid growth, peaking at 9.54% (1995) thanks to economic integration and investment attraction. The 1997 Asian financial crisis led to negative growth in Thailand and Malaysia, but Vietnam sustained a growth rate of 5-8% due to its relative isolation from international financial markets. From 2000-2008, Vietnam's economy boomed, achieving 6-7.5% growth after joining the WTO (2007), while ASEAN economies stabilized at lower growth rates. Despite the global financial crisis (2008), Vietnam still managed to grow at 5.66% in 2008.

From 2009-2019, Vietnam solidified its position with a growth rate of 5.4-7.5%, outperforming Thailand and Malaysia, while Singapore grew at a slower rate (2-4%). During 2020-2024, the COVID-19 pandemic posed a major challenge, but Vietnam maintained positive growth at 2.86% (2020), far exceeding the Philippines (-9.52%), Malaysia (-5.46%), and Thailand (-6.05%), demonstrating strong economic resilience.

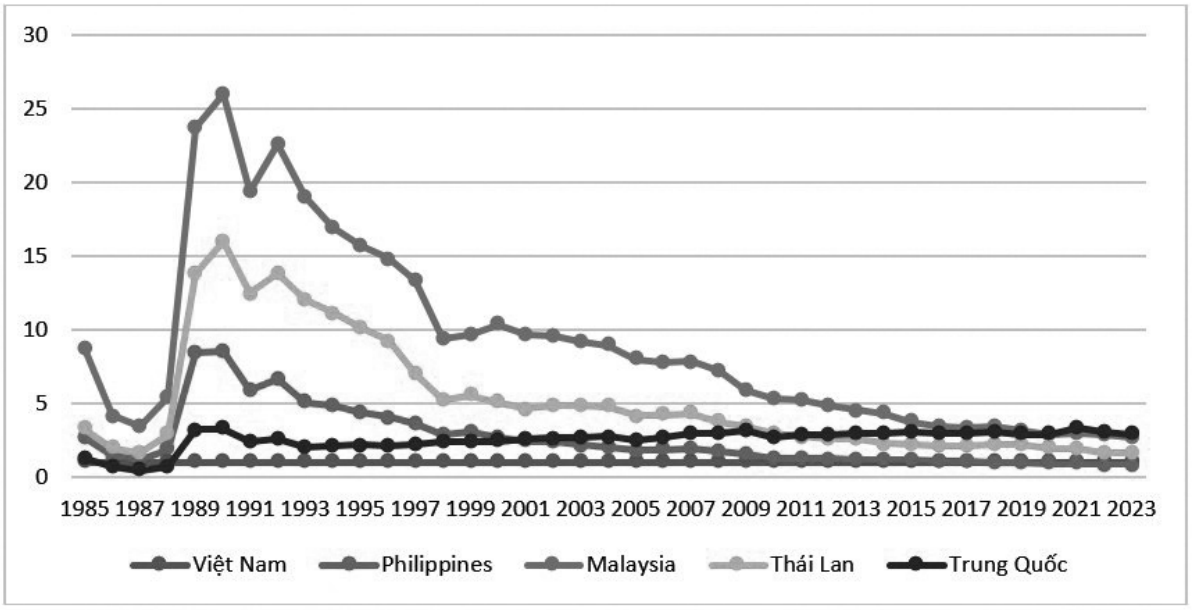
Vietnam has made strong changes but still has a large gap with other countries in the region. In 1985, Vietnam's GDP per capita was only 235.65 USD, much lower than that of the Philippines (637.83 USD), Malaysia (2,065.09 USD), Thailand (768.87 USD), and Singapore (7,001.77 USD). Since 1986, Vietnam has implemented Doi Moi, shifting from a planned economy to a socialist-oriented market economy, helping GDP per capita increase from 430.19 USD (1986) to 585.30 USD (1987). Since 2000, economic growth has been stronger, with GDP per capita increasing

GDP growth rate of Vietnam and other countries



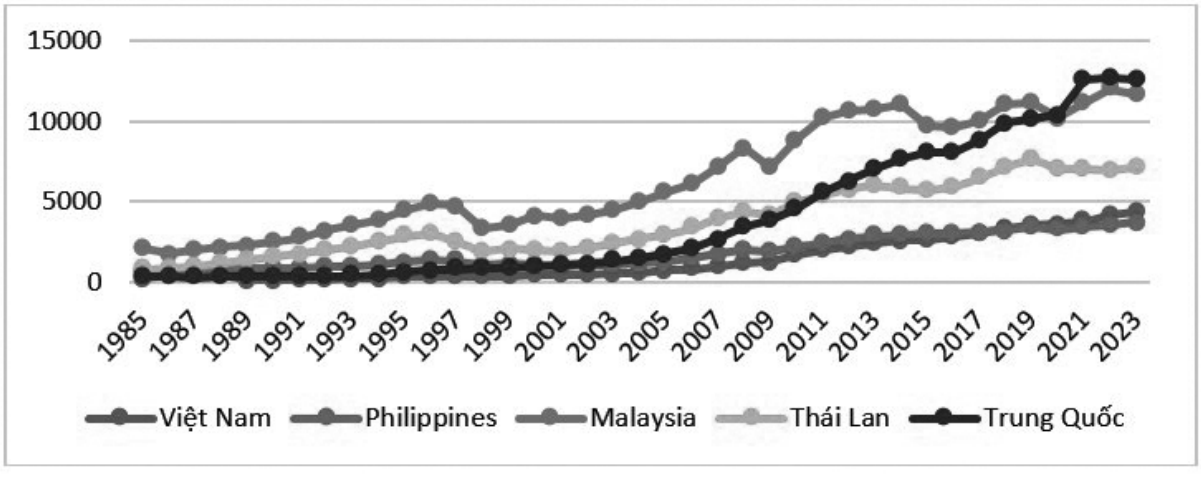
(Source: World Bank)

Vietnam's GDP per capita gap compared to other countries



Source: World Bank

Vietnam's GDP per capita compared to other countries (USD)



(Source: World Bank)

from 394.58 USD to 1,684.01 USD (2010), contributing to poverty reduction and improving living standards. During the 2011-2024 period, this figure continued to increase, reaching 4,346.77 USD (2023) and is expected to reach 4,649 USD (2024). However, Vietnam is still far behind the Philippines (3,725.55 USD), Malaysia (11,648.67 USD), Thailand (7,171.81 USD), and Singapore (84,734.26 USD) in 2023. Major challenges include low labor productivity, poor infrastructure, dependence on traditional industries, and environmental issues, climate change, and resource management, whichhinder sustainable development.

Over the past 40 years, Vietnam has emerged as one of the fastest growing economies in Southeast Asia, affirming its international position. Transforming from a planned economy to a socialist-oriented market economy, Vietnam has achieved many remarkable achievements, with GDP increasing from 14.1 billion USD (1985) to 429.7 billion USD (2023), expected to reach 468.49 billion USD (2024). After Doi Moi in 1986, the economy has flourished thanks to extensive reforms, especially in the 2001-2020 period with high growth rates thanks to international integration, industrialization, and investment attraction. By 2023, Vietnam will surpass Malaysia (399.6 billion USD), catch up with the Philippines (437.1 billion USD), and narrow the gap with Thailand (514.9 billion USD) and Singapore (501.4 billion USD). To maintain growth momentum, Vietnam needs to invest in infrastructure, improve labor productivity, and respond to climate change, aiming to become a developed country and consolidate its position in the region.

2. SOLUTIONS TO MOBILIZE ENVIRONMENTAL RESOURCES SO THAT VIETNAM CAN ACHIEVE BREAKTHROUGH GROWTH IN THE COMING TIME

Since the 12th Party Congress, Vietnam has focused on institutional reform, infrastructure development, and human resource development to improve growth quality, ensure stability, and achieve sustainable development. Despite numerous achievements, Vietnam's economy still depends on investment capital and low-cost labor, while labor productivity and technological innovation are limited. Environmental challenges, climate change, and regional competition, especially from the Philippines, require Vietnam to quickly improve. Leveraging its 40-year foundation, Vietnam has the potential to maintain high growth through technology investment and building a more sustainable and competitive economy.

First, Vietnam should refine its legal framework and strengthen coordination between authorities at all levels and private investors in urban development planning along key transport routes such as expressways, high-speed trains and subways. This approach will help reduce dependence on private vehicles and form sustainable economic and urban corridors. These areas should be planned with business centers, high-density residential areas, green spaces and close public transport connections, to balance urban and rural development and reduce traffic and population pressure in large cities. The development strategy based on the TOD (Transit-Oriented Development) model emphasizes planning high-density, multi-functional, pedestrian-friendly urban areas around public transport routes. This is a solution to reduce traffic pressure while promoting sustainable economic, social and environmental growth. Auctioning development rights, reclaiming adjacent land, and planning according to the TOD model will optimize land resources and create transparent and effective financial resources from the added value of transport infrastructure. The auction process needs to be conducted publicly and fairly, with a clear commitment from investors to sustainable development and ensuring community benefits, while encouraging the private sector to participate in the urban development process.

Second, Vietnam needs to focus on training high-quality human resources and increase investment in research and development (R&D) in the field of semiconductor technology and rare earth elements. With the world's second largest rare earth elements reserves, Vietnam has the potential to become an important supply center in the global value chain, especially when rare earth elements is an essential component in the production of semiconductor components, permanent magnets and modern electronic devices. To effectively exploit this advantage, Vietnam needs to develop investment incentive policies to attract domestic and foreign enterprises to participate in the exploitation and processing of rare earth elements, while strictly controlling these activities to ensure transparency, environmental protection and the interests of local communities. Developing rare earth elements to participate in the semiconductor value chain not only enhances Vietnam's position in the global high-tech industry but also requires the construction of a complete industrial ecosystem. This includes the exploitation of rare earth elements, refined processing and the production of high-tech products. Investment in modern processing technology is key to increasing the value of resources instead of just exporting them in their primary form, while processing plants need to comply with high technical standards to minimize negative impacts on the environment. In addition, Vietnam needs to promote strategic cooperation with countries with developed semiconductor industries such as Japan, South Korea and the United States to transfer technology, expand markets and ensure stable output for rare earth products. However, Vietnam is facing many challenges in attracting investment, especially in the context of other countries implementing attractive support packages and the application of the Global Minimum Tax (GMT) mechanism. The GMT requires multinational enterprises to pay a minimum tax rate of 15%, reducing the effectiveness of traditional tax incentives. While the US, Poland, South Korea, and Indonesia have attracted large corporations such as Intel and LG Chem with huge financial support packages, Vietnam has failed to meet the requirements of similar investment projects. Intel, which considered a $3.3 billion project in Vietnam, chose Poland thanks to a $1.9 billion support package from the EU, while LG Chem decided to invest in Indonesia because Vietnam did not meet its desired 30% support cost. This highlights the need to improve Vietnam's investment policy to compete more effectively in the international market.

Third, developing special economic zones such as Phu Quoc, Van Don and Van Phong following the model of Singapore, Hong Kong and Shenzhen is a potential strategy to turn Vietnam into an economic, financial and technological center of the region. The development model of Singapore, Hong Kong and Shenzhen offers many valuable lessons. Singapore has

become a leading center of trade, finance and technology thanks to transparent policies, modern infrastructure and an attractive investment environment. Hong Kong has developed thanks to its strong legal system and preferential tax policies, while Shenzhen has risen from a small fishing village to a modern technology and manufacturing center thanks to its open-door policy and investment attraction. Phu Quoc, with its strategic location and tourism potential, can become an international financial center like Singapore, if it invests in developing synchronous infrastructure, attracting global financial corporations and establishing flexible tax policies. Van Don, with its convenient transportation system, can develop into a logistics and high-tech manufacturing hub, similar to Shenzhen, by building green industrial parks and encouraging investment in information technology, artificial intelligence and renewable energy. Van Phong, with its leading deep-water port in the region, has the potential to become an international trade and energy industry hub like Hong Kong, if it builds a flexible economic ecosystem that combines seaports, logistics and finance. To achieve success, it needs special preferential tax policies, transparent management mechanisms and a focus on training high-quality human resources. The development of these special zones needs to protect the environment and harmonize the interests of the economy, society and local communities, while improving the quality of life and maintaining indigenous culture. With proper planning and management, Phu Quoc, Van Don, and Van Phong have the potential to become exemplary special economic zones, fostering sustainable development and strengthening national competitiveness.

Fourth, developing regional financial centers in Phu Quoc, Van Don and Van Phong following the model of international financial centers such as Singapore, Hong Kong, Luxembourg and Switzerland can boost Vietnam's economic growth. These countries have succeeded by creating an open financial environment, liberalization policies, and minimizing administrative procedures, helping to attract international businesses and investors. Vietnam can apply preferential tax policies, exempting income tax, sales tax and VAT for businesses in international financial zones. At the same time, building modern infrastructure, especially transportation and information technology, will facilitate financial transactions and attract technology companies, especially in the field of FinTech. In addition, it is necessary to build a transparent legal system, protecting investors' rights to create trust and attract investment capital. If Vietnam applies liberal financial policies, builds modern infrastructure and creates a favorable legal environment, financial centers in Phu Quoc, Van Don and Van Phong will become attractive destinations, enhancing national competitiveness and sustainable development.

Fifth, Vietnam needs to shift from a line-based budget management model to a results-based budget management model, focusing on applying digital transformation and green transformation to optimize the efficiency of public finance use. This new model will improve transparency and efficiency in resource allocation, while ensuring sustainability and alignment with long-term development goals. Applying digital transformation will help allocate the budget based on specific targets, geographical units and indicators related to economic, social and environmental development. This not only optimizes budget allocation but also establishes a flexible and accurate monitoring system, clearly assessing the impact of each expenditure on sustainable development goals. Applying this model will create a mechanism to evaluate the performance of programs and projects, helping to adjust the budget appropriately and develop effective and sustainable financial strategies. In particular, the application of system of environmental economic accounting (SEEA) according to indicators of quantity, quality, circulation and monetary value, combined with location zoning, will help manage resources from "the center of the earth to the end of the atmosphere".

Vietnam needs to make breakthroughs in strategic solutions to promote sustainable growth and enhance national competitiveness, by perfecting the legal framework, building modern transport infrastructure and developing urban areas along key transport routes. These factors will create a solid foundation for economic development. Investing in high-quality human resources, especially in high-tech and research industries, will help Vietnam make the most of the potential from rare earth elements resources and technology industries. Developing special economic zones and regional financial centers following the model of advanced countries such as Singapore and Hong Kong will open up opportunities to attract international investment, promote sustainable development and enhance Vietnam's role in the international arena, not only maintaining high growth but also creating a breakthrough for the economy in the future ▪

Scientific basis, tasks, solutions and roadmap for implementing the National Action Plan to implement circular economy by 2035

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The circular economy is one of the effective solutions to help address the relationship between the economy and the environment, with the potential to create new growth drivers, value chains, and jobs, while reducing greenhouse gas emissions and achieving the Sustainable Development Goals (SDGs). Many countries and regions are adopting roadmaps, strategies, or visions for CE as a growing trend. The ASEAN Economic Community's circular economy framework was adopted with a vision to position ASEAN as a hub of innovation and investment in circular economy development, characterized by high competitiveness, economic prosperity, environmental sustainability, and social equity. At the same time, a global roadmap for circular economy is also under discussion. In practice, initiatives and actions are being taken in production, business, and consumption to shift investment flows, financial systems, production and business models, and value chains toward circular economy. Many global agreements and next-generation free trade agreements under negotiation directly or indirectly refer to circular economy, gradually becoming new 'rules of the game'. In Vietnam, the policy direction for circular economy development has been unified at the central level and concretized in some localities. Environmental protection legislation has included provisions on circular economy, including criteria, roadmaps, and incentive mechanisms for implementation. Several other key policy instruments also play a vital role in circular economy development. In practice, there have been positive signs of circular economy adoption among businesses, communities, and individuals through the development of models and initiatives in agriculture, industry, commerce, tourism, and waste management, ect. However, circular economy development in Vietnam still faces limitations in terms of awareness, institutional framework, legal basis, and mechanisms. It has not yet successfully established new sustainable value chains through circular economy practices, especially in the context of increasing pollution, environmental degradation, and scarcity of raw materials and resources.

The National Action Plan for the Implementation of the Circular Economy by 2035 specifies the roadmap for the implementation of the Circular Economy in accordance with the provisions of the Law on Environmental Protection 2020, Decree No. 08/2022/ND-CP dated January 10, 2022 of the Government detailing a number of articles of the Law on Environmental Protection and the Party and State's policies and guidelines on the development of the Circular Economy with viewpoints, goals, tasks, solutions, sectors and priority areas for the implementation of the Circular Economy nationwide. The Plan is the basis for ministries, sectors and localities to develop and organize the implementation of the Circular Economy in accordance with their assigned functions, tasks, scope and management areas.

On January 23, 2025, the Prime Minister approved Decision No. 222/QD-TTg on the National Action Plan for the Implementation of the Circular economy by 2035. The article summarizes the approach, principles, methods, contents, tasks, solutions, priority sectors and areas as well as roadmap for assessesing the impact of the National Action Plan for the Implementation of the Circular economy by 2035.

1. APPROACH, PRINCIPLES AND METHODS FOR DEVELOPING THE PLAN

1.1. Approach

The National Action Plan for the Implementation of the Circular economy by 2035 is built on the harmonious application of the following approaches:

(i) The system approach is applied to perceive the movement of production sectors in the overall relationship of the entire economy, to see the correlation between the production sector, specific production sectors and the rest of socio-economic activities. On that basis, we could find out the positive and negative points in implementing the goal of developing circular economic models at different levels, each specific sector and sub-sector in the economy.

(ii) Market-based approach to clearly identify the role of the State and the subjects in the market economy, apply the objective principles, rules and laws of the market economy to determine appropriate priority actions to promote changes in thinking, behavior and technology, and consumption methods based on economic benefits, social and environmental responsibilities of businesses and consumers.

(iii) The interdisciplinary approach is applied to examine the cyclical cycles in the economy and in production sectors in a systematic, inter-sectoral, and inter-regional manner, thereby seeing the connections in production sectors, the position and role of the circular economy in the value chain; as well as the position and role of subjects in the production sector to find ways

to have policy interventions appropriately and effectively.

(iv) The bottom-up approach is carried out during the survey to collect information and data from stakeholders on the current status of commodity production in various sectors, the level of waste collection, treatment and recycling, as well as the capabilities and desires of these businesses. The bottom-up approach contributes to supporting research and consideration of management issues arising from the practical needs of localities, businesses, and relevant entities, and ensures that policy proposals are closely linked to local needs and practical situations.

(v) Top-down approach to clarify the needs of State management agencies at all levels in applying circular economy models in serveral manufacturing industries including plastics, paper, and construction materials, and at the same time grasp the necessary directions of the State for participation of these aforementioned industries.

1.2. Methodology for developing the Plan

The methods and processes for developing the National Action Plan to implement the Circular economy by 2035 are implemented, including:

(1) Overview method, inheriting published documents of ministries, branches and localities, international organizations in the country and abroad to inherit and use as a basis for analysis, evaluation and making proposal of tasks and solutions of the Plan;

(2) Market analysis method considers the needs, potentials and challenges in expanding and developing the market for goods and services related to the circular economy;

(3) The SWOT strategic analysis method is used to synthesize, analyze, and evaluate the domestic and international context; the current status of the institutional and policy systems; the capacity of manufacturing industries in the context of environmental challenges as well as sustainable development that are increasingly being focused on... to select and fully identify the strengths, weaknesses, opportunities and challenges in encouraging and promoting the application of circular economy models in a number of manufacturing industries;

(5) Statistical analysis (descriptive, comparative), correlation analysis method to review and evaluate trends and opportunities for applying circular economic models; identify the impact levels of factors affecting the implementation of circular production;

(6) Quantitative modeling analysis method is used to model the flows of raw materials and materials in the economy to find key points that need to be impacted to achieve the criteria of the Circular economy;

(7) Policy analysis method is used to research and evaluate the system of policies and laws of Vietnam related to circular economy and application of circular economy models to a number of production sectors;

(8) Expert methods are used through consultation and exchange with experts in relevant fields, carried out through various forms such as direct consultation, discussion at scientific seminars consulting experts and managers.

(9) Method of assessing the level of readiness and necessity for the circular economy. Based on a full analysis of the level of readiness in terms of institutions, policies, laws, practices; the level of urgency in environmental protection, responding to new regulations of the world on circular economy to select priority fields and sectors, as well as roadmap and phase on implementation of circular economy in the Plan.

During the implementation process, expert methods were used, specifically: (1) consulting with experts and managers through scientific seminars and workshops; (2) consulting with ministries, branches, People's Committees of provinces and centrally-run cities, relevant agencies and organizations; (3) organizing 03 forums and many seminars on the basis of sending the draft Decision dossier to experts, scientists, and management agencies for research and consultation; (4) posting the draft Decision dossier on the electronic information portal of the Ministry of Natural Resources and Environment to widely collect opinions.

2. THE PLAN'S VIEWPOINTS AND GOALS

2.1. Viewpoint

(1) Prioritize the implementation of circular economy to create new growth momentum, enhance resilience and recovery for the economy, create breakthroughs in development, promote growth model innovation, improve quality, efficiency and competitiveness, create new value-added chains, harmonize the relationship between the economy and the environment, contribute to the implementation of international commitments on nature conservation, biodiversity, net zero emissions by 2050 and sustainable development.

(2) Promote the proactive and creative role of enterprises, cooperatives, production, business and service establishments in applying the circular economy; the rights and interests of consumers and people are the driving force for the development of the circular economy; the State plays a central role in creating an institutional environment, policies, management and regulatory organizations in order to encourage the participation of economic sectors, communities, agencies, organizations and individuals on the basis of the laws of the market economy with State regulation, in accordance with common international practices, principles and standards.

(3) Implementing a circular economy (CE) is a regular, continuous task with a long-term roadmap, closely linked to innovation, achievements of the Fourth Industrial Revolution, and breakthroughs in science and technology. It is an essential component of green transition, a green and

low-carbon economy; involves the development of integrated infrastructure across regions; and the advancement of high-quality human resources and the creation of new jobs. The goal is to maximize the value of raw materials, resources, and waste throughout the entire stages of design, production, distribution, consumption, and waste management.

(4) Maximize the advantages, potential, and characteristics of various sectors, regions, and localities, ensuring an interdisciplinary, interregional, and holistic approach to developing appropriate circular economy models. Promote best practices and foster a culture of sustainable production and consumption. Strengthen independence and self-reliance in mobilizing and effectively utilizing domestic and international resources for circular economy implementation. Digital transformation serves as a key driver for developing advanced, modern, and sustainable circular economy models.

(5) Ensuring the harmony of interests of relevant entities, taking people as the center, focusing on improving social welfare and quality of life of the people; consistent with the viewpoints, guidelines, policies, and laws of the Party and State on socio-economic development of the country and international trends in implementing circular economy.

2.2. Objectives

Firstly, the general objective

Forming a sustainable production and consumption structure system, effectively using natural resources, optimizing the use of reclaimed raw materials and resources, minimizing waste, and reducing negative environmental impacts; strongly developing the circular economy models in production and business; creating motivation for innovation and improving labor productivity; developing good practices, creating a green culture and lifestyle, promoting green job creation and developing new value chains in the circular economy sector.

Secondly, specific goals and targets are divided by 2030 and 2035.

The proposed objectives and targets of the Plan reflect the true nature of the macro-level circular economy model, in accordance with the circular economy criterias specified in Article 138 of Decree No. 08/2022/ND-CP, in accordance with the assigned tasks of the Circular Economy Development Scheme in Vietnam in Decision No. 687/QD-TTg dated June 7, 2022 of the Prime Minister. These goals and targets are also consistent with the circular economy indicators applied by many countries around the world and ensure continuity and coherence with the Party's and the State's orientations for socio-economic development across sectors and fields through 2030. The detailed goals and targets through 2030 are presented in Table 1.

The proposed goals and targets by 2035 include: (1) Realizing an inclusive circular economy linked to innovation, creativity, high competitiveness, economic prosperity, environmental sustainability, and social equity; making Vietnam become one of the innovation hubs providing technology, equipment, products, services, and mobilizing investment for the circular economy within the ASEAN Economic Community (AEC); (2) Contributing to the successful achievement of targets related to the efficient use of resources, environmental protection, climate change adaptation, and sustainable development by 2035 and in subsequent phases, as outlined in the Party's documents, strategies, policies and laws of the State.

3. TASKS, SOLUTIONS, PRIORITY SECTORS AND AREAS, AND ROADMAP OF THE PLAN

3.1. Priority tasks and solutions

- Raise awareness, knowledge, and skills through the development of materials, implementation of communication programs, and education and training to enhance awareness and capacity on the circular economy for all levels, sectors, areas, and relevant stakeholders. This includes prioritizing communication, training, and dissemination of knowledge and laws related to circular economy implementation; integrating circular economy education content into school curricula at all levels; and developing and operating a platform for connecting information and sharing data on circular economy model application.

- Complete the institutions, laws, regulations and standards to create a foundation for the circular economy. In the immediate future, focus on removing barriers to put current regulations into practice such as: Extended Producer Responsibility (EPRs) to operate the extended responsibility mechanism of manufacturers and importers in the collection and recycling of waste; environmental industry and environmental services to develop recycling technologies and equipment; green credit, green bonds; standards and regulations on post-treatment waste, secondary raw materials, products using recycled materials; incentives and support for products and projects investing in recycling and reuse... Continue to integrate the circular economy into the process of amending and supplementing other relevant laws, especially regulations on taxes, fees and consumption. Encourage experimentation with new mechanisms and policies that play a breakthrough role for the circular economy. The specific tasks and solutions of the Plan include: organizing the development and promulgation of action plans, integrating circular economy into strategies, planning, development programs, waste management plans of ministries, agencies, and localities; improving legal regulations, standards, and technical norms to encourage circular economy implementation;

- Support the promotion of circular economy application in production, business

Table 1. Goals and targets by 2030 of the National Action Plan for implementing the circular economy

No.	Goal and targets
I	**Reduce exploitation and use of non-renewable resources and water resources; increase efficiency in the use of resources, raw materials and materials; and save energy:**
1	Strive to achieve targets on efficient use of resources (land, water, minerals) equivalent to the leading ASEAN countries.
2	The capacity of power plants from biomass and solid waste sources by 2030 will reach 2,270 MW, equivalent to 1.5% of the total capacity of power plants.
3	The proportion of renewable energy in total primary energy strives to reach 47%
4	Achieve savings of 8 - 10% of total national energy consumption
II	**Extend the life of materials, equipments, products, goods, components and structures; limit waste generation and minimize negative impacts on the environment**
5	The rate of collected and treated domestic solid waste in urban areas reaches 95%.
6	The rate of collected and treated rural solid waste reaches 80%.
7	The proportion of domestic solid waste treated by direct landfill method compared to the amount of collected waste decreased below 50%.
8	The rate of wastewater treatment from production, business, service establishments, concentrated production, business, service areas, and industrial clusters into the river basin environment reaches over 70%.
9	Greenhouse gas emission intensity per gross domestic product reduced by at least 15% compared to 2014
III	**Focus on and enhance economic aspects, increase benefits, promote innovation and mobilize resources in implementing the circular economy.**
10	Models for efficient use of natural resources, reuse and recycling of waste, and production and business models applying circular economy are built, replicated, and developed appropriately for each industry, field, region, and at each level.
11	Forming and developing new, sustainable value chains associated with high added value, creating many new jobs through the application of circular economy
12	The number of technologies, equipment, and products transferred for application and granted patents for recycling and reuse has increased over the years.
13	Strongly attract resources from green credit, green bonds and other legal resources for investment projects in developing circular economy.

(Source: Decision No. 222/QD-TTg)

and consumption activities, including: support for the implementation of ecological design to meet circular economy criteria; support for the application and development of circular economy models in production and business; promote innovation, application of digital technology, environmentally friendly technology, and best available techniques to implement circular economy; support the formation and development of markets for goods and services related to circular economy; promote the implementation of circular economy in consumption activities, ensuring consumer rights;

- Synchronously deploy waste management requirements; pilot, replicate and develop waste management models by region, area and locality; promote the role and value of the informal labor force, small and medium enterprises in creating value chains associated with circular economy; pilot and develop regional and inter-regional recycling industrial park models.

- Develop linkage and cooperation mechanisms between ministries, sectors, fields, regions, localities and organizations and individuals to connect and create value chains associated with typical material flows of circular economy. Encourage the establishment of linkage and cooperation models for waste collection and recycling. Develop toolkits and indicators to measure, evaluate and monitor the implementation of circular economy associated with material flows.

3.2. Priority sectors and fields

Priority sectors and fields to implement circular economy by 2035 include: (1) Agriculture, Forestry and Fisheries; (2) Energy; (3) Mineral exploitation and mineral processing; (4) Processing and manufacturing industry; (5) Chemicals; (6) Construction; (7) Transport; (8)

Services and tourism; (9) Waste management; (10) Development of urban areas, concentrated residential areas; industrial parks, industrial clusters, concentrated production, business and service areas. In particular, the plan identifies a list of specific sectors and fields that need guidance on applying circular economy by ministries, ministerial-level agencies, provincial People's Committees, relevant agencies and organizations according to the assigned tasks in this National Action Plan; Types of investment projects, facilities, production and business corresponding to products, materials, waste and services encouraged to apply one or more measures to implement circular economy by 2035 are detailed in Appendix II of the Plan (Table 2).

3.3. Tasks and roadmap for implementing circular economy for priority and specific sectors and fields; investment projects, production and business establishments; products, materials, waste and services

The action plan defines the tasks and roadmap for implementing circular economy by 2035 for the above priority sectors and fields allocated to 2035. In particular, priority is given to implementation before 2030 for the waste management sector; other sectors and fields that meet one or more of the following criteria: generating a lot of waste, having a large impact on the environment, emitting large greenhouse gases; exploiting and using a lot of resources, raw materials, fuels and energy; having the potential to create high added value and new jobs; being bound to implement circular economy in trade, investment activities and international relations.

Encourage priority and specific sectors and fields; types of investment projects, production and business establishments; products, materials, waste and services listed in Appendix II of the Plan to apply measures and requirements to implement circular economy earlier than the roadmap of this National Action Plan; encourage sectors and fields; types of investment projects, production and business establishments; products, materials, waste and services not listed in the Action Plan to proactively select and apply measures and requirements to implement circular economy in accordance with the provisions of the Law on Environmental Protection and other relevant laws.

Mobilize and diversify resources to implement circular economy, including: (1) state budget sources: central budget, local budget; (2) international support: official development assistance (ODA), support capital and preferential loans; (3) commercial loans and private investment sources: green credit, green corporate bonds; foreign direct investment (FDI); other commercial loans and private investments; (4) other community and social capital sources: public-private mobilized capital for investment projects, domestic funds.

4. COMPATIBILITY OF THE PLAN WITH INTERNATIONAL TREATIES AND ITS SOCIO-ECONOMIC AND GENDER EQUALITY IMPACT

4.1. Conformity with international commitments, treaties and trends

The contents of the National Action Plan for the implementation of the circular economy by 2035 are consistent with the commitments and international treaties that Vietnam has signed and is a member of. In particular, the implementation of this Plan will directly or indirectly contribute to the successful implementation of commitments such as: the United Nations Framework Convention on Climate Change (UNFCCC); the United Nations 2030 Agenda for Sustainable Development; the Convention on the Protection of the Ozone Layer (VIENA); the Stockholm Convention on Persistent Organic Pollutants; the Basel Convention on the Control of Transboundary Movements and the Disposal of Hazardous Wastes. In particular, the National Action Plan for the implementation of the circular economy by 2035 will realize the 2030 Agenda and the National Action Plan for the implementation of the 2030 Agenda with 17 sustainable development goals.

In the context of many new generation Free Trade Agreements being signed, more and more contents related to the environment, green economic development, circular economy, greenhouse gas emission reduction; at the same time, binding the parties' obligations on environmental protection at a higher level. Some important Agreements that Vietnam has signed or is in the process of negotiating are: Vietnam - EU Free Trade Agreement (EVFTA); Trans-Pacific Partnership Agreement (TPP); The Regional Comprehensive Economic Partnership (RCEP) Agreement between ASEAN and 6 partners that have FTAs with ASEAN, namely China, Korea, Japan, India, Australia, New Zealand, etc. Along with that, many countries and regions in the world have introduced specific circular economy measures in import and export activities such as the regulations of the European Union in the textile, electronics, chemical industries, etc. Therefore, the implementation of solutions and tasks in the National Action Plan for Circular Economy will contribute to supporting domestic enterprises to participate in new value-added chains that take into account climate, environmental and sustainable development factors; contributing to supporting the promotion of competitiveness for Vietnamese products and services in the world market.

A comparison with the plans, strategies, visions, or roadmaps that have been issued or are being developed by other countries and regions around the world such as the European Union, the Netherlands, Finland, Japan, Australia, Chile, etc… shows that the contents, sectors, and priority areas

in Vietnam's draft National Action Plan for the implementation of the Circular Economy by 2035 are well aligned. In particular, when compared with the ASEAN Circular Economy Framework adopted in 2021, it is evident that the Vietnamese National Action Plan has been developed in line with ASEAN's overall development orientation. At the same time, it will contribute positively to achieving the strategic goals of the ASEAN Economic Community in establishing a resilient economy, enhancing resource efficiency, and promoting inclusive and sustainable growth.

Table 2. List of priority and specific sectors and fields; investment projects, production and business establishments by 2035

No.	Priority and specific sectors and fields; investment projects, production and business establishments	Products, materials, waste and services
I	**Agriculture, forestry and fisheries**	
1	Crop	- Potential materials, products, by-products, wastes and services from farming activities - Cultivation to reduce greenhouse gas emissions
2	Animal husbandry	- Potential materials, products, by-products, wastes and services from livestock activities - Livestock farming to reduce greenhouse gas emissions
3	Forestry	- Increase carbon absorption and storage capacity and reduce greenhouse gas emissions in forestry - Materials, products, by-products, waste and services with potential from afforestation and logging activities
4	Seafood	- Potential materials, products, by-products, wastes and services from aquaculture activities - Reducing greenhouse gas emissions in aquaculture
II	**Energy**	
1	Thermal power	- Materials, fly ash, bottom slag of thermal power plants - Water used in the process of thermal power production
2	Energy recovery through waste incineration	- Organic waste - Electricity is produced from domestic solid waste and common industrial solid waste.
3	Renewable Energy	- Developing renewable electricity from hydroelectric, solar, wind, geothermal, tidal, green hydrogen sources; nuclear power - Equipment used to produce electricity from renewable energy sources
4	Nuclear energy	- Nuclear power
5	Power transmission, distribution and electrical equipment	- Equipment for receiving, transmitting and transmitting electricity - Electronic products and household electrical appliances
III	**Mineral exploitation and mineral processing**	
1	Exploration, mining, minerals	- Solid waste from tailings, waste rock and soil; waste materials from mineral exploitation activities, excess rock and soil from construction investment projects - Water used in the ore selection process; waste water at mineral mining sites; water collected from mineral mining activities
2	Mineral processing	- Waste-water from ore processing activities - Excess materials and other wastes in the mineral processing process

No.	Priority and specific sectors and fields; investment projects, production and business establishments	Products, materials, waste and services
IV	**Processing and manufacturing industry**	
1	Food processing	- Food packaging - Solid waste and wastewater in food processing activities
2	Wood processing	- Potential materials, products, by products, waste and services from wood processing activities - Repair, refurbishment, reuse and other life-extending services for wooden products
3	Beverage	- Plastic, metal, glass packaging used for beverages including beer, wine, soft drinks - Solid waste, wastewater from production activities
4	Paper and pulp	- Paper used for various purposes, cardboard - Solid waste, wastewater, emissions from production activities
5	Plastic	- Packaging and products made from plastic materials such as PE, PP, PET, ABS, PVC, PP, PU... - Solid waste, waste water, exhaust gas
6	Metallurgy	- Precious metals, waste-water, residual heat, exhaust gas from metallurgy - Scrap iron, steel and other metals
7	Ceramics and glass	- Glass bottles and jars; all kinds of construction glass - Waste from glass processing activities
8	Dyeing, textile	- Wastewater from textile and dyeing - Fabric, fashion
9	Electrical and electronic equipment	- Electrical and electronic equipment for civil and industrial use - Materials recovered from electrical and electronic equipment - Repair, refurbishment and other services that support the life cycle of electrical and electronic equipment for domestic and industrial use
V	**Chemical**	
1	Plant protection	- Pesticide packaging - Natural chemicals, environmentally friendly
2	Fertilizer	- Raw materials, materials, water in the fertilizer production process - Organic fertilizer from by-products and waste
3	Rubber	- Rubber tires for vehicles and machinery
4	Batteries, accumulators and electricity storage	- Batteries, accumulators, solar panels - Electrical storage devices used in industry and civil use
VI	**Build**	
1	Construction materials	- Ordinary industrial waste that meets technical and environmental requirements for use in the production of construction materials and as landfill materials. - Construction materials using waste from production and construction activities

No.	Priority and specific sectors and fields; investment projects, production and business establishments	Products, materials, waste and services
2	Construction works	- Construction works - Support services to extend the life cycle of construction works
VII	**Transportation**	
1	Mean of transportation	- Means of transport and motor vehicles - Support services to extend the life cycle of means of transport and machinery
2	Transport infrastructure	- Traffic works - Materials for traffic works - Support services to extend the life of traffic works
3	Transportation services	- Freight transport - Passenger transport
VIII	**Services and tourism**	
1	Service	- Distribution, wholesale and retail services - Restaurant and hotel services - Consulting, assessment, support services for implementing circular economy, refurbishment, repair services and other potential services
2	Tourism	Management and exploitation of relic sites, relic sites, tourist areas, tourist attractions, and tourist accommodation facilities
IX	**Waste Management**	
1	Solid waste	- Urban and rural solid waste - General industrial solid waste, sludge, boiler ash - Construction solid waste
2	Waste water	- Domestic wastewater from urban and residential areas - Waste water from industrial parks, industrial clusters, concentrated production and business areas; production and business establishments
3	Emissions	- Methane, CO_2 from activities: farming, livestock; waste management and waste water treatment; oil and gas exploitation and processing, coal mining and fossil fuel consumption
X	**Development of urban areas, concentrated residential areas; industrial parks, industrial clusters, concentrated production, business and service areas**	
1	Urban area, concentrated residential area	- Urban area - Concentrated residential area
2	Industrial parks, industrial clusters, concentrated production, business and service areas	- Industrial park - Industrial clusters, concentrated production, business and service areas

(Source: Decision No. 222/QD-TTg)

4.2. Socio-economic impact and gender equality

The circular economy has three basic principles, including: (i) Conserving and developing natural capital through control, aiming to rationally use resources and regenerate natural systems; (ii) Optimizing the benefits of resources by circulating products and materials as much as possible; (iii) Improving the overall efficiency of the entire system by minimizing negative externalities, through waste design, pollution-free design right from the beginning of the production process. The benefits of implementing circular economy have been proven by many international organizations and scientists around the world. Accordingly, implementing circular economy according to the contents of the National Action Plan for implementing circular economy to 2035 will actively contribute to the implementation of viewpoints, goals and tasks on socio-economic development, specifically as follows:

Regarding economic development: According to the United Nations Development Program (2023), the circular economy will shift from the "extraction - production - consumption - disposal" model to a more sustainable circular system. This model emphasizes the design of durable products, maintenance, repair, reuse, recycling, and renovation, to minimize the amount of natural resources used unsustainably. This is not only beneficial for the environment but also helps sustainable economic growth, especially in the context of global material consumption expected to double by 2060. The Plan is comprehensively designed to promote the application of the circular economy throughout the economy from design, production, distribution, consumption, disposal, recycling, and reuse with the full participation of economic sectors. Therefore, implementing the tasks in the Plan will contribute to creating new, sustainable value-added chains for the economy.

Regarding cultural, social and human development: Implementing the circular economy is likely to create millions of new jobs by 2030, with employment growth of about 0,1%. These jobs are not only limited to developed countries but also extend to developing economies, through sectors such as recycling, repair and renovation. Therefore, the synchronous and effective implementation of tasks and solutions such as the National Action Plan will make an important contribution to creating new jobs in the fields of ecological design, consulting, and assessment of circular economy implementation; repair and refurbishment for reuse towards extending product life cycles; and the field of recycling and waste treatment. In particular, with the focus on the main economic subjects of the Action Plan, which are producers and consumers, the successful implementation will make an important contribution to the formation and development of good cultural features and sustainable culture in production and consumption; contributing to the formation of a material circulation society.

On saving, resource efficiency, environmental protection and climate change response: Applying processes to maintain product value such as recycling, repair and renovation can help reduce 79% to 99% of greenhouse gas emissions in some industries. According to the United Nations Environment Program, the implementation of circular economy contributes significantly to achieving global goals on climate change and reducing the impact of climate change. The national action plan for implementing circular economy will promote the process of shifting the growth model towards sustainability, contributing significantly to the implementation of the orientation of strengthening climate change response, resource management and environmental protection. The measures, solutions and tasks stated in the draft national action plan for implementing circular economy are in line with the relevant orientations of the Party and State on socio-economic development; agricultural, rural and farmer development; industrialization, modernization; urbanization; sustainable development of regions and localities... In particular, through the implementation of circular economy, proactively responding to climate change, strengthening resource management, and environmental protection will become the center of development tasks as stated in Conclusion No. 56-KL/TW dated August 23, 2019 of the Politburo. In the long term, the implementation of solutions and tasks for implementing circular economy of the Plan will contribute to creating an economic growth trend (GDP and income), a trend of reducing resource exploitation, improving the efficiency of resource exploitation/GDP; reducing the level of waste generation/GDP; thereby harmoniously resolving the relationship between economic growth and development with efficient use, saving resources, environmental protection, and responding to climate change (especially reducing greenhouse gas emissions).

Regarding gender equality: With the view of promoting the role, strength, spirit of innovation and creativity in the entire political system, economic sectors, organizations and individuals involved to promote the implementation of circular economy. The National Action Plan for the Circular economy does not stipulate the difference between men and women in the implementation of circular economy. All actions are aimed at encouraging the participation of all genders, including women in mountainous and difficult areas, waste collection forces (mostly women). Therefore, it will contribute to the implementation of the Law on Gender Equality: "eliminating gender discrimination, creating equal opportunities for men and women in socio-economic development and human resource development, moving towards genuine gender equality between men and women and establishing and strengthening cooperative and supportive relationships between men and women in all areas of social and family life". Nowadays, in reality, women are increasingly participating actively and effectively in the country's socio-economic development and environmental protection ▪

Law on Marine and Island Resources and Environment - Implementation issues and solutions

NGUYỄN ĐỨC TOÀN

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The **Law** on Marine and Island Resources and Environment (the Law) was passed by the 13th National Assembly of the Socialist Republic of Vietnam, 9th session on 25 June 2015. Provisions of the Law have created a synchronous legal system, an important legal corridor, creating a breakthrough in the marine and island resource management and environmental protection; improving the efficiency and rational use of resources, promoting protection of the marine and island environment, sustainable development of the marine economy; protecting national sovereignty; ensuring national defence and security. However, after the period of application of the Law, some limitations and shortcomings have been revealed, such as: The development of documents detailing and guiding the implementation of the Law is completely new and faces many difficulties, easily overlapping with other legal documents; Resources for the dissemination, education of legislations are still limited, not meeting practical needs; the development of the Strategy for the Sustainable Exploitation and Use of Natural Resources and Protection of the Marine and Island Environment, the Master Plan for Sustainable Extraction and Use of Coastal Resources, establishment of coastal protection corridors, establishment of island records still face difficulties in implementation... Therefore, this article focuses on assessing the situation and results of the implementation of the Law; difficulties, obstacles and shortcomings in the implementation of the Law and guiding documents, thereby proposing amendments and supplements to the Law and recommending new issues arising in practice.

1. RESULTS OF THE IMPLEMENTATION OF THE LAW ON MARINE AND ISLAND RESOURCES AND ENVIRONMENT 2015

Immediately after the Law was promulgated, the MONRE developed and submitted to the Government for approval of the Strategy for the Sustainable Exploitation and Use of Natural Resources and Protection of the Marine and Island Environment to 2030 with a vision to 2050 in Resolution No. 48/NQ-CP dated 3 April 2023. The objective of the Strategy is to better understand the potential and advantages of the sea, the adverse impacts from the sea on Vietnam's seas and adjacent international waters; to build and complete the database on marine resources and environment as a basis for ministries, sectors and coastal local authorities to plan to exploit and use marine resources, respond to climate change and achieve the targets set out in the Resolution. To date, 27/28 People's Committees of coastal provinces have developed a Plan to implement the Strategy for the Sustainable Exploitation and Use of Natural Resources and Protection of the Marine and Island Environment to 2030 with a vision to 2045 for their localities (Soc Trang province is in the process of developing). In general, the Plan to implement the Strategy in localities has closely followed the objective, orientation, and strategic tasks set out in Resolution No. 48/NQ-CP, the content of the Plan to implement the Strategy is consistent with the orientation of socio-economic development, national defence and security of localities.

In addition, the MONRE has advised the Prime Minister to promulgate Decision No. 28/QD-TTg dated 7 January 2020 approving the Key Program for Baseline Survey of Marine and Island Resources and Environment to 2030. The Prime Minister also promulgated Decision No. 216/QD-TTg dated 19 February 2021 on the regulation on coordination in management and implementation of this Key Program. To date, 2 projects have been completed, 13 projects have been approved and are being implemented, 7 projects have received opinions from line ministries and sectors and are being submitted to competent authorities for approval, and the remaining 14 projects are in the process of developing explanations and estimates. The main reason is that the funding source provided by the state budget is not guaranteed according to approved project implementation phases, or has not been provided; the implementing personnel still lack experience.

At the same time, the MONRE has granted 7 licenses to foreign organizations and individuals to conduct scientific research in Vietnam's seas. These research activities have contributed to improving our understanding of marine resources and environment; taking advantages of resources, equipment and improving the qualifications of Vietnamese scientists through research trips of foreign organizations. The MONRE also issued a separate Ministerial-level Science and Technology Program in Decision No. 2249/QD-BTNMT of the Minister dated 4 September 2015 approving the objectives, research contents, main products and evaluation criteria of this Key Program on "Science and Technology on Integrated Management of Marine and Island Resources and Environmental Protection for the 2016-2020 period", code TNMT.06/16-20. Results of the Program have provided a basis for the work of synthesizing marine and island resources

and environmental protection. In addition, by the end of 2023, the MONRE has ordered/assigned the completion of 42 science and technology subjects with 4 main research groups, with a total budget of VND75,324 million, serving the work of integrated management of marine and island resources and environmental protection in general, and serving the implementation of the Law in particular.

Regarding the formulation, development and organization for implementation of the Master Plan for Sustainable Extraction and Use of Coastal Resources: The Law has 8 Articles (from Article 26 to Article 33) stipulating the formulation, adjustment and organization for implementation of the Master Plan. However, to ensure consistency and unity in the national planning system, on 24th November 2017, the National Assembly promulgated the Law on Planning, which stipulates the formulation, appraisal, decision or approval, announcement, implementation, assessment and adjustment of planning in the national planning system; the responsibility for state management of planning, including this Master Plan. Additionally, the National Assembly also promulgated a Law amending and supplementing a number of articles of 37 laws related to planning, thereby amending and supplementing a number of articles of the Law on Marine and Island Resources and Environment related to the Master Plan. To carry out the task of formulating the Master Plan, the Prime Minister promulgated Decision No. 25/QD-TTg dated 23 April 2020 approving the task of formulating the Master Plan for Sustainable Extraction and Use of Coastal Resources for the 2021-2030 period with a vision to 2050.

In recent times, the work of statistics on marine and island resources has been implemented, this has provided data on marine resources as the basis for developing and adjusting policies and legislations on integrated management of marine and island resources and environmental protection in accordance with reality, unifying state management of seas and islands among ministries, sectors and local authorities. Marine biological resources in Vietnam are quite diverse with about 11,000 species residing in more than 20 typical ecosystems, belonging to 6 different marine biodiversity regions. Vietnam's marine aquatic resources are relatively abundant; the entire sea area has identified 1,700 aquatic species belonging to more than 730 genera, 260 families; of which over 130 species have high economic value. In the 2016-2020 period, immediate reserves of main resource groups are about 3.9 million tons, of which the Gulf of Tonkin accounts for nearly 16%; the Central Sea area is about 22%; the Southeast is about 25%; the Southwest is more than 13% and the middle of the East Sea is about 24%. The allowable exploitation capacity from aquatic resources in Vietnam's sea is estimated at more than 2.83 million tons/year. In recent years, aquatic resources and habitats of aquatic species in particular and marine aquatic species in general, are declining in terms of species diversity, quantity and quality. Main causes are overexploitation of aquatic resources, especially in coastal waters and waste sources from coastal socio-economic activities, especially industrial parks, urban areas, tourist areas, etc.

Up to now, 14/28 coastal provinces have been implementing the establishment of records for managing island resources, of which 10 provinces have completed the establishment of records, put them into storage and management, including the provinces of Thanh Hoa, Quang Tri, Phu Yen, Thua Thien - Hue, Ba Ria - Vung Tau, Ho Chi Minh City, Tien Giang, Soc Trang, Ca Mau, Kien Giang. 4 localities are implementing: Quang Ninh, Hai Phong, Khanh Hoa, Quang Ngai. According to provisions of Clause 2, Article 79 of the Law, People's Committees of coastal provinces and cities are responsible for establishing coastal protection corridors under their management within 18 months from the effective date of the Law from 1st July 2016. As of 30th June 2024, 27/28 coastal provinces have approved the List of areas requiring the establishment of coastal protection corridors. According to statistics from the Law implementation summary reports of 28 coastal provinces, there are about more than 560 coastal and island areas with established coastal protection corridors having a total length of nearly 1,700km (about 50% of the coastline).

Implementing the Project "Development and Implementation of Programs and Plans for Management of Waste; Control of Environmental Pollution Sources from Land and Activities at Sea", agencies under the MONRE have reviewed policies and legislations on integrated management of waste at sea; improved the institution for integrated management, unified marine environmental pollution sources from land and sea; developed a Program for Waste Management Plan; controlled environmental pollution sources from land and activities at sea; analysed and evaluated the quality of seawater and coastal sediments in the area surrounding waste sources; took samples and instantly measured on site waste sources from land to sea, at sea, conducted surveys of coastal areas in the North and North Central regions, 4 provinces in the Central region and South Central region... Currently, the coastal seawater environment is quite clean, most of which meet QCVN 10-MT:2015/BTNMT-QCVN on seawater quality. However, locally, some aquaculture areas, boat mooring areas, river mouths, etc. are polluted by compounds containing nitrogen, phosphate and suspended solids; the offshore seawater environment is stable and less volatile.

On 7th March 2024, the Prime Minister approved Decision No. 224/QD-TTg on the Master Plan on National Environmental

Monitoring for the 2021-2030 period with a vision to 2050, as an important basis for line ministries, sectors and local authorities to organize the implementation of unified environmental monitoring on the system nationwide. The MONRE issued Decision No. 1899/QD-BTNMT dated 10 July 2024 on the Plan for Implementation of Decision No. 224/QD-TTg on the Master Plan on National Environmental Monitoring for the 2021-2030 period with a vision to 2050. In coastal provinces, 18/28 provinces reported that they have carried out coastal water environmental monitoring (Hai Phong, Thanh Hoa, Nghe An, Quang Binh, Quang Tri, Thua Thien - Hue, Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Ninh Thuan, Binh Thuan, Ba Ria - Vung Tau (Con Dao), Ho Chi Minh City, Tra Vinh, Soc Trang, Ca Mau, Kien Giang). Results of annual monitoring and supervision have provided important information and data for management of marine environment such as: scientific research, development of the State of National Marine Environment Report; development of normative documents on marine environment. In addition, above results also provide information and data on the state and changes in the quality of the marine environment, environmental incidents (red tides, oil pollution, earthquake data, tsunamis, etc.), information on environmental protection in medical activities at medical facilities nationwide, including medical care in coastal and island areas, and negative impacts on the environment in Vietnam's seas; serving the work of monitoring and warning the marine environment, contributing to the socio-economic development, security and sovereignty of Vietnam's seas.

From 2015 to 2023, the MONRE has directed the organization for implementation of 37 examinations; 3 inspections of the implementation of legal regulations on marine and island resources and environment in coastal provinces and centrally-run cities. Through the process of examination of the implementation of legal regulations on marine and island resources and environment in localities, organizations and individuals, it shows that the situation of administrative violations in the field of marine and island resources and environment is mainly related to violations of the allocation and use of sea areas such as: using sea areas without a decision on allocation of sea areas by a competent state agency; violating provisions at Point a, Clause 2, Article 27b of Decree No. 162/2013/ND-CP dated 12 November 2013 (supplemented at Clause 19, Article 3 of Decree No. 37/2022/ND-CP dated 6 June 2022). In addition, coastal provinces have established 372 inspections and examinations in the period from 2015 to 2024, conducted examinations of compliance with legal regulations on marine and island resources and environment in the area; field examinations of coastal protection corridor boundary markers; examinations and handling of violations of the legal regulations on dredging, sand transportation, illegal dumping of mud and soil, and violations of maritime traffic safety and order, etc. The total amount of fines imposed by local authorities for administrative violations in the field of marine and island resources and environment is VND23,061,826,100. In addition, local authorities also imposed fines for administrative violations in the field of fisheries of VND74,105,935,000, and fines for administrative violations in other fields at sea of VND 235,500,000.

2. SOME SHORTCOMINGS AND LIMITATIONS IN THE IMPLEMENTATION OF THE LAW

The Law on Marine and Island Resources and Environment is the first legal document with the highest legal effect promulgated to stipulate tools for integrated management of marine resources. Therefore, the development of documents detailing and guiding the implementation of the Law is completely new and faces many difficulties, easily overlapping with other legal documents. The participation of agencies and local authorities in drafting legal documents guiding the implementation of the Law has not been effective, so some regulations after promulgation have encountered difficulties and obstacles in the implementation process, not suitable to reality. In addition, resources for the dissemination and education of legislations are still limited, not meeting practical needs, so the dissemination and propaganda of legislations is not regular, continuous and proactive. The team of legal reporters and propagandists at the grassroots level still cannot meet the needs and requirements of the work; local dissemination and propaganda conferences often have to invite reporters at the Central level to carry out dissemination tasks.

In addition, human resources for integrated management of marine resources and environmental protection are increasingly limited in number and are also responsible for other fields. Some Departments of Natural Resources and Environment in 28 coastal provinces only arrange 1-2 full-time staff and 1 Division Leader in charge of work related to integrated management of marine resources and environmental protection. Most Divisions of Natural Resources and Environment in coastal districts do not have full-time staff for integrated management of marine resources and environmental protection, but mainly perform many different fields concurrently. The funding source for the implementation of the Law is still limited, not meeting the needs for organizing dissemination and propaganda work; performing tasks such as baseline survey; establishing records of island resources; marking coastal protection corridors; purchasing and investing in equipment and conducting patrols, controlling, combating and preventing violations, etc.

Some tasks are implemented slowly, such as developing the Strategy for the Sustainable Exploitation and Use of Natural Resources and Protection of the Marine and Island Environment; Master Plan for Sustainable Extraction and Use of Coastal Resources; establishing coastal protection corridors; establishing island records. Some tasks are still being implemented and have not been completed, such as classifying islands, developing and implementing program for integrated management of coastal resources, and zoning risks of marine and island environmental pollution.

Along with that, the work of drafting documents and implementing regulations on administrative sanctions for violations of provisions of the Law and documents guiding its implementation still has some difficulties and obstacles, such as: Decree No.37/2022/ND-CP dated 6 June 2022 of the Government amending and supplementing a number of articles of Decrees on administrative sanctions for violations in the fields of national defence, cryptography; management and protection of national borders; in the seas, islands and continental shelf of the Socialist Republic of Vietnam stipulates administrative sanctions for: (i) Violations of regulations on scientific research by foreign organizations and individuals in Vietnam's seas; (ii) Violations of regulations on dumping at sea. However, these regulations on handling administrative violations do not cover all violations of legislations on marine and island resources and environment, such as no regulations on sanctions for violations of regulations on coastal protection corridors, marine environmental protection, etc.

The Law does not have specific provisions on compensation for damage caused by oil spills. The determination and compensation for damage caused by oil spills at sea are regulated by many different legal documents, including the Civil Code 2015, the Law on Environmental Protection 2020 and their guiding documents for implementation, Decision No. 12/2021/QD-TTg, etc. However, these legal documents overlap, thus making it difficult to claim compensation for damage caused by oil pollution at sea. In addition, the Law stipulates the definition of "dumping at sea", but it is not consistent with provisions of UNCLOS and MARPOL 73/78 (Vietnam is a member) and overlaps with legislations on environmental protection. The integrated monitoring and supervision of marine and island resources and environment is stipulated in Section 1, Chapter VII, consisting of 3 Articles (from Article 64 to Article 66). However, it has not been implemented yet because in order to establish an integrated monitoring and supervision system of marine and island resources and environment, it is necessary to have regulations on planning the monitoring network and system.

The rigid stipulation in the direction of listing marine and island resources and environment data as in Article 68 of the Law is facing many shortcomings when new types of marine data arise or data names change according to other relevant legal provisions. Therefore, it is necessary to amend Article 68 in the direction of more open stipulation on data types in the new context and situation. In addition, Clause 3, Article 68 of the Law stipulates that "ministries, sectors and local authorities must provide data to the MONRE to build a national marine and island resources and environment database" but has not yet specified methods, forms and types of data... to carry out the data provision, so it is difficult to implement...

▲ *Sustainable exploitation and use of marine and island resources in Phu Quoc*

3. PROPOSING CONTENTS THAT NEED TO BE AMENDED AND SUPPLEMENTED IN THE LAW

Baseline survey of marine resources and environment: Amend and supplement more specific provisions to ensure that ministries, sectors and local authorities implementing schemes, projects, tasks on baseline survey of marine resources and environment not included in the Key Program for Baseline Survey of Marine and Island Resources and Environment must consult with the MONRE on the necessity, subjects, scope, contents of the survey, feasibility and efficiency; after approval, the approval decision and information on location, boundaries, area, coordinates of the survey area of schemes, projects, tasks must be sent to the MONRE; after acceptance, the product must be submitted to the database on marine resources and environment of the MONRE.

Marine scientific research by foreign organizations and individuals in Vietnam's sea areas: Amend and supplement provisions in Clause 3, Article 17 to clarify whether the subject of "foreign organizations and individuals" conducting research in Vietnam's sea areas includes foreign investors who have a need for scientific research for developing projects to exploit and use marine resources or not; Amend provisions in Clause 2, Article 19 and Clause 3, Article 21 in the direction of not rigidly stipulating the need to obtain specific opinions from each ministry, not rigidly stipulating the mandatory consensus of four ministries to license/permit to publish and transfer information and scientific research results; Amend and supplement to more specifically stipulate the roles and responsibilities of ministries in examining and supervising scientific research activities in Vietnam's sea areas...

Management of scientific research, measurement, monitoring, survey, exploration activities at sea not using state budget: To manage scientific research, measurement, monitoring, survey, exploration activities at sea not using state budget with non-budgetary capital, it is necessary to amend and supplement a Section to Chapter III with some provisions such as: Provisions on the basis, conditions, order, procedures, and dossiers for requesting licenses/approval for scientific research, measurement, monitoring, survey, exploration activities at sea without using the state budget; Provisions on the authority and responsibilities of state management agencies for licensing/approval for scientific research, measurement, monitoring, survey, exploration activities at sea without using the state budget.

Master plan for sustainable extraction and use of coastal resources: Amend and supplement provisions on responsibilities of agencies, organizations, order and procedures to determine areas for exploitation and use activities with specific purposes in the Law to suit reality.

Coastal protection corridor: Amend and supplement provisions in Article 23, thereby clarifying provisions on adjusting areas where coastal protection corridors need to be established or amend Clause 5, which assigns the Government to specify in detail the adjustment of areas where coastal protection corridors need to be established; Amend provisions in Clause 3 on the width of coastal protection corridors to suit the coastal conditions of some provinces with high tide lines deep inland; Amend provisions in Point b, Clause 1, Article 25 in the direction of abolishing the phrase "encroaching on the sea" to suit the Land Law 2024.

Supplement of provisions on new issues - provisions on coastal protection: To be consistent with the zoning of use (including prohibited exploitation areas, conditional exploitation areas, areas requiring special protection and areas encouraged for development) in the National Marine Spatial Master Plan and the Master Plan for Sustainable Extraction and Use of Coastal Resources zoning of use, therefore a Section in Chapter IV is supplemented to stipulate the protection of coastal areas, including following provisions: Supplement provisions on prohibiting and restricting activities in conditional exploitation areas (according to the Master Plan for Sustainable Extraction and Use of Coastal Resources and the National Marine Spatial Master Plan); Supplement provisions on prohibiting the construction of works/factories carrying out certain production activities with high risks of polluting the marine environment in conditional exploitation areas (according to the Master Plan for Sustainable Extraction and Use of Coastal Resources and the National Marine Spatial Master Plan)...

Management of island resources: Amend and supplement provisions in Chapter V on management of island resources to ensure compliance with the National Marine Spatial Master Plan and practical requirements on island management; Amend and supplement provisions of Clause 1, Article 40 on island classification to suit reality; Amend and supplement provisions at Point a, Clause 2, Article 41 to ensure the implementation of new construction activities and installation of necessary equipment for the protection and conservation work.

Control of marine and island environmental pollution, response to oil spills, toxic chemicals at sea and dumping at sea: Amend and supplement provisions on control of marine environmental pollution sources originating from the mainland and from activities at sea; Amend and supplement provisions on zoning risks of marine and island environmental pollution; Supplement provisions on control of marine waste; Amend and supplement provisions on response to oil spills; Supplement provisions on compensation for oil pollution... ▪

Enhance private sector participation in solid waste management through public – private partnership

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Currently, the demand for solid waste treatment is rising as the amount of solid waste continues to grow alongside socio-economic development. On the other hand, the funding sources for solid waste management (SWM) are mainly allocated from the limited State budget, which is a key weakness in this area. Therefore, enhancing participation in SWM plays an important role in contributing to funding mobilization and reducing pressure on the State budget, especially through investments in solid waste management public-private partnership (PPP) projects. The article introduces key findings from the World Bank (WB) research conducted in 2024, which aims to analyze the legal framework, identify challenges, and propose solutions to enhance private sector participation in SWM. This is achieved by promoting investments in PPPs for domestic solid waste (DSW) treatment, contributing to funding mobilization, and reducing pressure on the State budget in this sector.

1. INTRODUCTION

Economic growth and rapid urbanization, along with a population boom in Vietnam, have led to an increase in domestic solid waste (DSW) generation. It is estimated that 67,877.34 tons of DSW are generated nationwide per day, with 38,143.05 tons per day produced in urban areas, accounting for 56.19%, and 29,734.30 tons per day generated in rural areas, accounting for 43.81%. Regarding treatment methods, out of the 59,961.68 tons of collected DSW per day, 62.98% is disposed of by land filling, 10.09% is treated using the waste-to-energy method, 14.08% through incineration, and 12.85% is processed into compost from food waste (Pollution Control Department, 2024).

The demand for solid waste treatment is rising as the amount of solid waste continues to grow alongside socio-economic development. The SWM system is currently facing infrastructure challenges, such as a lack of sanitary landfills, the absence of appropriate advanced methods for solid waste treatment, and reliance on State budget allocations for domestic solid waste management (DSWM) expenditures. The funding for this activity comes from the fees for DSWM services charged to households, residents, and the local budget (Gia Chinh, 2023). The World Bank's 2024 research shows that public expenditure on SWM in Viet Nam accounts for 0.23% of the Gross Domestic Product (GDP). Additionally, the State budget allocates 75–80% of recurrent expenditure to collection, transport, and treatment, and 80% of the budget to invest in building DSW facilities. In 2020, the total expenditure on SWM in Vietnam was approximately 610 million USD, including 463.7 million USD from the State budget and 146.3 million USD from fees for domestic solid waste management (DSWM) services charged to residents (WB, 2024).

Enhancing private sector participation in providing DSWM services can offer numerous benefits to enterprises, communities, and the country. The private sector brings economic benefits and innovations to public service delivery in the SWM sector, as it is more motivated to optimize expenditures, invest in advanced technology, and improve management processes. PPP and direct investment are effective ways to mobilize private sector funding for infrastructure development, especially as the Government faces budget constraints.

The 2020 Law on Environmental Protection introduced several regulations on domestic solid waste management (DSWM), including source segregation of domestic solid waste (DSW), fee collection based on waste mass or volume, and Extended Producer Responsibility (EPR). Moreover, the Government has clearly prioritized DSWM in the National Strategy for Integrated SWM to 2025, vision to 2050, as well as in the National Master Plan for 2021-2030 and the National Strategy for Environmental Protection 2021–2030, focusing on DSW reduction, recycling, and recovery.

The article introduces key findings from the WB research conducted in 2024, which aims to analyze the legal framework, identify challenges, and propose solutions to enhance private sector participation in SWM. This is achieved by promoting investments in PPPs for domestic solid waste (DSW) treatment, contributing to funding mobilization, and reducing pressure on the State budget in this sector.

2. LEGAL FRAMEWORK FOR PRIVATE SECTOR PARTICIPATION IN SOLID WASTE TREATMENT

The LEP 2020, along with the Law on Investment and the Law on PPP Investment (PPP Law), introduced regulations to encourage investments and the implementation of PPP projects in this sector. However, in reality, no PPP projects on solid waste treatment have been implemented across the country to date. The private sector primarily engages through service contracts and participates only in certain stages of the DSWM value chain, such as collection and transportation...

2.1. Policies on selection methods, investment forms, types of contract

The PPP Law came into effect on January 1st, 2021, marking a significant effort by Vietnam to attract PPP projects, with the potential to contribute to the long-term and sustainable outcomes of PPP project implementation (The National Assembly, 2020). Then, in 2021, the Government issued two resolutions to introduce financial management mechanisms and the enforcement the PPP Law, including Decree No. 28/2021/ND-CP, dated March 26, 2021, which provides the financial management mechanism applicable to investment projects in the form of PPP and Decree No. 35/2021/ND-CP dated March 29, 2021 detailing and guiding the implementation of the Law on Investment in the Form of PPP. Moreover, on November 16, 2021, the Ministry of Planning and Investment issued Circular No. 09/2021/TT-BKHDT providing guidelines for selection of investors to implement investment projects in the form of PPP and land-using investment projects.

According to the PPP Law and Resolution No. 35/2021/ND-CP of the Government, procurement, ordering, and assignment are the methods for selecting suppliers for public services using the State budget in DSWM. Investments in the form of PPP are applicable to solid waste treatment projects with a total investment of at least 200 billion VND (approximately 8 million USD). Regarding direct private investment methods, the private sector is permitted to collect and transport DSW. Moreover, the private sector is permitted to build recycling factories and develop treatment facilities through two approaches: (i) selection of investors for DSW treatment projects in accordance with the Law on Procurement; and (ii) private investment procedures in accordance with the Law on Investment (Figure 1).

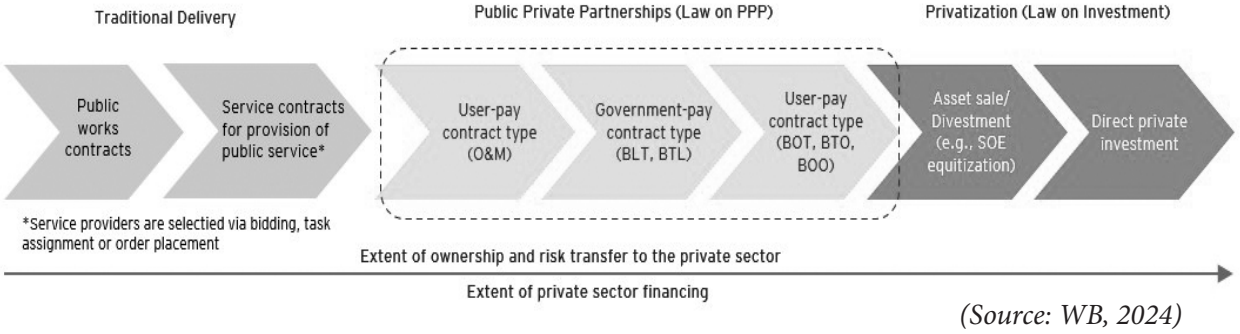
The LEP 2020 introduces three types of applicable PPP contracts, including: (i) Contracts in which the investor collects fees directly from users (Build–Operate–Transfer (BOT), Build–Transfer–Operate (BTO), and Build–Own–Operate (BOO); (ii) Contracts in which the investor collects fees directly from users (Operate – Manage (O&M); (iii) Contracts in which the Government pays the investor, such as Build – Lease – Transfer (BLT) and Build – Transfer – Lease (BTL) (Table 1).

2.2. Institutional framework for implementing of investment projects in the form of PPP in the DSW treatment sector

Policies on socialization and the attraction of private investments for SWM have been institutionalized; the legal framework supporting PPP investments in DSWM has been finalized with laws and guiding documents (Figure 2). According to Decree No. 35/2021/ND-CP of the Government and Circular No. 30/2021/CT-TTg dated November 23, 2021 of the Prime Minister on enhancing the enforcement of legal documents regarding investment in the form of PPP and procurement through investor selection, the Government has assigned the Ministry of Agriculture and Rural Development (MAE) (formerly the Ministry of Natural Resources and Environment (MONRE) and the Ministry of Construction to collaborate in developing and issuing a Circular to guide PPP investment projects in the solid waste sector. Currently, the MAE is collaborating with stakeholders to develop a draft Circular for submission, which will serve as the basis for mobilizing private investments in DSWM.

In Vietnam, the implementation of PPP projects is decentralized to local authorities, who are responsible for identifying, preparing, and implementing projects at the provincial level. Based on the rights of DSWM (Article 78, LEP 2020), PPP projects in this sector are typically under the management of provincial people's committees, including DSW treatment projects (Article 3).

Figure 1. Three main current PSP forms for development of infrastructure and provision of public service



(Source: WB, 2024)

Table 1. Types of service contracts in DSWM in Vietnam

No	Types of service contracts in DSWM	Current regulations and templates
1	**Order Placement Contract** for provision of public service using State budget (Collection, segregation, transportation and treatment of waste are in the list of public service using state budget obtained through the ordering or tendering process (Decree 32/2019/ND-CP, Appendix I, Chart 02 – Several classification lists of public service using state budget obtained through the ordering or tendering process)	Decree No. 32/2019/ND-CP on task assignment, order placement and bidding for public goods and services funded by the state budget's recurring expenditures (Article 14, Article 19, Article 20 and Form No. 03)
2	**RFP and bidding contract** (in cases where bidders are selected to deliver public services using the State budget) (*Type of contract for bidding packages of collection, transportation, treatment of domestic solid waste*)	Law on Public Procurement 2023 Decree No. 32/2019/ND-CP Circular No. 08/2022/TT/TT-BKHDT on bidder selection on Viet Nam national e-procurement system (RFP form No. 3A, 3B)
3	**PPP contract**	Law on PPP 2020 Decree No. 35/2021/ND-CP (Appendix IV – Instructions for developing PPP contract template)
4	**Investment and Business Project Contract**	Law on Bidding (Article 71,72,73,74) Decree No. 23/2024/ND-CP Decree 23/2024/ND-CP detailing Bidding Law regarding selection of investors to implement projects falling into cases subject to organization of bidding (Appendix II – Guidelines for developing the contract template for business investment projects.) Circular No. 03/2024/TT-BKHDT prescribing forms of bidding documents for selection of investors for projects requiring bidding as prescribed by specialized laws (Appendix II, III – Request for proposal template)

(Source: WB, 2024)

3. CHALLENGES AND SOLUTIONS FOR ENHANCING PPP INVESTMENT IN DSW TREATMENT

3.1. Key challenges

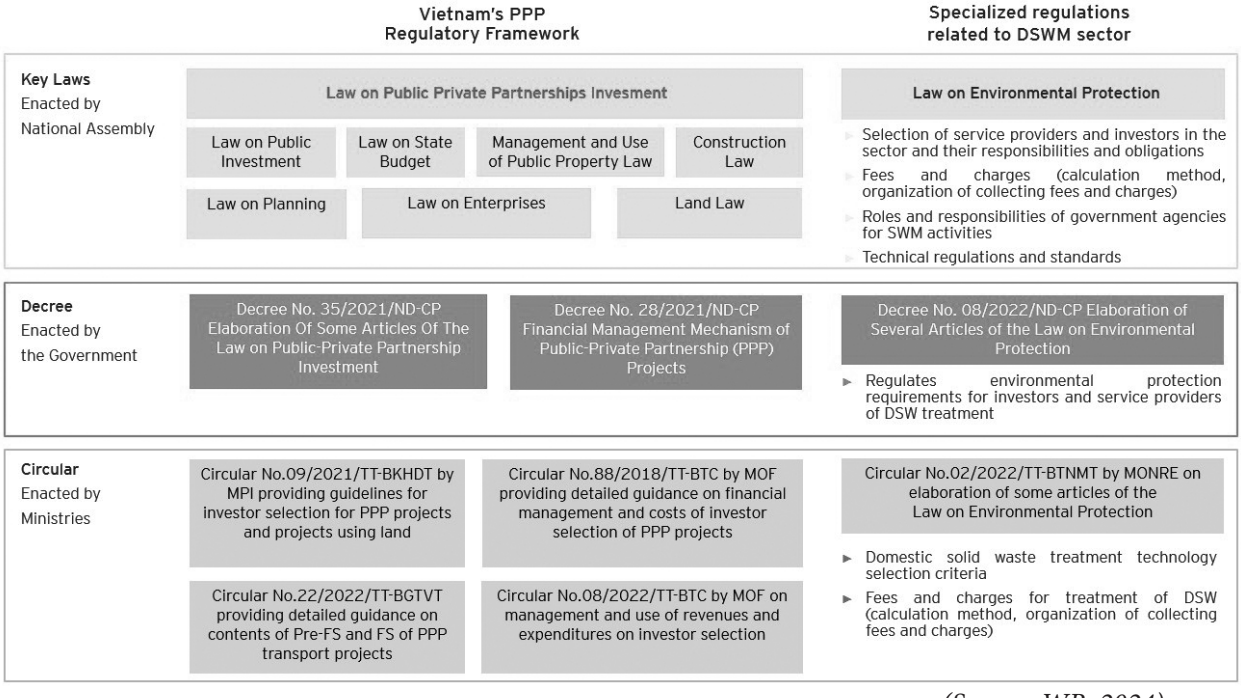
Challenges relating to access to green finance

In principal, with proper design using clean technology, DSWM projects can be eligible for green/climate finance. However, businesses in Vietnam are generally still at early pathway to unlock green/climate finance solutions.

The current scale of green finance is quite small. By the end of 2022, outstanding loan for green projects only accounts for 4.2% of the total outstanding debt of the economy, at more than VND 500,000 billion (equivalent to USD 20,83 billion). However, most of green financing is allocated to renewable energy sector and green agriculture, which has recorded a share of 47% of 30% of green loan respectively. By contrast, DSWM projects have very poor access to green loan. Among some solid waste treatment project in operation, only Hanoi Thien Y Environmental Energy Joint Stock Company has been granted a green loan of USD 160 million. Other projects such as Thuan Thanh EJS and Everbright Can Tho... have received loans from international and regional institutions.

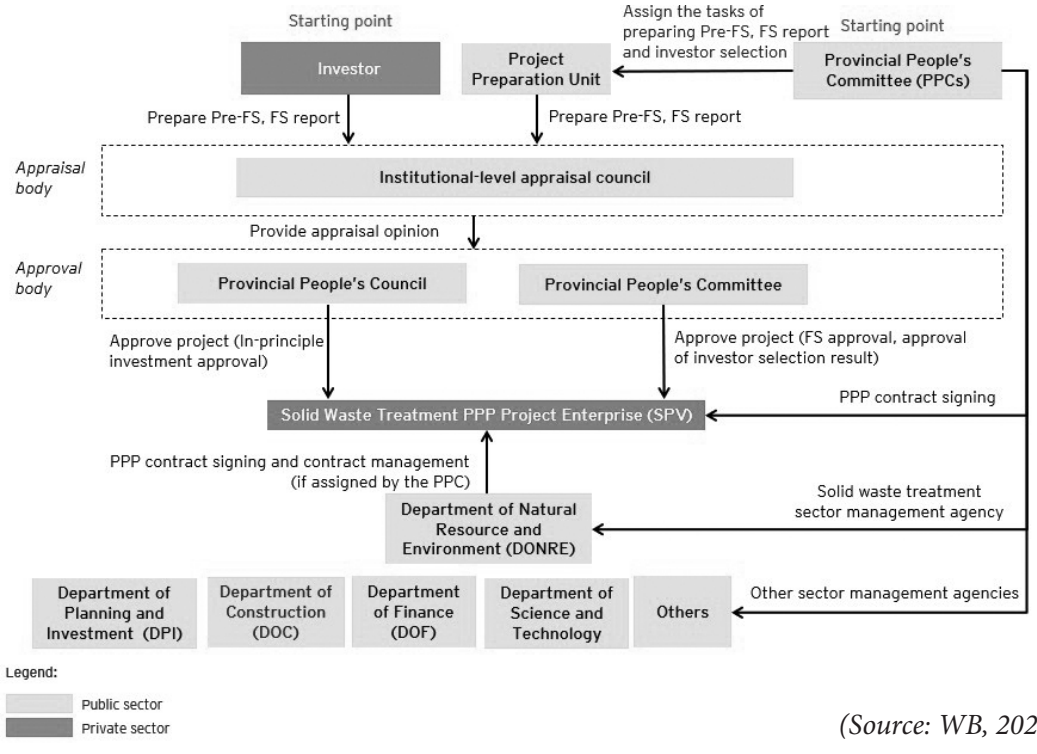
Similarly, the green bond issuance also faces regulatory challenges. Although the Bond Market Development Roadmap for the 2017-2020 period, with a vision towards 2030 mentioned green bond as a funding for green projects, Viet Nam's government has neither issued regulation to provide financial policy framework for the development of the green bond market, nor created incentives to attract green bond issuers.

Figure 2. Overview of Vietnam PPP regulatory framework



(Source: WB, 2024)

Figure 3. Institutional framework for PPP solid waste treatment projects



(Source: WB, 2024)

Lack of detailed guidance for PPP projects in solid waste treatment

Decree No. 35/2021/ND-CP (Appendix VI) provides high-level guidance on PPP contract. The Prime Minister assigned MAE (formerly the MONRE) and the Ministry of Construction (MOC) to agree on the focal point to develop and issue a Circular guiding PPP investment project in the fields of solid waste. However, detailed guidance on the PPP contract template in the field of DSW is currently being developed, which will support local authorities in mobilizing PPP investments in the near future.

Limited capacity to develop and implement PPP contracts at the local level

Currently, DSWM activities are strongly decentralized to provincial-level and district-level People's Committees. Specialized staffs, who often possess technical expertise, find

it challenging in preparing investment projects in the form of PPP or to carry out investor selection, especially for BTL/BLT/O&M contracts. Additionally, with the decentralization of PPP project preparation and implementation, the local government agencies, are facing challenges in PPP project structuring, financial appraisal, understanding of overall risk allocation, PPP contract drafting and contract management. The capacity to comply with PPP regulations in accordance with related guidance documents remains limited, particularly in areas such as contract template preparation, work plan appraisal, approval, and implementation.

3.2. Solutions and recommendations to enhance PPP project implementation in DSW treatment

Further development of legal frameworks for PPPs in the DSWM sector

It is recommended that the MAE (formerly MONRE) collaborate with line ministries and local authorities to issue a Circular providing guidance on PPP projects in the DSWM sector. This should include detailed instructions on preparing the pre-feasibility and feasibility studies, a standardized PPP contract template, and criteria for investor selection,... It will be important legal document for the private sector to participate in investments in DSWM in general and DSW treatment in particular in accordance with regulations of Decree No. 35/2021/ND-CP.

Enhancing recycling through the operation of material recovery facilities (MRFs)

Currently, the collection, transportation and recycling of domestic recyclable waste is carried out by the private sector and transferred to the recycling centers (except for composting – which is regarded as a solid waste treatment technology and therefore a public service funded by the Government). Also, the EPR policy requires producers and importers of products and packaging to fulfill their recycling obligations. Thus, it is recommended to develop MRF to facilitate the sorting process and increase the amount of recyclable material diverted from landfills. In particular, it is recommended that the Government issue a mechanism for the selection of public service providers, along with guidance on technical regulations, technological standards, cost norms, and pricing related to the development and operation of MRFs. At the local level, it is recommended that provincial planning be revised to integrate MRFs into solid waste treatment area planning.

Mobilizing green finance for DSW treatment

Unlocking green/climate finance in this DSW treatment sector will help local private sector tap to wider finance pool, not only limited at local financing sources. It is recommended that the Government issue a green taxonomy and establish a financial policy framework to support the development of green bonds, along with incentives for companies that issue them. Unlocking green/climate finance in domestic market in general and in DSW treatment sector specifically need co-operation and supports among multi ministries (such as MONRE, MPI, Ministry of Finance (MOF), State Bank), development partners and other market builders.

Capacity building for the development and implementation of PPP projects

Decentralization in environmental protection in general and DSWM in particular is a key policy direction of the Party and the State. After the Circular on PPP is issued, it is recommended that the MAE (formerly MONRE) focus on organizing training courses to strengthen the capacity of staff, private enterprises, and local banks in the design and appraisal of PPP projects in the DSWM sector, thereby enabling them to more confidently secure financial agreements ▪

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"Middle-income trap" - Environmental perspective and implications for Vietnam

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Getting rich and bringing the country to prosperity and wealth is the legitimate desire of every nation. Countries have been setting goals to become developed economies such as China by 2035, India by 2047... and Vietnam is a no exception. Our country is striving to enter the era of nation's rise, with the goal to become an upper-middle-income by 2030, and a high-income country by 2045. However, not all developing countries can overcome the middle-income stage to become high-income; on the contrary, most countries fall into the "middle-income trap". From an overview of research documents, especially the World Development Report 2024 of the World Bank, this article aims to provide some information about the "middle-income trap", analysed from an environmental perspective with challenges and solutions for Vietnam.

THE "MIDDLE-INCOME TRAP" ON A GLOBAL SCALE

According to the World Bank, the middle-income trap is a situation in which a middle-income country systematically slows down its growth because it fails to adopt new economic structures needed to achieve high-income levels (World Bank 2024). Of the 217 countries in the world, it is estimated that in 2023 there are 108 middle-income countries, accounting for 75% of the population, more than 38% of GDP, 64% of greenhouse gas (GHG) emissions, and 62.5% of the world's poor in 2022 (Table 1). Since the 1990s, only 34 middle-income economies have succeeded in transitioning to high-income, while the rest - 108 economies by the end of 2023 - are stuck in the "middle-income trap." Since 1970, the average per capita income of middle-income countries has never grown above 10% of the average per capita income of the United States.

Regarding the cause, the World Bank Report stated that the development of the economic scale leads to changes in economic structure; however, middle-income countries do not change their management methods, leading to being stuck in the middle-income trap. In the current context, achieving high-income status will be even more difficult because of high public debt and aging populations in developing countries as well as rising protectionism in developed countries, especially rising import tariff by the United States. It can be seen that developing countries often lack the capacity to innovate, invest in education and technology, and reform institutions to be able to break through and achieve high-income levels.

Regarding solutions to escape the middle-income trap, the Report suggests that it is necessary to implement the *3i Strategy (investment, infusion, innovation)* in 3 stages: (1) Low-income countries focus on policies designed to increase *investment - 1iStrategy*; (2) Lower-middle-income countries must shift and expand to *2i, investment + infusion*; (3) Upper-middle-income countries need to shift again - to *3i*: *investment + infusion + innovation* (Table 2).

The Report emphasizes that to move to high-income status, middle-income countries must engineer two

Table 1. Classification of countries by income and selected global indicators in 2022

Groupsof countries by income	Share of global population (%)	Share of global GDP (%)	Share of people in poverty globally (%)	Share of global CO_2 emissions (%)
Low-income	8.9	0.6	36.5	0.5
Lower-middle-income	40.3	8.3	55.4	15.7
Upper-middle-income	35.1	30.3	7.1	48.6

Notes: According to the World Bank, in 2022 there are 26 low-income countries (GNI per capita below US$1,135/year in 2022); 54 lower-middle-income countries (GNI US$1,136-4,465); 54 upper-middle-income countries (GNI US$4,466-13,845); and 83 high-income countries (GNI above US$13,846).

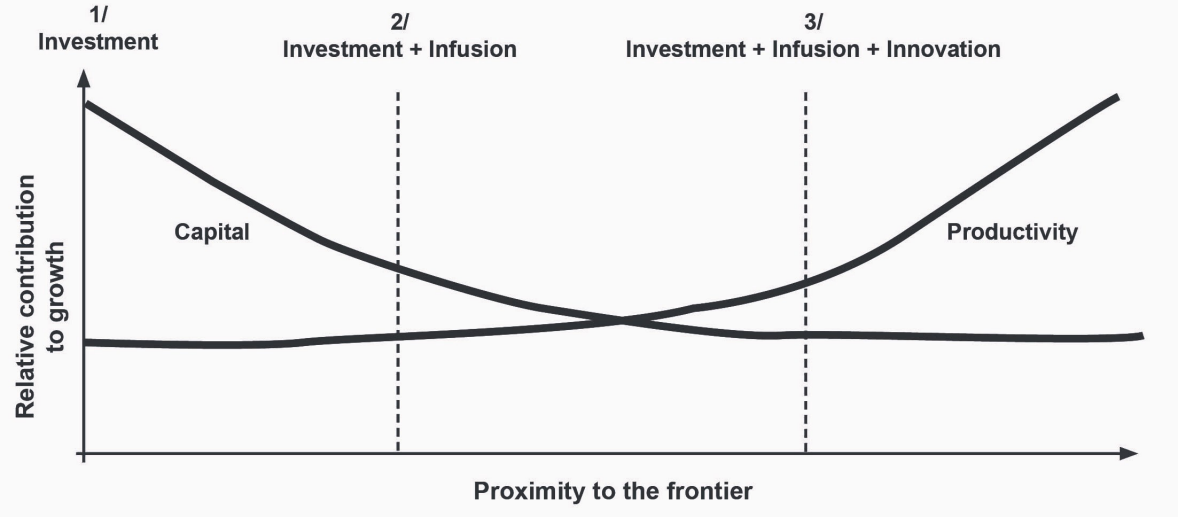
(Source: World Bank, 2024)

Table 2. To achieve high-income status, countries will need to recalibrate their mix of investment, infusion and innovation

Income classification	Investment	Infusion	Innovation
Low-income	Higher priority	Lower priority	Lower priority
Lower-middle-income	Higher priority	Higher priority	Lower priority
Upper-middle-income	Higher priority	Higher priority	Higher priority

(Source: World Bank, 2024)

Figure 1. Middle-income countries must engineer two successive transitions to move to high-income status



(Source: World Bank, 2024)

fundamental transitions, including reducing dependence on capital and increasing productivity to drive economic growth (Figure 1). Some key solutions that countries need to implement are, first of all, eliminating group interests, ensuring equality under the law and creating a fair competition regime. Middle-income countries need to focus on developing human resources, improving the efficiency inusing human resources through talent utilization mechanisms. In addition, it is necessary to take advantages of and turn challenges into opportunities, including energy conversion, energy saving and efficiency to reduce emissions; from climate change and emergency situations to create the necessary consensus for tough policy reforms.

MIDDLE-INCOME TRAP- ENVIRONMENTAL PERSPECTIVE

Economic growth is closely related to environmental pollution and degradation. According to the "Kuznets curve" theory, this relationship has an inverted U shape. Accordingly, in the early stages of development, environmental pollution and degradation increase with economic growth (usually expressed through GDP per capita), however, at a certain threshold of GDP per capita, economic growth leads to improvements in environmental quality (Cole, 2003).

The question is, how are environmental pollution and degradation related to the "middle-income trap" through their impacts on economic growth? A study by Acheampong and Opoku (2023) attempted to analyse this issue from three perspectives: human health; foreign direct investment (FDI) and; science, technology and innovation, and pointed out some key findings as follows:

Firstly, environmental degradation negatively impacts human health, thereby reducing the labour and productivity. Environmental degradation and climate change impact biodiversity, quality of air, water resources, food and infrastructure, thereby greatly affecting human health. Air pollution increases stroke, respiratory diseases, chronic obstructive pulmonary disease (COPD), cardiovascular disease, and lung cancer (Prüss-Üstün et al., 2016; WHO, 2021). Currently, it is estimated that 90% of the world's population is exposed to PM2.5 and 7 million people die prematurely due to air pollution (IQAir, 2019), with 400,000 people in Europe alone (EEA, 2022). Environmental pollution and degradation increase the burden of disease, increasing costs for governments and households. Environmental impacts on human health have negative impacts on economic growth due to reduced number and productivity of workers.

Secondly, environmental degradation has a reciprocal effect on FDI, which in turn affects economic growth. Since 2003, some scholars have proposed the "pollution haven" hypothesis, implying that developing countries are more likely to suffer from environmental pollution/degradation due to lax environmental regulations (Eskeland and Harrison, 2003). Advanced countries (with strict environmental regulations) often transfer polluting industries to developing countries through FDI. Therefore, environmental degradation due to low environmental protection standards and requirements has also increased the attraction of trade and FDI in developing countries (Cole, 2003; Copeland, 2008). Opoku et al. (2022) have shown that environmental degradation increases FDI in low- and lower-middle-income countries (such as in Sub-Saharan Africa, South Asia, Latin America and the Caribbean), while discouraging FDI in upper-middle-income countries (Europe, Central Asia, the Middle East and North Africa regions); due to the stricter environmental regulations in upper-middle-income countries.

In the current context, the green transition is taking place strongly, with commitments to reduce greenhouse gas emissions to respond to climate change under the Paris Agreement, creating a clean environment, ensuring full environmental conditions will attract high-quality FDI. Multinational corporations are paying more attention to environmental sustainability and are more likely to invest in countries with the best environmental sustainability practices (Acheampong and Opoku, 2023).

Thirdly, strict environmental regulations can promote science, technology and innovation, thereby positively affecting economic growth. According to many scholars, environmental pollution and degradation are often associated with inefficient use of resources. Therefore, strict environmental regulations will encourage companies to apply science, technology and innovation, thereby saving costs and using resources and energy efficiently (Jaffe and Palmer, 1997; Lanoie et al., 2008). Innovation will promote the development of new technologies that increase productivity, reduce costs, increase profits, and increase the competitiveness of enterprises. In many cases, innovation will lead to the development of environmentally friendly technologies and products, thereby promoting economic growth while reducing environmental pollution and degradation (Chen and Lei, 2018; Fernandez et al., 2018). This is the direction that many middle-income countries want to take.

IMPLICATIONS FOR VIETNAM

Risk of falling into the middle-income trap

Since the renovation in 1986, our country has achieved many successes, escaped the state of underdevelopment, became a middle-income country with an estimated GDP per capita of US$4,700 in 2024, a model in the world in poverty reduction. However, many studies have also shown that the risk of Vietnam falling into the middle-income trap is very high, with the following manifestations: (1) Economic growth over periods tends to slow down, specifically the average growth of the whole country in the 1991-2000 period was about 7.6%; the 2000-2010 period was about 6.6% and the 2011-2020 period was about 6%; (2) The contribution of total factor productivity (TFP) is low, on average in the 2016-2020period, TFP increased by 2.88%/year; growth is more capital-driven than labour-driven;(3) Labour productivity is still low, although it increased by an average of 5.4% per year in the 2011-2020period, it is still low in the ASEAN bloc; (4) Economic restructuring is still slow; (5) National competitiveness is still low (Pham Ngoc Hoa, 2024). It can be seen that although economic growth in 2024 reached 7.09%, exceeding the set target, Vietnam is still at great risk of falling into the middle-income trap if there is no breakthrough in the coming time.

Environmental pollution and degradation, impacts of climate change and natural disasters pose major challenges to sustainable growth

Looking back over the past time, the results of the 10-year summary (2013-2023) of implementing Resolution No. 24-NQ/TW on active response to climate change, improvement of natural resource management and environmental protection show that, despite many achievements, our country's environment still faces many challenges. Air pollution in large cities, especially Ha Noi and Ho Chi Minh City, tends to increase. Water pollution in urban areas, industrial clusters, river basins, and craft villages has not been prevented. Marine pollution due to aquaculture and plastic waste occurs in some localities. Still 85% of urban domestic wastewater and most of the wastewater from rural residential areas have not been collected and treated. Environmental protection infrastructure for the collection and treatment of domestic wastewater and domestic solid waste has not met the requirements; 29% of rural domestic solid waste has not been collected and treated; the technology for treating domestic solid waste is mainly landfill (65-70%). The establishment of new and expanded areas of nature reserves is slower than the set target; by 2022, it will only reach about 2.6 million hectares in area. Environmental pollution, degradation have been causing damage to human health in Vietnam, with an estimated 70,000 people dying each year from diseases related to air pollution;

economic losses due to impacts on agricultural production, typically environmental pollution incidents that damage aquaculture such as the Formosa marine environmental incident in 2016... and; losses to tourism activities due to a decrease in the number of tourists, especially due to plastic waste.

In addition, climate change and natural disasters continue to become more and more complex while response infrastructure in some places has not met requirements; by 2022, 17% of dams have not been upgraded, nearly 50% of boat shelters have not been invested in; 91 dangerous landslides have not been handled. The damage caused by natural disasters is still large, it is estimated that in the 2013-2022period, the average annual damage caused by natural disasters is about VND23,000 billion equivalent to US$1 billion (MONRE, 2023). Typhoon Yagi in 2024 caused severe damage, estimated at about US$3.3 billion, of which Yen Bai province alone had 54 deaths, 42 injuries, and damage of about VND5,738.2 billion, erasing growth achievements. Greenhouse gas emissions are increasing rapidly, reaching 284 million tons of CO_2e in 2014 and are forecast to reach 927.8 million tons of CO_2e by 2030 (MONRE, 2022).

SOME ENVIRONMENTAL SOLUTIONS

According to the World Bank's ranking criteria, Vietnam is currently at the threshold of transitioning from lower-middle-income to upper-middle-income. To escape the middle-income trap, according to the World Bank's recommendations, Vietnam needs to implement the *3i Strategy*, on the one hand, needs to continue to promote investment attraction and technology dissemination, on the other hand, needs to strongly promote science, technology and innovation. This is also the guideline, policy that the Party and State are implementing through the Resolution of the 13th National Congress and most recently Resolution No. 57-NQ/TW of the Politburo on breakthroughs in the development of science, technology, innovation and national digital transformation. From an environmental perspective, the following solutions need to be implemented:

- Firstly, accelerate the improvement of environmental quality to minimize damage, increase labour productivity, promote sustainable economic growth. Improving environmental quality will minimize economic damage, promote a strong increase in labour productivity, and increase the attraction of high-quality FDI. Preventing environmental pollution and effectively using natural resources will facilitate the development of agriculture, tourism, etc., increasing the competitiveness of the economy. Vietnam needs to have a plan with tasks and solutions in the short, medium and long term to minimize air pollution, especially in large cities such as Ha Noi and Ho Chi Minh City. Develop and implement policies to mobilize resources to invest in dealing with environmental pollution from industrial clusters, craft villages, and water pollution in urban areas; restore and revive rivers. Invest in infrastructure, successfully implement regulations on classification, collection, and treatment in the direction of limiting the landfill of domestic solid waste; reduce, collect, recycle, and treat plastic waste. Vietnam needs to continue to improve institutions, policies, and strengthen law enforcement on environmental protection.

- Secondly, develop infrastructure, improve capacity to proactively respond to climate change, prevent natural disasters and minimize damage. Climate change continues to evolve rapidly, the year 2024 is assessed as the hottest year ever with the average global temperature having increased by about 1.6°C compared to the pre-industrial period (1850-1900), exceeding the target of 1.5°C by the end of the century. This will increase extreme weather events, causing major impacts on socio-economic development. Vietnam needs to continue to build economic and social infrastructure and enhance capacity to respond to climate change, prevent and mitigate natural disaster risks. The system of river dykes, sea dykes, lakes, dams, storm shelters for boats, etc. need to be upgraded and built. Build disaster-resistant residential areas; survey, assess, and relocate people from areas at high risk of landslides. Build irrigation infrastructure, develop agriculture that is adaptive and resilient to the impacts of climate change, especially in the Mekong Delta.

- Thirdly, continue to innovate FDI attraction policies, shifting to high-tech, quality and greener industries; develop green infrastructure to attract green investment. As a country starting to enter the upper-middle-income threshold, Vietnam should not focus too much on quantity but must focus on attracting high-quality FDI flows, focusing on high-tech industries such as semiconductors, digital technology, artificial intelligence, etc. Gradually limit and move towards not attracting FDI from industries with resource-intensive, energy-intensive, and environmentally polluting technologies such as textiles, dyeing, leather, etc.; do not let economic growth depend on industries with low added value that are harmful to the environment.

In the context of the whole world moving towards the Net-Zero goal, multinational corporations and large enterprises are implementing green production strategies to meet the green needs of the market. The strong development of the artificial intelligence (AI) field is promoting the development of big data centers with high energy demand. These enterprises require investment in countries with green energy infrastructure and low emissions. Vietnam needs to promote the development of renewable energy, clean energy, develop ecological industrial parks; promote sustainable forest management... as a foundation to attract green FDI.

- Fourthly, greening manufacturing industries and products to meet the requirements of export markets. Vietnam is a highly open economy, participating in many free trade agreements (FTAs). Besides the domestic market, exports will still be a major driver to promote economic growth in the coming time. In the context of green transformation, with increasingly high environmental requirements of major markets, besides creating green infrastructure, Vietnam needs to green manufacturing industries, especially export industries. It is necessary to implement legal

regulations on inventory and reduction of greenhouse gas emissions, and develop carbon markets in accordance with the provisions of the Law on Environmental Protection 2020 and Decree No. 06/2022/ND-CP. Vietnam needs to shift to a circular economy model, in which recycling, reusing resources, and reducing waste become core factors in production activities. This not only helps protect the environment but also reduces costs and increases competitiveness for enterprises when entering international markets.

- *Fifthly, create favourable conditions to promote the development of science, technology, innovation, and encourage green investment.* Strengthen the application of strict and stringent regulations, improve environmental protection standards, and additionally encourage and support the development of science, technology, innovation, and digital transformation to promote the application of green technology and the production of green products. Institutionalize the guidelines, policies of Resolution No. 57-NQ/TW to unleash creativity, develop science, technology, and apply digital transformation in the whole society. Strengthen institutional reforms and encourage green investment; it is necessary to soon issue criteria for classifying green projects to unlock investment capital flows into green projects, while applying strict regulations to protect the environment. Vietnam also needs to strongly implement digital transformation to contribute to the economical and efficient use of resources and energy, and minimization of environmental pollution.

CONCLUSIONS

The middle-income trap is closely linked to the level of environmental pollution and degradation reflected in aspects of human health, FDI, science, technology, and innovation. Overcoming the middle-income trap, becoming a high-income country and achieving sustainable development is not an easy task for many developing countries, including Vietnam. However, if Vietnam knows how to closely combine economic development and environmental protection, it can completely promote economic growth while ensuring a green and healthy future for future generations. To achieve that, it is necessary to prevent environmental pollution and degradation; develop infrastructure, improve capacity to respond to climate change, prevent natural disasters; innovate policies to attract FDI, develop green infrastructure to attract green investment; green manufacturing industries and products to meet the requirements of export markets; create favourable conditions to promote the development of science, technology, innovation, and encourage green investment. Entering the era of nation's rise, Vietnam not only attaches importance to escaping the middle-income trap to become a high-income country, but also must escape environmental pollution and degradation to become a liveable country, ensuring that every citizen has the right to live in a clean environment as affirmed in the Constitution ▪

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Law on Geology and Minerals - Strengthening the effectiveness and efficiency of state management for the new development era

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The Law on Geology and Minerals was passed by the 15th National Assembly on November 29th, 2024 (Law No.54/2024/QH15) with 446/448 Delegates voting in favor. The Law has added a number of new provisions to overcome practical shortcomings, making minerals a worthy resource in socio-economic development, creating a synchronous and unified legal corridor contributing to improving the effectiveness and efficiency of state management of geology and minerals.

CONTEXT AND REQUIREMENTS IN THE NEW SITUATION

After the implementation of the Ordinance on Mineral Resources in 1989, Vietnam has gone through three generations of Mineral Laws, starting with the Mineral Law in 1996, then amended and supplemented in 2005 and the Mineral Law in 2010. It can be said that, according to each stage of the country's development, the mineral law has been adjusted appropriately and has made many important contributions to the cause of socio-economic development. Basic geological surveys have achieved remarkable results. Many new mineral areas have been discovered and evaluated, contributing to increasing the resources and reserves of some major minerals. The inspection and examination of mineral activities have had many positive changes, contributing to putting mineral activities into order and improving the effectiveness and efficiency of state management of minerals.

However, after 14 years of implementing the Mineral Law 2010, some legal regulations are no longer suitable for reality, many regulations on principles for mineral activities arising in practice need to be supplemented and adjusted to suit the new context. Moreover, the global context is changing in terms of approaches to strategic and critical minerals. Meanwhile, Vietnam is still in the early stages of developing the strategic and critical mineral industry. Some strategic and critical minerals have not yet been efficiently exploited, requiring comprehensive cooperation, including substantial investment in infrastructure, the transfer of advanced technology and technical expertise, as well as the sharing of knowledge and best practices. The Party and the State have adopted policies and strategic initiatives to develop a sustainable mining industry, leveraging Vietnam's geographical advantages (proximity to downstream markets), significantly lower operating costs compared to many other countries, and a highly skilled workforce. This makes our country a promising destination for midstream processing facilities such as refining, smelting and producing final products from strategic and critical minerals.

Based on the above context, the agency drafting the Law on Geology and Minerals has clearly established the objectives and viewpoints for building the Law, specifically:

Fully institutionalize the Party and State's viewpoints, particularly those outlined in Resolution No.24-NQ/TW of the Central Committee and Resolution No.10-NQ/TW of the Politburo. Accordingly, geological and mineral resources are both a crucial driver for the country's socio-economic development and a long-term national reserve. They must be thoroughly surveyed, assessed, and planned for exploration, with centralized and unified management. Their extraction and utilization should be sustainable, reasonable, economical, and efficient to meet both immediate and long-term needs.

The provisions of the Geology and Mineral Law must be consistent with the Constitution and aligned with relevant legal frameworks. They should be clear, comprehensible, and highly feasible, fostering investment and social engagement while strengthening resource protection and enhancing the efficiency of state management over geological and mineral resources. This should be accompanied by well-defined, transparent decentralization and delegation of responsibilities, as well as administrative reforms aimed at simplification and effectiveness.

Inheriting the provisions of the Mineral Law 2010 that have proven effective; abolishing inappropriate regulations; updating, amending, and supplementing existing regulations to align with practical realities and the requirements of state management in the field of geological resources and minerals in the new context.

Establishing a comprehensive legal framework for the protection of unexploited geological and mineral resources; strengthening environmental protection and occupational safety in mining activities; ensuring a balance of interests between the State, mining organizations and individuals, and local communities in mining areas.

Promoting decentralization and delegation of authority to local governments, enabling them to take the initiative in socio-economic development in line with local realities and their assigned responsibilities; while also establishing mechanisms for power control and implementation supervision to address existing issues and negative aspects in the field of geology and minerals.

▲ *The XV National Assembly delegates voted to pass the Law on Geology and Minerals.*

Creating a synchronous and unified legal corridor in the management of geological and mineral resource exploitation.

With 12 Chapters and 111 Articles, the Law on Geology and Minerals comprehensively regulates various aspects, including fundamental geological investigation, geological survey of minerals, protection of unexploited geological and mineral resources, mineral activities, mineral recovery, mineral processing, financial matters related to geology and minerals, auction of mineral exploitation rights, and state management of geology and minerals. These regulations apply within the territory of the Socialist Republic of Vietnam, covering land areas, islands, internal waters, territorial sea, contiguous zone, exclusive economic zone, and continental shelf.

NEW POINTS OF THE LAW INCLUDE

Regulations on fundamental geological investigation: The law clearly defines the scope and responsibilities of the State in fundamental geological investigations, including the survey, delineation, and mapping of geological sites, geological heritage, and positional resources. It also covers environmental geology, geological hazards, engineering geology, urban geology, and other geological conditions such as geological space mapping, subsurface mapping, geothermal resources, and renewable geological resources. Furthermore, it outlines the rights and obligations of organizations and individuals engaged in geological investigations, as well as the management of geological information and data. These provisions will enhance the efficient utilization of geological resources and establish a mechanism for using geological data to support socio-economic development, environmental protection, and other activities.

Classification of minerals: Based on their usage and management objectives, minerals are categorized into four groups: I, II, III, and IV. This classification allows for a more structured approach in mineral planning, exploration licensing, mineral exploitation, resource recovery, mining activity control, and mine closure. Additionally, it serves as a basis for decentralizing and delegating authority to local governments while streamlining administrative procedures specific to each mineral group.

Strengthening decentralization for local governments: The law continues the decentralization framework established in the Mineral Law 2010 while expanding the authority of provincial-level People's Committees: (i) Approval of geological investigation projects and reports – Provincial governments can approve projects and reports funded by local budgets, allowing them to assess geological conditions for subsurface spatial planning and the construction of durable infrastructure. (ii) Assessment of mineral potential – Local authorities can evaluate the potential of Group III minerals (mainly used for common construction materials) and Group IV minerals using state budget funds, facilitating the auction of mineral exploitation rights and improving the efficiency of licensing mineral activities. (iii) Approval for mineral recovery in reserved areas – Provinces have the authority to approve the recovery of reserved minerals when implementing investment projects in national mineral reserve areas. (iv) Management and licensing of mineral exploration and exploitation – Provincial governments can issue exploration and mining licenses for natural mineral water and geothermal water, aligning with investment decisions for urban and tourism development projects utilizing these resources. In addition to granting new powers, the law establishes the responsibility of provincial-level People's Committees to oversee, monitor, and regulate all mining activities and mineral recovery within their jurisdiction.

On Administrative procedure reform: Administrative procedures have been thoroughly reviewed and simplified to the maximum in order and procedures for settlement: (i) Additional special cases are allowed for mineral exploitation without requiring mineral planning, including scattered and small-scale mining, mineral recovery, and residual mineral extraction. (ii) Specific regulations for the exploitation of Group IV minerals are introduced with a strong administrative reform approach. Notably, the extraction of Group IV minerals for special cases (serving the construction of important national projects, urgent public investment projects, works, implementing emergency mobilization measures) is exempt from procedures for granting exploration licenses, approving reserves; procedures for submitting to competent state agencies to decide or approve investment policies, approve investment projects, appraise and approve the results of appraisal of environmental impact assessment reports, issue environmental licenses, and register the environment.

On mine director: The law clearly defines the cases in which a mine director is required and expands

the criteria for mine directors to better align with current industry practices and realities, including personnel management in mining operations.

On mineral mine closure: The law clearly defines mineral mine closure as an activity aimed at restoring all or part of the area used for mineral extraction projects to a safe condition, ensuring compliance with environmental protection requirements and optimizing land use after mining. Additionally, the law categorizes four different cases and establishes a hierarchical approach, ranging from stringent to simplified, for mineral mine closure procedures and formalities. Furthermore, it includes provisions for the use of state budget funds to cover the shortfall in financial obligations of mining entities in specific cases, such as when the mining organization is dissolved, goes bankrupt, or is unable to carry out the mineralmine closure process.

On funding for basic geological investigation, mineral geological survey, and mineral exploration: The law has expanded the use of local budget funds in alignment with the principle of "local decision, local implementation." In particular, the law includes a specific provision (Article 49) on the use of state budget funds for the exploration of strategic and important minerals, as well as minerals with high economic value and significant demand.

On supplementing and clarifying mineral recovery activities: This refers to integrated activities aimed at extracting minerals during the implementation of construction investment projects or other activities as approved or authorized by the competent state management agency. Mineral recovery is conducted under a different mechanism from mineral extraction.

On introducing a mechanism for investment projects in national reserve areas: The Law has stipulated the types of projects that can be implemented in national reserve areas and attached specific conditions. This regulation aims to exploit and make maximum use of land funds for socio-economic development while still meeting the requirements of mineral reserves for the country.

On mineral exploitation right fees: Originating from the state ownership regime of mineral resources as stipulated in the Constitution. Accordingly, mineral resources are public property (Article 53). Therefore, when the State grants a license to an enterprise for exploitation, the State must collect mineral exploitation right fees to transfer ownership from state ownership to private ownership and avoid mine speculation. It is important that the total amount of resource tax and right fees collected must be reasonable, administrative procedures must be simple and ensure fairness, harmonization of interests, and risk sharing among the parties. The Law stipulates that mineral exploitation right fees are calculated based on the mineral reserves allowed to be exploited or the volume of minerals allowed to be recovered; mineral exploitation right fees are collected annually and settled based on actual exploitation output. This provision creates fairness for organizations and individuals exploiting minerals and corrects errors (reliability) in mineral reserves in mineral exploration and exploitation.

On strengthening the management of riverbed, lakebed, and marine sand and gravel: The law clearly stipulates that the exploration and extraction of sand and gravel from riverbeds, lakebeds, and marine areas must comply with regulations applicable to Group II or Group III minerals. These activities must be monitored and controlled using modern technological equipment to ensure effective oversight of mineral reserve fluctuations, mitigate safety risks and severe environmental impacts, and prevent erosion and instability of riverbeds, riverbanks, floodplains, and coastal areas.

IMPLEMENTATION OF THE LAW IN PRACTICE

The Law on Geology and Minerals No.54/2024/QH15 will take effect from July 1st, 2025. However, for Group IV minerals, the law shall come into effect earlier, on January 15th, 2025, to address existing bottlenecks related to the use of Group IV minerals as filling materials for public investment projects, ensuring the timely completion of construction projects. In this regard, Ministry of Natural Resources and Environment in coordination with the Ministry of Justice and the Government Office, will undertake the following key actions:

First, expedite the development of detailed regulatory documents for the implementation of the law, including: (i) Drafting a Decree detailing specific provisions of the Law on Geology and Minerals regarding the extraction of Group IV minerals, along with a Circular providing detailed regulations on this matter (following an expedited procedure) to take effect from January 15th, 2025; (ii) Developing a Decree guiding the implementation of several provisions of the Law on Geology and Minerals, as well as a Circular specifying the format and content of mining activity licenses, reporting templates, submission deadlines, requirements for maps and cross-section drawings of authorized mining areas, and the standards for geological and mineral samples, including museum specimens (to take effect concurrently with the law); (iii) Submitting for approval or issuing, as authorized, relevant legal documents as mandated by the law.

Second, it is necessary to disseminate legal provisions to relevant agencies, organizations, and individuals, particularly focusing on new and significant provisions that address practical challenges.

Third, it is necessary ensure adequate human and technical resources, with a special emphasis on the development and operation of a geological and mineral database system.

Fourth, there is a need for conducting scientific research on newly introduced aspects, including the application of circular economy models in mineral extraction and processing, deep-sea mineral resource management, and mine closure strategies for clusters of mines, all aimed at promoting the sustainable development of the mining industry ▪

China's experience in responding to urban heat island

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1. URBAN HEAT ISLAND (UHI) INCREASES COOLING ENERGY CONSUMPTION IN CHINA

China has a North-South length of about 5,500 km and an East-West width of about 5,000 km, with an area of 9,597 km^2, ranking 3rd in the world, after the Russian Federation (17,075 km^2) and Canada (9,971 km^2), 30 times larger than Vietnam. China's population has surpassed 1.4 billion people, the largest in the world and 15 times larger than Vietnam [1]. China has five main climate types, including: Temperate continental climate; temperate monsoon climate; subtropical monsoon climate; tropical monsoon climate; highland mountain climate.

Over the past 40 years, the urbanization rate in China has developed rapidly, ranking first in the world, the urban population has increased from about 200 million to about 700 million [2]. According to World Urbanization Prospects (2024), the urban population ratio of China in 1980 was only 19.4%, increased to 36.2% in 2000 and reached 50% in 2010. It is forecasted that by 2050, the urban population ratio of China will reach 80% (Table 1).

Figure 1. Temperature variation across urban and rural areas (US. EPA, 2008)

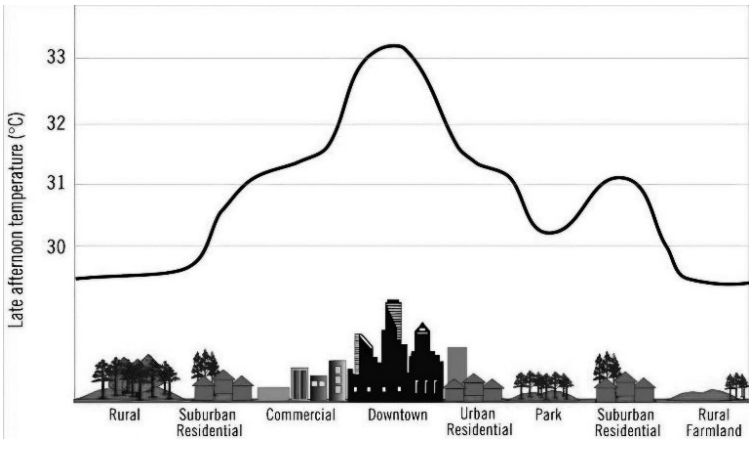


Table 1. Urbanization rate in China over the past 40 years

Year	1980	1990	2000	2010	2020	2050
% urban people	19,4	26,4	36,2	50	61,4	Forecast 80

(Source: [2])

China's rapid urbanization has also led to remarkable economic growth. Estimates from the 2023 Global Digital Economy Conference show that the size of China's digital economy has increased to 50.2 trillion yuan (about 6.96 trillion USD) by 2022, with an annual double-digit growth rate of 14.2% since 2016, China's current gross domestic product ranks second in the world after the United States. However, economic development along with increasing urban construction density gives rise to urban heat island effects (Urban Heat Island - UHI) [2]. According to Jump up to: "Glossary". Climate Change (2022) defines UHI as "The relative otherness of a city compared to surrounding rural areas" [1].

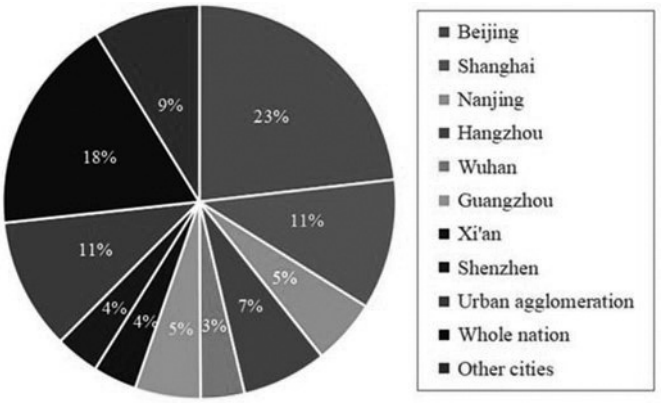
In many urban areas of China, especially those in subtropical and tropical monsoon climates, much of the urban land area for planting trees and wetlands due to urbanization has been converted into concentrated construction land, increasing the surface area for absorbing solar radiation (SIR). In addition, the amount of artificial heat waste from urban cooling equipment (air conditioning systems); transportation activities; industrial production and other manufacturing industries... has made the temperature in urban areas higher than the temperature in surrounding rural areas. This is the UHI phenomenon, increasing greenhouse gas emissions (CO_2) and accelerating climate change (CC) [1].

Over the past 15 years, many cities in China have increased UHI, mainly in the eastern and southern regions. Therefore, hundreds of scientific research works on UHI in China have been carried out, with the following four methods: (i) Meteorological observation method is a method that uses long-term meteorological data from both pre- and post-urbanization periods, as well as urban and suburban meteorological data in the same period; (ii) Using fixed measurements or the horizontal measurement method is a method that uses mobile or horizontal mini weather stations focusing on short-term data to assess UHI; (iii) The remote sensing method is performed using thermal images from satellites, commonly used satellite data are MODIS (1 km), ASTER (90 m), Landsat-5-TM (120 m), Landsat-7-ETM+ (60 m) and Landsat-8-OLI/TIRS (100 m); Among them, many researchers use MODIS and Landsat TM/ETM+/OLI data to study UHI with open access to data collection and spatial coverage of the study area; (iv) Numerical simulation methods are methods to predict various environmental parameters (e.g., temperature, humidity, and wind speed) in urban spaces. Actual air temperature or

surface temperature measurement data are often used as boundary conditions in numerical simulation calculations, and the results of numerical simulation studies are compared with measured data for analysis and optimization [2,3,4,5,6,7]. Among them, remote sensing method is applied the most by Chinese scientists to study UHI. Most of the studies on UHI in China in recent times have used remote sensing method. According to Chart 2, the proportion (%) of UHI studies using remote sensing methods is distributed by locality as follows: Beijing (11%); Shanghai (11%); Nanjing (11%); Wuhan (11%); Guangzhou (5%); Xi'an (9%); Hangzhou (4%); Shenzhen (4%); Yangtze River Delta Urban Cluster (18%); research on national issues (7%) and in other urban areas (9%) [2].

China has also led to a significant increase in energy consumption. According to statistics, energy demand in construction in China accounted for about 24.1% of the total national energy use in 1996, reaching 27.5% in 2010, increasing to 35% in 2020 [2]. Studies around the world have shown that energy consumption of construction works accounts for about 47% of

Figure 2. Proportion (%) of UHI studies using remote sensing methods distributed by locality, based on analysis of hundreds of scientific research works on UHI published in China in the past 15 years [2].



total primary energy consumption in Switzerland; 42% in Brazil; 40% in the USA; 39% in the UK; 25% in Japan and 23% in Spain [2]. The UHI effect is considered as one of the important factors that increase building energy consumption due to increased space cooling demand in summer and space heating demand in winter [3]. Li et al. [3] reviewed the existing literature on the impact of UHI on building energy consumption and found that UHI increased the average cooling energy consumption by 19.0% at the national, regional and global levels. The impact of UHI on building energy consumption depends largely on the local climate, as well as the type and characteristics of the building. Compared to rural areas, UHI in urban areas of Beijing increased cooling by 11% and heating by 16% [4]. Similarly, the UHI effect increased air conditioning energy demand by about 10% in Hong Kong. In addition, the impact of UHI on building energy consumption varies according to building type. Studies in Nanjing, China (2017) [4] showed that the cooling load of office buildings increased by 4.0 - 7.1%, while the cooling load of apartment buildings increased by 11.2 - 25.2%. The impact of UHI on building energy consumption also differs between urban centers and urban suburbs. Research results by Chu et al., 2017 show that the heat load index of buildings located in the city center in winter is 1.5-5.0% lower than that of buildings in the suburbs [4].

2. SOLUTIONS TO MITIGATE THE IMPACT OF URBAN HEAT ISLANDS IN CHINA

2.1. Development of urban green space

Developing urban green spaces is an important solution widely applied in China to cool the city by natural, sustainable measures and prevent the formation of UHI. Trees have the effect of shading, absorbing solar radiation (SIR), reducing ambient air temperature and ground temperature, reducing energy costs for air conditioning.

In addition, trees have the effect of absorbing dust, smoke and some toxic chemicals that pollute the air environment, reducing noise. During the day, trees absorb CO_2, absorb heat from the environment and absorb underground water, releasing O_2 according to the following reactions:

$$6\,CO_2 + 5\,H_2O + 674\ carlo = C_6H_{10}O_5 + 6\,O_2 \quad (1)$$

$$6\,CO_2 + 6\,H_2O + 674\ carlo = C_6H_{12}O_5 + 6\,O_2 \quad (2)$$

Thus, the chlorophyllization process of green trees will increase the amount of O_2 in the air (increase by about 20%) and reduce the concentration of CO_2 in the surrounding air. Therefore, to cope with the UHI effect, it is necessary to first ensure the minimum green area ratio in urban areas. Urban greening can clean the air, regulate temperature, regulate local climate and improve the city's ecosystem. There have been many studies evaluating urban greening measures to protect human health when urban temperatures increase rapidly [1].

Landscape planning and development of urban green spaces (UGS) including parks, flower gardens, street trees, green spaces in campuses, agencies and public works... can form the urban cooling island effect (UCI). Research by Tan et al. (2015) found that small parks with lots of trees are green spaces that significantly reduce urban air temperatures. Research by Yan et al., 2018, shows that the cooling effect of parks can extend beyond the park border by nearly 1.4 km; Research by Chang et al. (2014) shows that the larger the park size, the stronger the regional cooling effect.

2.2. Green Roof (GR)

Green Roof (GR), also known as eco-roofs, living roofs and rooftop gardens, has great potential to impact the urban environment, as rooftops account for nearly 20-25% of a city's surface area. In China, where the majority of buildings in some major cities such as Beijing, Shanghai, Chongqing and Hong Kong are densely packed, the deployment of GR helps save energy, reduce noise and air pollution. Although GRs increase the initial investment compared to traditional roofs, they mitigate the UHI effect in urban areas because green vegetation can significantly change albedo values and reduce heat transfer to buildings. A sensitivity test by He et al (2017) showed that better thermal performance in both summer and winter can be achieved by

increasing the substrate thickness or using GR on uninsulated buildings. The study by Tam et al [6] showed that GR can reduce the indoor temperature on the top floor by up to 3.4°C, with the cooling effect of GR being strongest in summer and weakest in winter for the Shanghai area.

2.3. Cool roof

Cool roofs are roofs with solar panels installed and covered with materials with high solar radiation reflectance (SAR) Albedo coefficient. In China, the installation of solar panels on all roofs is encouraged, both to supplement renewable energy sources and to reduce the thermal load on building cooling equipment, resulting in effective reduction of UHI effect and CO_2 emissions.Coating roofs with highly reflective solar radiation coatings has been shown to be an effective measure to reduce heat gain. Calculations also show that a vinyl roof reflects at least 75% of the sun's rays and emits at least 70% of the solar radiation absorbed by the building envelope. In contrast, asphalt roofs have a solar reflectance of only 6% to 20% [9]. When installed on rooftops in dense urban areas, passive radiant cooling panels can significantly lower outdoor air temperatures during the day. Green roofs provide insulation during hot months and can also have a positive impact on stormwater management and reduce energy costs for cooling buildings.

2.4. Green trees on the facade of construction works

Green plants on building facades are also called "vertical greening systems", "vertical gardens", "green walls" and "bio-walls". This model is becoming more and more popular in China because of its small scale, high aesthetic value and good UHI reduction ability. These effects can further benefit psychological well-being and reduce noise, protect the building envelope and provide biodiversity. Greenery on building facades can reduce wall temperatures to save energy through interception of solar radiation, insulation due to vegetation, evaporative cooling and acting as a windbreak. Yin et al. (2017) found that trees on building facades can significantly reduce the surface temperature of building facades by up to 4.67°C and the cooling effect of trees on building facades is most obvious at noon. Research by Cheng et al. (2010) showed that building envelopes with green facades reduce air conditioning energy consumption and the cooling efficiency is closely related to the green coverage area and humidity in the growing environment. Pan et al. (2016) showed that greenery on building facades can save 16% of total electricity consumption. A study on applying greenery on building facades for high-rise apartment buildings showed that greenery on building facades can reduce 2651 × 106 kWh of electricity and 2200 × 106 kg of carbon dioxide emissions per year (Wong and Baldwin, 2016). Different types of trees have different characteristics including plant species, leaf area, canopy thickness, etc., of which canopy thickness is considered the most important factor affecting the thermal performance of trees on building facades. In addition, the maximum surface temperature of walls with trees on facades is reduced by 6.3°C compared to walls without trees. Building orientation, climate and weather contribute significantly to the thermal performance of trees on building facades.

2.5. Appropriate urban planning and construction form

Urban planning determines urban form and affects urban climate, and conversely, urban climate can be adjusted and improved through urban planning to meet the needs of people. Urban planning and urban design have practical environmental implications to minimize the UHI effect of some urban areas by adjusting or optimizing urban form. Urban scale, urban geometry and vegetation coverage are the most basic urban morphological factors affecting the urban thermal environment. From the perspective of mitigating the UHI effect, China has planned the development of small cities, medium-sized cities and large cities with multi-centers and multi-directional development. From the perspective of minimizing the UHI effect, small and medium-sized cities and large multi-centered cities should be planned to develop in a strip-like direction, in accordance with the hydrological network, taking into account the enhancement of green areas with various plant species. The main structures should be oriented parallel or slightly oblique (no more than 15 degrees) to the main wind direction of the city. In addition, urban development planning needs to preserve and expand green areas and water surfaces to reduce UHI generation. Ensure that at least 40% of public urban spaces have shade from trees. On the other hand, planning the direction of roads in urban areas to maximize natural ventilation, create air flow patterns through neighborhoods, shape wind corridors, and promote biodiversity development to minimize UHI formation during the hot season. Rows of trees on urban streets need to have thick, wide canopies and be about 10-15 m high so that the trees can both provide good sun protection and not obstruct the wind flow easily through the streets. Arranging clusters of buildings in a linear layout is more effective in cooling the city than a "U" or "口" layout. The UHI effect will be mitigated by using white materials or materials that reflect solar radiation on walls, roofs, sidewalks and roads [7].

2.6. Cool sidewalks and roads

The pavement and road surface have changed the original thermal properties of the natural ground, and when the pavement and road surface temperature increases, the air temperature near the pavement and road also increases, causing the UHI effect. Chinese studies have recommended specific solutions to cool the pavement and road surface: Qin et al. (2015) recommended that reflective pavement and road surfaces should be used when the aspect ratio of urban alleys is less than 1.0 m. Ziang et al. (2019) [9], designed a solar reflective coating to cool pavement and asphalt pavement. Experimental results show that the reduction in surface temperature of sidewalks and roads is about 8.5°C - 9.5°C. Luu et al. (2018) showed that permeable sidewalks and roads help reduce street flooding when it rains, and when it is sunny, water seeps from the ground to the surface, evaporates, and absorbs heat from the BXMT, so it contributes

greatly to reducing UHI, with a maximum cooling level of 9.4°C compared to traditional sidewalks and roads. In addition, Giang et al. (2018) designed a road-based thermoelectric generator system that can convert or transfer road surface heat into electricity, lowering the surface temperature by 8 - 9°C in summer.

2.7. Urban water surfaces

Urban water bodies are one of the main components of urban areas, with high thermal capacity and low thermal conductivity, which can effectively mitigate the UHI effect. Urban water bodies mainly include rivers, canals and reservoirs, forming urban cool areas.Yang et al. (2016) showed that rivers and lakes in Bozhou, China are the main source of urban cooling in summer. Wang et al. (2014) showed that wetlands have a good temperature-regulating effect, and the closer the urban area is to wetlands, the more significant the urban temperature-regulating ability is.Xue et al. (2019) showed that the average cooling capacity index of wetlands in Changchun City (China) was 2.3 times higher than that of conventional urban land, and the average cooling value of wetlands with flows connected to other surface water bodies was 6 times higher than that of isolated wetlands. Du et al. (2017) found that urban rivers change the surrounding air flow and the UHI near the river is lower. By studying the effect of artificial ponds on the urban thermal environment using experimental methods, Syafii et al. (2017) found that urban environments with ponds are better than urban environments without ponds, especially during daytime hours, and ponds arranged with larger surface areas show better cooling effects.

2.8. Urban ventilation

Urban ventilation, which takes advantage of wind characteristics to bring fresh air from the suburbs into the city, is considered one of the main mitigation strategies to reduce the UHI effect. In addition to removing heat, urban ventilation is also important for improving living environment quality, eliminating air pollution and saving energy. For example, in a new district of Shenzhen, the initial actual urban development did not use the urban ventilation scheme, which resulted in the blocking of urban wind channels and enhanced the UHI effect. Research results of many authors suggest that the increase in near-ground air pollution in Chinese cities and the frequent occurrence of smog during winter in China, as well as the increase in UHI effect in summer are all related to poor ventilation in cities, so urban ventilation planning is very necessary.Xu et al. (2016) analyzed the spatial distribution of UHI and cool sources based on the daily average temperature distribution map of typical meteorological conditions and proposed the planning of urban ventilation channels to reduce UHI. Based on the urban expansion model of Dalian City (China) with high construction density, leading to a decreasing trend in annual wind speed, Guo et. al (2017) studied the natural ventilation performance evaluation of different building types using a fluid dynamics computational simulation tool. The research results show that urban areas, such as row houses and high-rise buildings with large foundations, are not conducive to natural ventilation, while reasonable planning and measures such as open urban space, creating ventilation channels, appropriately increasing building height, reducing the foundation volume of high-rise buildings, adopting reasonable building shapes and reducing building facade areas all have significant effects on promoting urban ventilation and alleviating the UHI effect ▪

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Promoting Public-Private Partnership or Waste-to-Energy: Lessons from China

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Nowadays, to manage the sustainably and effectively the rapidly increasing volume of municipal solid waste (MSW), many countries have sought the implementation of Waste-to-Energy (WTE) projects under Public-Private Partnership (PPP) frameworks. This approach aims to reduce pressure on public budgets and attract private sector participation in WTE initiatives. Thus PPP activities in MSW treatment have grown rapidly in China, contributing significantly to improved MSW management efficiency, active private sector engagement in energy recovery from waste, and the advancement of the national circular economy. In such a regards, this article analyzes the implementation of PPP-based WTE projects in China, focusing on incentive policies that encourage the development of such projects particularly those using the PPP model and provides policy recommendations for Vietnam.

PPP MODELS FOR WTE PROJECTS IN CHINA

In China, PPP arrangements have been widely applied in the WTE incineration sector to leverage private sector advantages in innovation, expertise, flexibility, and financial capacity. In 2004, China had only 54 incinerators with an annual design capacity of 6.17 million tons, treating 2.9% of the collected MSW (4.49 million tons). By 2018, this number increased to 331 incinerators with an annual capacity of 133.08 million tons, handling 44.67% of collected MSW (101.84 million tons), with at least 80 additional WTE plants planned. By 2019, over 80 projects were under development with a total investment of 35 billion yuan (CNY), with at least 80% of China's WTE incineration projects procured and operated through PPPs. Among these, the Shenzhen PPP project stands out as the largest WTE plant in China, with a capacity of 5,000 tons/day. In this project, private investors are responsible for both construction and operation, holding project management rights for 20 years. Additionally, WTE projects in Central and Western China, as well as in third- and fourth-tier cities, hold significant development potential due to saturated markets in developed areas and growing demand in less-developed regions. PPPs provide essential financial support for developing WTE incineration projects in these emerging areas. WTE projects are key to enabling a circular economy by maintaining the value of products, materials, and resources in the market for as long as possible and minimizing waste and resource use.

Several prominent and successful PPP-based WTE projects currently in operation in China include: Lujiashan Plant, with a capacity of 3,000 tons/day, operating since 2013 in Beijing, invested by private partner Shougang Bio Technology; Jiangqiao Plant, with a capacity of 1,500 tons/day, operating since 2005 in Shanghai, invested by private partner Shanghai Environment; Jiangnan Plant, with a capacity of 5,000 tons/day, operating since 2014 in Nanjing, invested by private partner China Everbright; Heimifeng Plant, with a capacity of 2,000 tons/day, operating since 2017 in Nanjing, invested by private partner Junxin Environment; Shenzhen WTE Project, with a capacity of 5,000 tons/day, operating since 2023, invested by private partner Shenzhen Energy Group.

China has implemented a comprehensive set of mechanisms and policies to promote the development of waste-to-energy projects using both municipal solid waste (MSW) and industrial solid waste (ISW). These policies include financial, tax, electricity pricing, technological, and socialization incentives aimed at optimizing resource use and minimizing environmental impacts.

Land Incentives: (1) Land Allocation: Priority is given to land located within renewable energy zones or green industrial parks to expedite project implementation; (2) Land Leasing and Tenure: WTE investors are granted exemptions or reductions on land lease payments during the initial 5–10 years. Continued incentives may apply based on project performance and scale; (3) Infrastructure Planning Support: The government assists in basic infrastructure planning, including grid connectivity, transportation access, and utility services.

Capital Incentives: (1) Direct Financial Subsidies: Provided for WTE projects employing advanced technologies that meet environmental standards, with subsidies covering 20–30% of total investment costs; (2) Preferential Loans: WTE projects are eligible for low-interest, long-term loans (10–20 years) from the China Development Bank and national financial institutions. Some projects may also receive government loan guarantees; (3) Fixed Power Purchase Tariffs (FiT): A fixed electricity purchase price mechanism ensures stable returns, with WTE-generated electricity priced higher than conventional sources-approximately USD 10/kWh; (4) Approval and Disbursement Timeline: Projects are typically approved within 3–6 months, depending on their scale and technology, with priority given to high-potential projects.

Electricity Price Incentives: (1) Preferential Tariff Policy: Introduced in 2012, WTE plants receive higher electricity prices than traditional power plants. Pricing is based on the calorific value of the waste, encouraging better pre-incineration sorting; (2) Electricity Price Subsidies: Direct subsidies are also provided to offset operating costs and sustain fixed tariffs, especially for plants using advanced flue gas treatment technologies meeting international environmental standards; (3) Higher Tipping Fees: To reduce landfill reliance, higher tipping fees are applied to WTE plants compared to landfills-ranging from USD 10 to 39 per ton, depending on region and waste type.

Tax Incentives: (1) VAT Exemptions or Reductions: For investments in essential WTE equipment and technology; (2) Corporate Income Tax Reductions: Available for WTE projects using MSW or ISW, with 5–10 years of preferential tax rates depending on project scale and performance; (3) Import Duty Exemptions: High-tech equipment used in WTE facilities such as advanced incineration systems, emission control technologies, and recycling technologies is exempt from import taxes.

Technology Incentives: (1) R&D Funding: The government funds 20 - 50% of research costs for projects developing advanced WTE technologies to ease the financial burden on enterprises and accelerate technological innovation; (2) International Technology Transfer: Financial and technical support is provided to help facilities adopt international best practices, optimize energy recovery, and meet global environmental standards. Enterprises can access training and technical support through research institutes or foreign partners;

Grid Connection and Waste Treatment Fee Incentives: (1) Grid Connection, the government offers full or partial exemptions on initial grid connection fees and prioritizes WTE plants for grid access to streamline deployment; (2) Waste Treatment Fees: Landfill disposal is priced higher than incineration, boosting the competitiveness of WTE facilities. Tipping fees at WTE plants range from USD 10 to 39 per ton and are higher than landfill charges. Plants may also receive subsidies for treating difficult waste types or operating in high-volume areas.

In addition to general policies promoting waste-to-energy projects, PPP projects in China have some specific policies to encourage socialization in solid waste treatment and ensure the effectiveness of projects under this model:

- The Chinese government encourages community and private sector participation through the implementation of Public-Private Partnership programs. Private investors are granted long term operational rights typically ranging from 20 to 30 years depending on the specific project to reduce the burden on public investment and attract private sector involvement in the construction and operation of WTE plants.

- Four common PPP models are prioritized in the WTE sector in China, namely: Build-Operate-Transfer (BOT), Build-Own-Operate (BOO), Transfer-Operate-Transfer (TOT), and Operation and Maintenance (O&M). For each PPP project, one of these models is selected based on the management and execution capacity of local authorities, as well as the investor's needs, in order to ensure sustainable and effective operation throughout the project lifecycle.

- Environmental access conditions are specified for WTE projects, focusing on the selection of advanced, highly reliable technologies that are adaptable to the specific characteristics of local municipal solid waste. Pilot programs for building "Zero-Waste Cities" are also being implemented to promote sustainable development.

- WTE projects, particularly those developed under the PPP model, are required to coordinate with local communities to raise awareness about waste management and environmental protection. This includes public education initiatives and campaigns to promote waste segregation at source, thereby improving the quality of feedstock for WTE facilities.

- Private sector providers participating in PPPs in the WTE sector are categorized into two main types based on the combustion technologies used: (1) Professional investment enterprises using imported combustion technologies, such as China Everbright International and China Environment Protection, which typically finance, construct, and operate WTE plants utilizing imported grate furnace technologies like Mitsubishi-Martin; (2) Professional investment enterprises using domestically developed combustion technologies, such as Jinjiang Environment and Dynagreen Environment, which generally finance, construct, and operate WTE plants using independently developed circulating fluidized bed incineration technologies.

- Administrative procedures are streamlined to reduce approval times, enabling projects to move quickly into the operational phase. The average duration from project approval to commissioning for PPP-based WTE projects in China is approximately 18 months.

RECOMMENDATIONS FOR VIETNAM

Vietnam is currently promoting WTE projects, with seven projects operational as of December 2024, including: Soc Son WTE Plant in Hanoi; Can Tho WTE Plant; Three projects in Bac Ninh Province: Ngoi Sao Xanh (2023), Thuan Thanh, and Luong Tai (2024); Phu Son WTE Plant in Thua Thien - Hue (2024); Bình Duong WTE Plant (2024); Additionally, two projects are in trial operation: Thăng Long WTE Plant in Que Vo, Bac Ninh, and Seraphin WTE Plant in Xuân Son, Hanoi. According to Decision No. 500/QĐ-TTg dated May 15, 2023, approving the National Power Development Plan for the period 2021–2030, with a vision to 2050, and Decision No. 262/QĐ-TTg dated April 1, 2024, approving the implementation plan of the same, 28 WTE projects are planned for implementation and operation between 2024 and 2030.

In Vietnam, WTE projects benefit from incentives under current legislation, including: Law on Environmental Protection (2020); Investment Law (2020); Land Law (2024); Electricity Law (2024); Corporate Income Tax Law (2013, revised 2023); Value-Added Tax Law (2024); Public Investment Law (2024); Science and Technology Law (2013); and related guiding documents. Key areas of support and incentives are illustrated in Figure 1 and include:

WTE projects under the PPP model in Vietnam, beyond general incentives, are also eligible for special incentives under the Public Investment Law (2024), including provisions to attract domestic and foreign private investors for priority project types specified in Article 9 - Criteria for Class-A projects - such as waste treatment projects with a total investment capital of VND 3,000 billion or more. After the Land Law (2024) takes effect, only PPP-based WTE projects will be eligible for land lease reductions, as stipulated in Decree No. 103/2024/NĐ-CP on land use and lease fees. Ho Chi Minh City is currently planning to attract investment for a new PPP-based WTE project with a capacity of 2,000 tons/day in Cu Chi District.

Ficture 1. Incentives, support and incentives related to promoting the development of power generation projects using solid waste

Incentives, support and incentives related to promoting the development of power generation projects using solid waste					
Land Incentives: - Allocation of land resources or prioritization of land use for WTE projects. - Financial support for land lease payments. -Exemptions or reductions in land lease fees and land use charges.	Tax Incentives: - Corporate income tax reductions for projects utilizing renewable energy derived from waste. - Exemptions or reductions in import taxes for equipment and technologies serving WTE projects. - Value-added tax (VAT) reductions. -Export tax policies for products generated from WTE projects.	Preferential Loans and Financial Support: - Provision of concessional loans and interest rate support for a defined period.	Technology Incentives: - Promotion of research, development, and transfer of new technologies in waste treatment and recycling. - Organization of training programs and capacity building for human resources in the sector. - Encouragement of international cooperation projects in environmental technologies and municipal solid waste (MSW) recycling	Electricity Price Incentives: - Establishment of preferential feed-in tariffs (FiT) for electricity generated from waste. - Long - term power purchase commitments to ensure investment security and capital recovery for investors.	Grid Connection and Waste Treatment Cost Incentives: - Technical and infrastructure support for grid connection. - Waste treatment fees determined through agreements between project developers and local authorities.

Based on the review of China's incentive policies for PPP-based WTE projects, several recommendations are proposed to help Vietnam effectively implement similar projects:

1. In addition to Circular No. 36/2024/TT-BTNMT on technical-economic norms for MSW collection, transportation, and treatment (including energy recovery incineration technologies), it is necessary to issue regulations on incinerable waste types, technical manuals, and guidance for technology selection tailored to local MSW characteristics and investment capabilities, whether at the provincial or interprovincial level.

2. Inter-regional and inter-provincial WTE projects should be incorporated into planning to ensure stable MSW supply. Designing large-scale projects instead of fragmented ones can save land, allow for modern, well-planned technology investments, and improve capital recovery efficiency for both investors and local budgets under the PPP model. This approach will increase the number of WTE projects implemented via PPP.

3. It is essential to specify how each incentive (land, capital, tax, technology, electricity price, grid and infrastructure connection, socialization) is to be applied. This will support diverse technologies (e.g., direct incineration, landfill gas recovery, gasification, biogas, co-incineration), and allow periodic adjustments so that investors have reliable information to assess market opportunities in the waste-to-energy sector.

4. For PPP-based WTE projects, the appropriate PPP model should be selected to ensure effective management, environmental protection, and financial feasibility for both local governments and investors. Transparent PPP frameworks should support private companies with maximum legal, financial, and procedural incentives while sharing operational risks.

5. Private partners should be selected based on criteria that ensure proven experience, credibility, financial sustainability, and technological readiness. This will help maintain and enhance the effectiveness of PPP-based WTE projects over the long term ▪

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Just coal transition in some countries in the world and lessons learnt for Vietnam

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Just energy transition is a shift from fossil energy to clean, low-carbon energy without causing negative impacts on society, people's jobs and livelihoods. This is a global trend, especially in the context of countries' commitments to achieving net zero emissions by the middle of the 21st century. At the COP26 Summit in 2021, the Group of Seven (G7) and the European Union (EU) launched the Just Energy Transition Partnership (JETP) Initiative to support the energy transition of developing countries with a high share of coal-fired power generation. In the context of increasingly limited climate finance due to global economic difficulties, the JETP is one of the solutions to help developing countries access the necessary resources to effectively build and implement low-carbon development pathways that are resilient to climate change. After the negotiation process, the Political Declaration on Establishing the Just Energy Transition Partnership (JETP Declaration) was adopted by Vietnam and the International Partners Group (IPG) on 14th December 2022 in Brussels, Belgium. International partners participating in the JETP with Vietnam include the European Union, the United Kingdom of Great Britain and Northern Ireland, the United States, Japan, Germany, France, Italy, Canada, Denmark, and Norway. As the third country after Indonesia and South Africa to sign the JETP, Vietnam is the first country to announce a Resource Mobilization Plan to implement the JETP. This is considered a crucial and essential step to unlock financial resources from JETP and transform them into breakthrough projects, strongly promoting Vietnam's just energy transition. This proves that Vietnam is ready and will create the best conditions to receive resources to implement a just energy transition. However, for developing countries like Vietnam, this transition not only faces financial and technological difficulties but also requires major institutional and policy changes. This article focuses on analysing the experience of just coal transition in countries like Indonesia, South Africa, and India, on that basis, draws some suggestions for Vietnam.

JUST COAL TRANSITION IN SOME COUNTRIES

Indonesia

Despite the bleak outlook for coal, countries with large coal-fired power sources are stepping up efforts to develop technology and operational innovations to improve the environmental impact, efficiency, flexibility and cost of coal-fired power. Indonesia, the world's fourth most populous country, is endowed with abundant resources, a young population, a potential domestic market, and strategic economic and policy reforms, gradually asserting its position as a leading regional and global economic prospect. Indonesia is also the world's largest coal exporter, investing in many coal-fired power plants, leading to overcapacity in some parts of the country. Faced with this situation, Indonesia has issued many response policies including the "Long-term Strategy on Low Carbon and Climate Resilience 2050", the "National Energy Grand Strategy" with the "National Energy General Plan". These strategies encourage the development of renewable energy based on available potential, technology, finance and social efficiency. In order to implement renewable energy development strategies, Indonesia has many tax incentive mechanisms, supports for loans to import renewable energy technology, human resource development, etc. In addition to the greenhouse gas emission reduction targets in the "Enhanced Nationally Determined Contribution 2022", Indonesia aims to increase the share of renewable energy in the primary energy mix to at least 23% in 2025, 31% in 2050; oil must be below 25% in 2025, below 20% in 2050; coal must be at least 30% in 2025, 25% in 2050; gas must be at least 22% in 2025 and 24% in 2050. From these targets, JETP in Indonesia aims to support policy reforms, help the Government facilitate green finance and investment and strengthen the legal framework. Accordingly, JETP investments will mainly be loans to the Government or to enterprises and guaranteed by the Government. Public sector financing will aim to promote private sector investment.

India

Coal is a major pillar of India's energy sector, accounting for around 70% of the country's electricity production. As the world's second-largest coal consumer, this country relies heavily on the coal mining industry to sustain its economic and social activities. However, this poses significant challenges related to the environment, public health, and sustainable development goals. India has pledged to achieve net zero emissions by 2070, but this transition is facing many obstacles because the coal industry plays a vital role in the economy, from providing

energy to creating jobs. At the same time, if the transition is accelerated without a support plan, millions of people could fall into poverty. According to India's Ministry of Power, coal-fired power accounts for 51% of installed capacity, but generates more than 70% of the country's total output by 2022. India is aiming for renewable energy to account for 50% of its energy mix by 2030. However, there is no plan to announce the retirement of any of its 172 existing coal-fired power plants before 2030. Instead, the country's largest power companies, such as NTPC, proposed a gradual approach to improving efficiency and reducing emissions. This includes the adoption of super-critical (SC) and ultra-supercritical (USC) technologies. In 2019, state-owned NTPC started up its first USC coal-fired power plant at the 1,320 MW (2 units) Khargone Super Thermal Power Station in Madhya Pradesh. In early 2023, India's independent power producer Adani Power began operating the 1.6 GW Goddam Supercritical Thermal Power Plant. The project in Jharkhand state, also known as India's first "cross-border power project" to supply 100% of its electricity to Bangladesh, is also India's first project to have 100% flue gas desulfurization (FGD), SCR and zero effluent discharge.

South Africa

South Africa is the most developed country in Africa, located at the southern tip of Africa. With three capitals and 11 official languages, it is considered Africa's bridge to the world. South Africa's coal industry is the fifth largest in the world, employing 90,000 miners, generating 80% of South Africa's electricity and providing raw materials for 25% of South Africa's liquid vehicle fuel. As a country that relies on coal for electricity, South Africa has reduced its dependence by choosing cleaner energy. South Africa became the first country to adopt the JETP Declaration with development partners from the UK, US, France, Germany and the European Union at COP26. Indonesia, Vietnam and Senegal followed suit, joining the JETP with the International Partners Group, and are developing implementation plans. South Africa began developing its Just Energy Transition Investment Plan after adopting the JETP Political Declaration, and completed it one year later in October 2022. The Plan identifies a need for US$98 billion in clean energy development and supports for a "just" transition over the long term, investing in green hydrogen infrastructure and electric vehicle manufacturing. South Africa needs another year to develop an action plan to implement the JETP. The EU and its member states recently announced that they will invest more than €280 million in South Africa to support green recovery reforms, green investment and development of a knowledge-based transformation process. This is part of the Just and Green Recovery Team Europe Initiative for South Africa, which was launched in Pretoria at the Global Gateway. The Initiative is expected to help South Africa address pressing socio-economic challenges through policy dialogue and investment facilitation, including in public infrastructure, and to open up the way for sustainable development, circular economy, biodiversity protection and climate change response. South Africa's commitment to the implementation of the just energy transition plan is internationally recognized, with the view that Africa's leading economy will benefit from a low-carbon, climate-resilient economy in the long term.

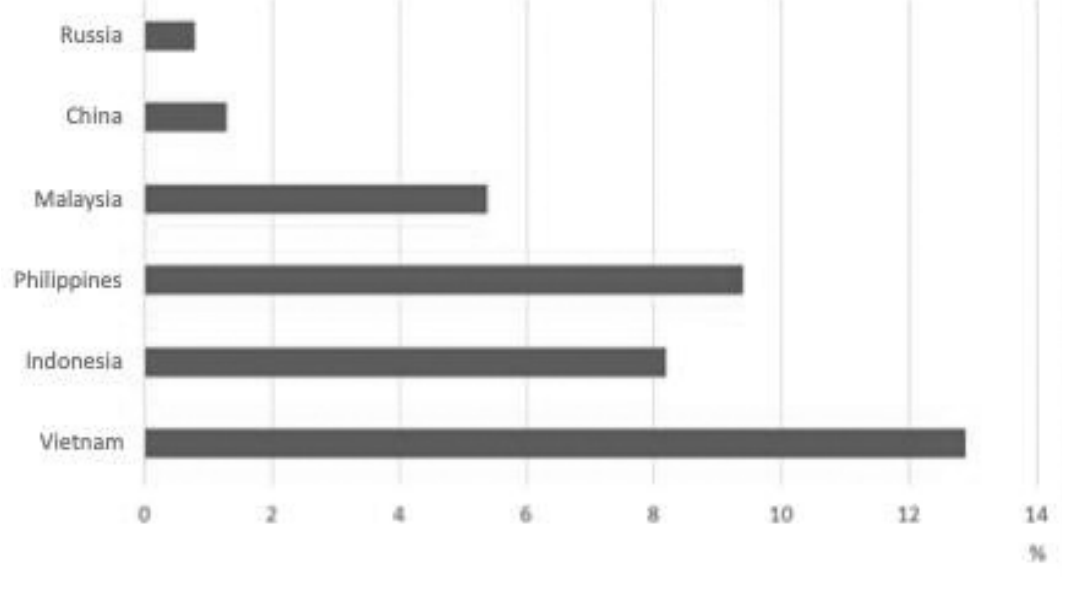

Figure 1. Average annual growth rate in coal consumption in some countries in the APEC region (2010-2020 period).

(Source: [1])

SOME SUGGESTIONS FOR VIETNAM

Coal is an accessible and affordable primary energy source, widely used in electricity generation and heavy industry sectors in our country, but has a high CO_2 emission intensity when used. According to the Nationally Determined Contribution (NDC) 2022, CO_2 emissions from the energy sector and industrial production processes in Vietnam in 2020 were 428 million tons of CO_2 equivalents, accounting for nearly 81% of Vietnam's total greenhouse gas emissions [2]. Vietnam is also the country with the highest coal consumption growth rate in the APEC region. Especially in the 2010-2020 period, the amount of coal consumed in Vietnam increased very rapidly with an average growth rate of 12.9%/year.

At COP26, Vietnam made a commitment to striving for net zero emissions by 2050 and joined the Global Coal to Clean Power Transition Statement. To implement the above international commitment, the Government of Vietnam has taken specific actions to realize climate change goals through a series of new policies issued in the past two years, specifically: Decision No. 896/QD-TTg dated 26 July 2022 approving the National Strategy on Climate Change to 2050, action plans of ministries and sectors on implementing the commitment at COP26. Most recently, on 15th May 2023, the Prime Minister approved the National Power Development Plan VIII. For coal-fired thermal power plants in this Plan, only projects that are already included in the adjusted Power Plan VII and are being invested in and built until 2030 will be continued. According to the development orientation, coal will not be used for power generation by 2050. For coal-fired thermal power plants that are still technically viable at that time, fuel will be converted to biomass and ammonia. For plants with a lifespan of more than 40 years, they will stop operating if they cannot convert fuels or capture CO_2. In the heavy industry sector, the proportion of coal consumed will also gradually decrease in the coming decades, but at a slower rate than the power generation sector. Thus, through a series of international commitments and specific policies, it can be seen that the transition from fossil energy to renewable energy is an inevitable trend of the whole world and Vietnam is no exception.

Experience from other countries shows that it is necessary to develop a comprehensive and overall strategy to successfully transition from energy to clean energy with specific goals including:

First, ensure energy security for economic development. For domestic coal mining, it is necessary to continue investing in basic construction and preparing for production to meet domestic coal needs, in order to minimize coal imports from abroad. For imported coal, continue maintaining long-term contracts with foreign suppliers and partners at appropriate rates, avoiding over-reliance on the spot coal market which is easily affected by many external factors. On the other hand, expand joint ventures, partnerships, and invest in mines abroad (if deemed appropriate) to ensure stable supply.

Second, the energy transition must be associated with social equity. The energy transition can only be considered successful if it puts people at the centre, especially the issue of job creation for coal workers after 2050. Therefore, it is necessary to develop an implementation roadmap and specific plans for retraining and supplementary training for coal workers. Switch to training in occupations that are suitable for the energy transition trends of the world and Vietnam. For example, in the coming years, the demand for key minerals and raw materials (lithium, nickel, cobalt, and rare earths, copper) will increase sharply to serve the production of clean energy technologies such as wind turbines, solar panels, electric vehicle batteries, and power transmission systems. At that time, coal workers need to be trained in additional expertise in mining technology, mineral and raw material processing to be able to work in mines and mineral processing sites. Along with that, there is new training to adapt to the requirements of new types of jobs in the energy transition period. For example, jobs in renewable energy, hydrogen production, electric vehicle production, and storage battery production. In addition, it is necessary to establish a "Just Energy Transition Fund" for the coal industry to support workers in the transition period to stabilize their lives after losing their jobs.

Third, the energy transition must aim at environmental protection. In particular, ensure the target and roadmap for reducing greenhouse gases; focus on waste treatment and other negative impacts from energy activities ▪

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Biodiversity - The strongest natural defense against climate change

Biological diversity is the variety of life on Earth, in all its forms, from genes and bacteria to entire ecosystems such as forests or coral reefs. The biodiversity we see today is the result of 4.5 billion years of evolution, increasingly influenced by humans. Biodiversity forms the web of life that we depend on for so many things – food, water, medicine, a stable climate, economic growth, among others.

CLIMATE CHANGE AND ITS IMPACT ON BIODIVERSITY

Climate change refers to the long-term changes in temperature and weather due to human activities. Increase in average global temperature and extreme and unpredictable weather are the most common manifestations of climate change. In recent years, it has acquired the importance of global emergency and affecting not only the wellbeing of humans but also the sustainability of other life forms. Enormous increase in the emission of greenhouse gases (CO_2, methane and nitrous oxide) in recent decades largely due to burning of coal and fossil fuels, and deforestation are the main drivers of climate change. Marked increase in the frequency and intensity of natural disasters, rise in sea level, decrease in crop productivity and loss of biodiversity are the main consequences of climate change. Obvious mitigation measures include significant reduction in the emission of greenhouse gases and increase in the forest cover of the landmass. Conference of Parties (COP 21), held in Paris in 2015 adapted, as a legally binding treaty, to limit global warming to well below 2°C, preferably to 1.5°C by 2100, compared to pre-industrial levels. However, under the present emission scenario, the world is heading for a 3–4°C warming by the end of the century. This was discussed further in COP 26 held in Glasgow in November 2021; many countries pledged to reach net zero carbon emission by 2050 and to end deforestation, essential requirements to keep 1.5°C target. However, even with implementation of these pledges, the rise is expected to be around 2.4°C. Additional measures are urgently needed to realize the goal of limiting temperature rise to 1.5°C and to sustain biodiversity and human welfare.

Increase in atmospheric temperature has serious consequences on biodiversity and ecosystems, and human wellbeing. The most important evidences of climate change is the long term data available on the CO_2 levels, global temperature and weather patterns.

Increase in temperature impacts two aspects of growth and development in plants and animals. One of them is a shift in distributional range of species and the other is the shift in phenological events. Plant and animal species have adapted to their native habitat over 1000s of years. As the temperature gets warmer in their native habitat, species tend to move to higher altitudes and towards the poles in search of suitable temperature and other environmental conditions.

Climate change induced shifts in species would threaten their sustenance even in protected areas as they hold a large number of species with small distributional range. The other impact of climate change on plant and animal species has been in their phenological shift. Phenology is the timing of recurring seasonal events; it is a sort of nature's calendar for plants and animals. In flowering plants, various reproductive events such as the timing of flowering, fruiting, their intensity, and longevity are important phenological events, and in animals some of the phenological events include building of nests in birds, migration of animal species, timing of egg laying and development of the larva, pupa and adult in insects. Phenological events of both plants and animals are generally fixed in specific time of the year as they are based on environmental cues such as temperature, light, precipitation and snow melt. Phenological timings of species are the results of adaptations over 100s of years to the prevailing environment.

Human activity has already altered over 70 per cent of all ice-free land. When land is converted for agriculture, some animal and plant species may lose their habitat and face extinction. But climate change is playing an increasingly important role in the decline of biodiversity. Climate change has altered marine, terrestrial, and freshwater ecosystems around the world. It has caused the loss of local species, increased diseases, and driven mass mortality of plants and animals, resulting in the first climate-driven extinctions.

Climate change affects the health of ecosystems, influencing shifts in the distribution of plants, viruses, animals,

and even human settlements. This can create increased opportunities for animals to spread diseases and for viruses to spill over to humans. Human health can also be affected by reduced ecosystem services, such as the loss of food, medicine and livelihoods provided by nature.

MITIGATION MEASURES

The principal mitigation measures against climate change are obvious; they include significant reduction in greenhouse gas emission, prevention of deforestation and increase in the forest cover. To reduce greenhouse gas emission, use of coal and fossil fuels needs to be reduced markedly. As climate change is a global challenge, local solutions confined to one or a few countries do not work; we need global efforts. Many attempts are being made to achieve these objectives at the global level since many decades. Mitigation measures are largely at the level of diplomatic negotiations involving states and international organizations, governments and some nongovernmental organizations.

When human activities produce greenhouse gases, around half of the emissions remain in the atmosphere, while the other half is absorbed by the land and ocean. These ecosystems and the biodiversity they contain are natural carbon sinks, providing so-called nature-based solutions to climate change.

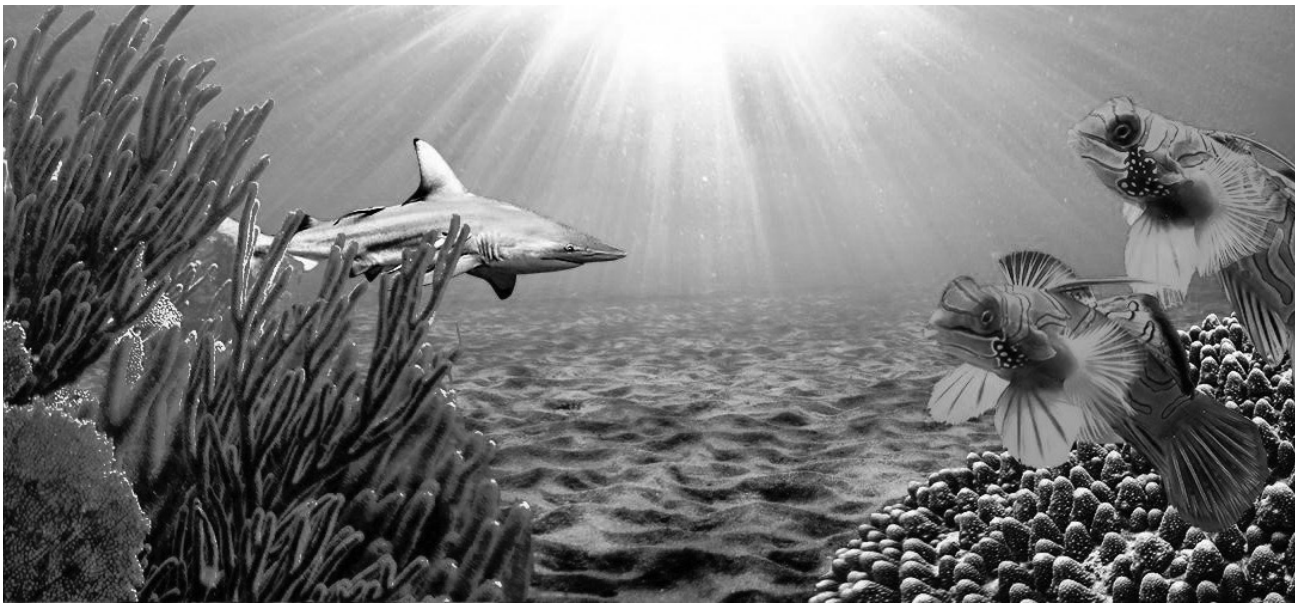
Protecting, managing, and restoring forests, for example, offers roughly two-thirds of the total mitigation potential of all nature-based solutions. Despite massive and ongoing losses, forests still cover more than 30 per cent of the planet's land. Preserving and restoring peatlands means keeping them wet so the carbon doesn't oxidize and float off into the atmosphere.

Ocean habitats such as seagrassess and mangroves can also sequester carbon dioxide from the atmosphere at rates up to four times higher than terrestrial forests can. Their ability to capture and store carbon make mangroves highly valuable in the fight against climate change.

Conserving and restoring natural spaces, both on land and in the water, is essential for limiting carbon emissions and adapting to an already changing climate. About one-third of greenhouse gas emissions needed in the next decade could be achieved by improving nature's ability to absorb emissions.

Effective implementation of the pledges made by different countries in COP 26 and actions to be taken in the coming COP meetings are going to be crucial and determine humanity's success or failure in tackling climate change emergency. COP 26 climate pact to cut greenhouse gas emissions, end of deforestation and shift to sustainable transport is certainly more ambitious then earlier COPs. There are also many other positive signals for reducing fossil fuels. Scientists have started using more precise monitoring equipment to collect more reliable environmental data, and more options are being developed by researchers on renewable and alternate energy sources, and to capture carbon from industries or from the air.

People are becoming more conscious to reduce carbon emission by following climate-friendly technologies. Human sufferings associated with an increase in natural disasters throughout the world have focussed public attention on climate change as never before. They also realise the benefits of improved air quality by



reducing consumption of coal and fossil fuels on health and ecosystems. The demand for electric vehicles is steadily growing. Reforestation is being carried out in a large scale in many countries. Recent studies across a range of tree plantations and native forests in 53 countries have revealed that carbon storage, soil erosion control, water conservation and biodiversity benefits are delivered better from native forests compared to monoculture tree plantations. This has to be kept in mind in reforestation programmes. Hopefully the world will be able to realize the goal of limiting the temperature rise to 1.5 °C by the end of the century and humanity would learn to live in harmony with nature.

SOLUTIONS FOR PROTECTING BIODIVERSITY

Human-caused threats to biodiversity, like habitat degradation and overfishing, require people-centered solutions that meet the needs of wildlife and local communities. To protect biodiversity and the prosperity of local communities worldwide, we must adopt and spur demand for more responsible and sustainable practices that safeguard soil, water, forests, and wildlife.

Rare is the global leader in developing, implementing, and scaling behavioral science for conservation. Building upon our deep experience in biodiversity conservation, our social marketing approach cuts across fisheries, regenerative agriculture, innovative finance, climate action, and other pressing environmental issues to foster individual and community action that helps people and nature thrive.

Solutions for protecting biodiversity must come from the local communities stewarding those resources. Rare balances conservation with human use, centering local communities in solving natural resource challenges. Through its people-centric approach to biodiversity conservation, rare deploys behavior change campaigns that help individuals and communities develop sustainable practices for protecting wildlife, using land, and managing coastal fisheries.

Taking account of nature will allow us to identify who benefits and how from the services that nature provides. And who would suffer and how if those services are no longer available. It also allows us to see how by making efforts to preserve and protect nature, we are in fact preserving and protecting the livelihoods and incomes of hundreds of millions of people who depend on nature. This is where we can start to formulate much more informed policies that can benefit groups that are otherwise disadvantaged.

One of the reasons we can insist on climate action is that the nature of the problem is clear. We can put a number on how much global warming we can live with before we are really in danger of irreversible problems.

We do not have that for biodiversity. The biodiversity of one ecosystem is entirely different to the biodiversity of another. So it is very hard to come up with one single number that can mobilize the entire world.

If every country measures their ecosystems and the value they get from them, it will be much less important that there are differences between types of ecosystems. What will be important will be the value that human beings derive, and understanding what we need to do to protect them. That will give a great boost to the global biodiversity agenda ▪

NGUYỄN XUÂN THẮNG

(Source: https://www.un.org)

Decree No. 05/2025/ND-CP - Strengthening decentralization and empowering localities to proactively control environmental issues

HOÀNG NHẤT THỐNG
Ministry of Agriculture and Environment

Decentralization and delegation of environmental oversight refer to a management mechanism that distributes authority and responsibilities from higher to lower levels, from the central government to local authorities. The implementation of this mechanism enhances the effectiveness of state management, promotes socio-economic development, and reduces the workload at the central level, allowing it to focus on policy planning, institutional development, and legal refinement. At the same time, it empowers local governments to take proactive and innovative approaches in managing environmental issues within their jurisdictions.

Based on the Party's guidelines and policy of "*Enhancing decentralization and delegation, clearly defining responsibilities between the Government and ministries; and between the Government, ministries, and local authorities" and "ensuring unified state management while promoting the proactive, initiative, creative role and sense of responsibility of each level and each branch*"[1] the Government and the Prime Minister have directed efforts to strengthen decentralization and delegation in state management, including in the environmental sector. In line with these directives, the Ministry of Natural Resources and Environment, in coordination with relevant agencies, has developed and submitted for approval the Decree No.05/2025/ND-CP, dated January 6, 2025, which amends and supplements certain provisions of the Decree No.08/2022/ND-CP, dated January 10, 2022, detailing the implementation of several provisions of the Law on Environmental Protection (hereinafter referred to as the Decree No.05/2025/ND-CP). Accordingly, the Decree No.05/2025/ND-CP provides for the decentralization and delegation of environmental oversight to local authorities in the following key areas:

Decentralization and delegation of responsibility for management and protection of natural heritage environment

The Decree No.05/2025/ND-CP stipulates: For heritages that are national parks, nature reserves, species-habitat conservation areas, landscape protection areas established in accordance with the provisions of the law on biodiversity, forestry and fisheries; scenic spots recognized as cultural heritages established in accordance with the provisions of the law on cultural heritage that have had regulations, plans and management strategies before this Decree takes effect, the People's Committee at the provincial level is responsible for directing the adjustment to integrate and update the contents as prescribed in this Decree into the regulations, plans and management strategies as prescribed by the law on biodiversity, forestry, fisheries and cultural heritage within 06 months from the effective date of this Decree.

This regulation has delegated authority to the Provincial People's Committee to direct the adjustment to integrate and update the contents as prescribed in this Decree into the regulations, plans, and management strategies for the conservation and environmental protection of natural heritage sites.

Decentralization of the People's Committee at provincial level to appraise environmental impact assessment reports and issue environmental licenses under the authority of the Ministry of Natural Resources and Environment

The Decree No.05/2025/ND-CP introduces provisions that decentralize the authority of provincial-level People's Committees to appraise environmental impact assessment (EIA) reports and issue environmental permits (where applicable) for investment projects that would otherwise fall under the Ministry of Natural Resources and Environment's jurisdiction. However, this does not apply to projects that extend across two or more provincial-level administrative units; are located in marine areas where the administrative responsibility of a People's Committee at provincial-level has not been determined; or discharge wastewater into inter-provincial surface water sources that have been designated by Ministry of Natural Resources and Environment under water resource regulations.

The decentralization applies to the following types of projects: (i) Public investment projects that do not require approval of investment policies by the National Assembly or the Prime Minister, except for projects involving waste recycling and treatment services. (ii) Livestock farming projects. (iii) Projects involving the establishment of livestock and poultry slaughterhouses. (iv) Projects classified solely based on the requirement to convert two or more consecutive rice-growing seasons into other land uses. (v) Projects classified solely based on the requirement to convert land or water surface within nature reserves, natural heritage sites, biosphere reserves, important wetlands, special-use forests, protection forests, or natural forests. This applies only to projects that do not require investment policy approval by the National Assembly or the Prime Minister. (vi) Investment projects in industrial zones, business-service clusters, and

1. Communist Party of Vietnam (2021), *Documents of the 13th National Congress of Delegates* , Volume I, National Political Publishing House Truth, Hanoi.

concentrated production areas, excluding Projects that involve hazardous waste treatment services, import scrap materials from abroad for production, engage in large-scale industrial activities with a high risk of environmental pollution, as specified in Column (3) of Appendix II of this Decree, and Expansion projects of existing facilities that are exempt from wastewater connection requirements under environmental regulations, with wastewater discharge levels requiring periodic monitoring. (vii) Hydropower projects that do not require investment policy approval by the National Assembly or the Prime Minister.

Along with the above content decentralization, the Decree No.05/2025/ND-CP also stipulates that the Provincial People's Committee is responsible for:

First, review, prepare, and complete the necessary financial, human resources, and other essential conditions to ensure the successful implementation of delegated duties and powers. The administrative procedures for delegated cases must be conducted in a transparent, public, and convenient manner for the relevant organizations and individuals during implementation.

Second, take responsibility before the Ministry of Natural Resources and Environment for the results of the environmental impact assessment report appraisal and the issuance of environmental permits for investment projects and facilities that have been delegated authority.

Third, organize inspections and audits to ensure compliance with environmental protection laws for projects that have been delegated the authority to approve environmental impact assessment reports and issue environmental permits, as directed by the Ministry of Natural Resources and Environment, except in cases of surprise inspections as per environmental protection law.

Fourth, submit periodic reports every six months (by January 15th and July 15th annually) or reports on the progress of delegated tasks to the Ministry of Natural Resources and Environment for monitoring.

Fifth, direct the development, operation, updating, and integration of environmental impact assessment and environmental permit databases for delegated entities into the provincial-level environmental database, ensuring interoperability with the national environmental database.

Decentralization and delegation of authority for the management and monitoring of the management and use of escrow funds and environmental restoration:

While the Decree No.08/2022/ND-CP did not specify the management and monitoring of the use of escrow funds and environmental restoration, the Decree No.05/2025/ND-CP clearly defines the authority of provincial-level People's Committees to manage and monitor the management and use of escrow funds and environmental restoration in mineral extraction activities and waste disposal at provincial-level environmental protection funds.

Decentralization and delegation of authority for solid waste management:

The Decree No.08/2022/ND-CP specifies that provincial-level People's Committees set specific prices for the collection, transportation, and disposal of solid waste at paragraph 3 of this article; the cost of treatment and collection methods for the cases in paragraphs 4 and 5 of this article must ensure that the cost of solid waste disposal is accurately calculated per unit of solid waste for treatment.

In the Decree No.05/2025/ND-CP, it is specified that Provincial People's Committees determine the price of solid waste collection, transportation, and disposal services at paragraph 3 of this article according to price laws, with treatment costs and collection methods for the cases in paragraphs 4 and 5 being calculated correctly and fully for each unit of solid waste.

Thus, the Decree No.08/2022/ND-CP specifies that Provincial People's Committees set specific prices for services, while the Decree No.05/2025/ND-CP provides that Provincial People's Committees determine the service price.

In addition to decentralizing the authority of Provincial People's Committees to control environmental issues, the Decree No.05/2025/ND-CP also grants district-level People's Committees authority to select facilities for the collection and transportation of solid waste through bidding, ordering, or task assignment according to legal regulations. At the commune level, People's Committees are responsible for coordinating and facilitating community consultation activities for environmental impact assessment reports.

With the provisions of the Decree No.05/2025/ND-CP, decentralization to local authorities for proactive environmental management will allow for more tailored and timely solutions. Local governments will be able to adjust measures more flexibly, taking on greater responsibility for environmental protection and accountability to local populations. This promotes creativity and innovation in line with local conditions, thus enhancing the effectiveness of environmental governance both locally and nationally ▪

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1. Communist Party of Vietnam (2021), Documents of the 13th National Congress of Delegates, Volume I, National Political Publishing House Truth, Hanoi.

2. Law on Environmental Protection 2020.

3. Decree No.08/2022/ND-CP dated January 10, 2022 of the Government detailing a number of articles of the Law on Environmental Protection.

4. Decree No.05/2025/ND-CP dated January 6, 2025 of the Government amending and supplementing a number of articles of Decree No.08/2022/ND-CP dated January 10, 2022 of the Government detailing a number of articles of the Law on Environmental Protection.

5. Resolution No.04/NQ-CP dated January 10, 2022 of the Government on promoting decentralization and delegation of power in state management.

Scheme on development of bioindustry in the field of environmental protection to 2030

TRẦN QUỐC TRỌNG
Department of Environment, Ministry of Agriculture and Environment

Over the years, biotechnology in Vietnam has made rapid progress and is now gradually being brought to an industrial scale. In the field of environmental protection, in order to promote the development and application of biotechnology, the MONRE has issued supporting policies such as: Developing and submitting to the Prime Minister to promulgate Decision No.1660/QD-TTg dated 7 November 2012 on "Scheme on development and application of biotechnology to environmental protection to 2020". However, activities of the Scheme have only stopped at implementing a number of ministerial-level subjects of the MONRE on monitoring, conservation and treatment of residual persistent wastes and chemicals, so they have not met the requirements of environmental protection. Especially now, with the economic development and industrial modernization, the process of environmental pollution is very complicated with scale and severity, requiring pollution treatment technology not only to be effective but also environmentally friendly. In order to improve the efficiency and scale of biotechnology application in the environmental sector and additionally promote the role of the environmental biotechnology sector as an economic sector contributing to GDP, the Prime Minister has promulgated Decision No. 553/QD-TTg dated 21 April 2017 approving the Master Plan for the development of bioindustry to 2030. Accordingly, on 24 December 2024, the Prime Minister promulgated Decision No. 1639/QD-TTg approving the Scheme on development of bioindustry in environmental protection to 2030.

Status of development and contribution of environmental industry to socio-economy in Vietnam

It is estimated that in the next 10 years, when the country's GDP doubles, if there is no solution, environmental pollution will increase 3 times, and by 2030 it could be 4 to 5 times the current pollution level. Economic losses due to industrial pollution affecting human health in Vietnam are currently about 0.3% of GDP, increasing to 1.2% of GDP in 2016. According to a research by the Vietnam Institute of Strategy and Policy for Industry and Trade, the need for investment in environmental protection in 18 sectors and fields that have great impacts on the environment such as alcohol, beer, soft drinks, seafood, paper, textiles & garment, steel... is up to VND120,000 billion, equivalent to USD7.6 billion. Urban pollution also poses many problems when the need for urban environmental protection in 20 provinces and cities (in the survey) requires up to VND 85,000 billion... These are quantifiable losses and investment needs. The above bases affirm the importance of environmental industry in Vietnam.

The context of Vietnam's import and export turnover of environmental goods and services (according to APEC's classification of environmental goods and services) in the 2010-2015 period shows that the average growth rate reached 20% per year and the turnover increased from USD 2.7 billion in 2010 to USD 5.3 billion in 2015. Of which, the market share of Vietnam's environmental goods and services only accounts for about 10-15%. Bioindustry enterprises are still limited in both quantity and scale, with low charter capital (52.6% of enterprises are small-scale with capital under VND 5 billion, the number of large-scale enterprises with capital over VND 500 billion accounts for only about 2.84%). Environmental industry enterprises mainly focus on the service sector, while there is a lack of strong enterprises to solve the country's big and important problems. The products and equipment supplied to the market are mainly mechanical products, simply manufactured, at low level, enterprises have not paid attention to investing in product research, development, improvement, and technology innovation. This weak industry has not met the annual demand for urban wastewater treatment, solid waste processing and recycling, and hazardous waste treatment.

In the structure of environmental enterprises in 2011, up to 50.97% of enterprises registered to operate in the field of waste collection, treatment and disposal, scrap recycling and 33.62% in the field of water exploitation, treatment and supply. Only 13.47% of enterprises registered in the field of water drainage and wastewater treatment and only 1.94% registered to operate in pollution treatment and other waste management activities. Initial statistics show that in 2007, in the field of wastewater treatment, the whole country had only 36 enterprises registered to operate (Industry code E), but by 2010, the number had increased to 153 enterprises. In the field of solid waste collection and treatment,

there were 270 enterprises in 2007 and by 2010, there were 463 enterprises. At the end of 2012, according to a survey by the Vietnam Environment Administration (MONRE), there were 3,982 enterprises registered to operate in the field of environmental services, of which 3,581 enterprises were established in the 2006-2012 period, and in the 2006-2009 period alone, there were 2,321 enterprises established and registered to operate in this field. For the field of wastewater treatment, in the 2007-2010 period, the average growth rate of registered enterprises reached 62%/year, the growth rate of labour force reached 45%/year, and the average growth rate of capital reached 78%/year. In the field of solid waste collection and treatment, the growth rate of the number of enterprises reached 20%/year in the 2007-2010 period, the increase in labour reached 8%/year and the increase in capital reached 36%/year.

Although there are no complete statistics, it can be seen that the quality of environmental services and products has been formed and plays an important role in environmental protection. However, in reality, it has not yet demonstrated its true role and potential, has not met the actual requirements of environmental protection and brought economic value. Currently, many recycling fields such as waste oil, waste plastic, waste electrical & electronic products, etc. have almost undeveloped. Meanwhile, attracting investment capital into developing environmental bioindustry and saving energy is still low, not commensurate with the requirements of society. The environmental service sector still relies mainly on funding from the State budget, especially in the field of urban wastewater treatment services. In addition, environmental bioindustry enterprises in Vietnam are not really linked to the development of scientific research, as well as scientific and technological achievements domestically and internationally. This has reduced many advantages and real development directions for environmental industry, significantly reducing the competitiveness of Vietnamese enterprises in both the domestic and foreign markets.

Develop biotechnology in environmental protection in a sustainable and friendly direction

In order to develop the bioindustry in environmental protection in a sustainable and friendly direction, to control and improve environmental quality and effectively use natural resources; to enhance the potential for research, application and mastery of biotechnology in environmental protection in the region and the world, the Prime Minister promulgated Decision No. 1639/QD-TTg dated 24 December 2024 approving the Scheme on development of bioindustry in environmental protection to 2030.

The Scheme sets out specific objectives such as implementing research and development of biotechnology in environmental protection in the direction of mastering core technologies, advanced biotechnology to produce waste treatment preparations in the production and processing of agricultural, forestry and aquatic products, medical waste treatment products; industrial, health care and domestic waste treatment products; in addition, promoting the establishment and development of at least 10% of enterprises producing industrial-scale biological preparations used in waste treatment and equipment lines for producing biological products in environmental protection; investing in developing human resources and key laboratory facilities to meet the needs of developing bioindustry in environmental protection, focusing on developing biological preparations in waste treatment; completing the system of legal documents and national database on the development of technologies and bioindustry in environmental protection.

Based on the overall review of Vietnam's environmental protection guideline, the National Environmental Protection Strategy to 2030 with a vision to 2050, the Scheme sets out the main contents for developing and applying biotechnology in environmental protection as follows: Build and improve the system of legal documents, mechanisms and policies to promote the development of biotechnology in environmental protection; Research, develop and apply biotechnology in monitoring and assessing environmental quality; Research, develop and apply environmental bioindustry in the production of biological preparations and materials to treat wastes that pollute the environment; Research, manufacture, upgrade and produce equipment and production lines for the production of biological products and waste treatment in environmental protection; Develop and apply bioindustry in incident response, environmental restoration and development of natural ecosystems, environmental protection; Apply environmental bioindustry in recycling and producing environmentally friendly products and materials; Develop information systems and national database on bioindustry in environmental protection; Strengthen international cooperation in the field of bioindustry in environmental protection; Communicate to raise awareness of bioindustry in environmental protection.

Promote technology research, application, transfer, and mastery of production technology

To implement the above contents, the main solutions proposed are solutions on science and technology development,

policy, investment and finance, resource development, international cooperation and communication, specifically:

Development of science and technology

Promote technology research, application, transfer, and mastery of technology of producing bioindustry products for environmental protection; prioritize the application of modern and synchronous bioindustry research results in production and business.

Use science and technology budget to support research, reception, decoding, development, and purchase of new technologies in the field of biotechnology from abroad to develop bioindustry enterprises. Support, encourage enterprises to increase investment in technology research and innovation, reception and transfer of advanced biotechnology, widespread and effective application of technical advances and new technologies to produce and trade key products and goods in the field of environmental bioindustry.

Promote and invest in depth in centers supporting the development of biological enterprises in a number of scientific and technological research units to create an effective bridge between scientific research units and enterprises in order to promptly apply new technologies in production.

Strengthen the application of modern, synchronous, environmentally friendly technologies, suitable to the characteristics of the environmental protection sector, apply biology and biotechnology in environmental pollution treatment.

Build pilot models, provide policy and technical solutions, advanced technologies in producing and perfecting products in the chain from research to production, trade and consumption, access the 4.0 technology platform between economic sectors, create the premise for sustainable and environmentally friendly development of biotechnology, thoroughly and effectively use technologies and raw materials.

Policy

Promulgate or submit to competent authorities to promulgate policies to support the development of bioindustry in environmental protection.

Review, develop and promulgate regulations on the development of bioindustry in environmental protection.

Develop, coordinate with line ministries and sectors to promulgate regulations on training and developing human resources for the development of environmental bioindustry.

Investment and finance

Review and submit to competent authorities to promulgate and improve policies and mechanisms to encourage enterprises to invest in industrial-scale production and commercialization of biotechnology products according to market mechanisms, including: Incentive policies for investment in development of investment projects and establishment of bioindustry enterprises, incentive land use tax, loan support, technology transfer support; Incentive policies on corporate income tax, import-export tax, income tax; attracting and diversifying domestic and foreign investment resources for the development of environmental bioindustry; Selecting focused investments, key sources of budget capital combined with non-budgetary investment capital; Effectively organizing for implementation and closely managing programs, schemes, projects on developing and applying biotechnology in environmental protection; funding for short-term training, funding for technology reception, and technology decoding from countries with technology sources suitable for the development orientation of environmental bioindustry;

State budget capital is used for implementing scientific and technological tasks and supporting budget capital based on orders from local authorities, enterprises, specialized state management agencies in the country, evaluation and appraisal opinions of the Scientific Advisory Council; investing in infrastructure, machinery, equipment and human resources for the enterprise supporting center; investing in building the key biotechnology laboratory of the MONRE; infrastructure for quality control, monitoring, assessment of biosafety of biotechnology products and strengthening technical facilities, machinery and equipment for biotechnology laboratories of research institutes and universities

by region; training human resources, implementing international cooperation tasks and some other related contents of the Scheme;

Develop and coordinate with line ministries and sectors to promulgate regulations on management and control of biosafety for biotechnology products in accordance with Vietnamese and international policies and legislations; on training and developing human resources for environmental biotechnology development in particular and related sectors in general.

Development of human and material resources

Invest in-depth, strengthen key facilities, techniques, machinery and equipment in environmental sector to meet the requirements towards modern and synchronous environmental bioindustry; Improve the capacity of scientific research staff of scientific and technological, technology transfer organizations and bioindustry enterprises; Train highly skilled workers to work in biological production enterprises & factories; Implement the planning for training human resources specialized in environmental biotechnology to meet the needs of developing environmental bioindustry, with focus on training a team of highly qualified post-graduate experts and leading experts to master technology for the development of bioindustry; provide short-term and long-term training, and vocational training to ensure quality according to new forms of training.

International cooperation

Promote international cooperation in developing human resources, training technology experts and transferring technology, focusing on cooperation with countries having developed bioindustry;

Strengthen cooperation in importing and transferring technologies and equipment, promote access to and mastery of some important areas of modern environmental biotechnology; purchase copyrights, receive and decode advanced, environmentally friendly technologies and materials; hire foreign experts when necessary;

Create favourable conditions for enterprises to proactively cooperate and receive technology transfer for industrial production of biotechnology products with competitive advantages from abroad.

Communication

Organize propaganda, dissemination and implementation of the contents of the Directive of the Party Central Committee's Secretariat, specifically Resolution No. 36-NQ/TW dated 30 January 2023 of the Politburo on the development and application of biotechnology for sustainable development of the country in the new situation and the Government's Master Plan on bioindustry development to 2030 to create a strong change in the awareness of all levels, sectors and the whole society about the role, position and importance of bioindustry in general, environmental bioindustry in particular for the cause of industrialization and modernization of the country, developing bioindustry into an economic-technical sector that makes great contributions to national economic growth;

Disseminate results of scientific research, technology transfer, and introduce environmental bioindustry enterprise models to the people;

Propagate to encourage all levels, sectors and people to use domestically produced agricultural bioindustry products and build Vietnamese brands;

Organize domestic technology workshops and forums to connect enterprises, science and technology units, domestic and foreign experts to promote cooperation, application, and development of technologies and products. Coordinate with socio-political organizations, unions, and relevant agencies to conduct training to improve communication capacity on environmental bioindustry; develop communication materials, disseminate knowledge on bioindustry;

Continue to build, upgrade and improve the webpage on environmental biotechnology to ensure compatibility and suitability with the national digital transformation program; disseminate information online on environmental bioindustry; provide information on technologies, equipment and technology transfer. Promote information, communication, dissemination and education to raise awareness of ecological environmental protection for all levels, sectors and the entire population.

Biotechnology is a high-tech field based on the foundation of life sciences, combined with processes and techniques to create technologies that exploit the life activities of microorganisms, animal and plant cells for socio-economic development and environmental protection. Starting from the industrial revolutions, biotechnology was transformed into a profit-making industry, called bioindustry.

Bioindustry is defined as the use of biotechnology in processing, industry, medicine, agriculture, food and environment to create a profitable high-tech economic-technical sector. Bioindustry includes the modern application of biotechnology to the sustainable processing and production of chemical products, materials and fuels ▪

Green Growth: A sustainable pathway for economic and environmental harmony

Sustained growth is necessary to achieve the urgent development needs of the world's poor and that there is substantial scope for growing cleaner without growing slower. Green growth is necessary, efficient, and affordable. It is the only way to reconcile the rapid growth required to bring developing countries to the level of prosperity to which they aspire with the needs of the more than 1 billion people still living in poverty and the imperative of a better managed environment. Indeed, green growth is a vital tool for achieving sustainable development. But sustainable development has three pillars: economic, environmental, and social sustainability. We cannot presume that green growth is inherently inclusive. Green growth policies must be carefully designed to maximize benefits for, and minimize costs to, the poor and most vulnerable, and policies and actions with irreversible negative impacts must be avoided. Green growth also requires improved indicators to monitor economic performance. National accounting indicators like GDP measure only short-term economic growth, whereas indicators like comprehensive wealth - including natural capital help us determine if growth is sustainable in the long run.

GREEN POLICIES CAN CONTRIBUTE TO GROWTH

Green policies and practices can contribute to growth through three channels: First, they can help to increase the amount of natural, physical, and human capital available. Healthier environments result in more productive workers. Second, they can promote efficiency. For instance, imposing environmental taxes (taxing "bads") and removing distortionary subsidies creates fiscal space for governments to lower labor taxes or subsidize green public "goods" such as public transport or renewable energy. Third, green policies stimulate innovation. Well-designed environmental regulations stimulate innovation by firms, as measured by R&D spending or patents. Similarly, international sustainability standards can help local firms to upgrade their environmental practices, a form of catch-up innovation. In developing countries, green policies can also encourage the adaptation and adoption of greener technologies that have been developed elsewhere. Finally, green policies also accrue non-growth gains to welfare. They can reduce inequality through job creation and poverty alleviation, and they can reduce output volatility by increasing resilience to environmental and economic shocks, like natural disasters or spikes in commodity prices.

GREEN INNOVATION AND INDUSTRIAL POLICIES

Innovation and industrial policies are potentially useful tools to spur green growth, as they can correct market (environmental and nonenvironmental) failures, but they should be designed to minimize risks from capture and rent-seeking behaviors. More advanced countries need to invest in frontier innovation through research and development; lower-income countries (with more limited technological capacity) should focus on adapting and disseminating technologies already developed and demonstrated. Although green growth and trade interact, it is not through the much publicized but seldom observed "pollution haven" effects. Green policies create opportunities for developing exports of green products; meanwhile, imports facilitate the adoption of greener, more efficient technologies.

Many market failures may justify the broad innovation policies and more targeted innovation and industrial policies that aim to support a specific green industry, firm, or technology: Knowledge externalities and capital market imperfections. Absent government intervention, knowledge spillovers create a gap between the private and social returns to producing knowledge that typically leads to under-provision of knowledge. And this is amplified by information asymmetry in capital markets. Competitive innovation projects may struggle to find financing, making it difficult for new businesses and activities to start. This is especially true because young businesses have more difficulty securing financing than large established companies, even though they may be very innovative. Latent comparative advantages and increasing returns. Latent comparative advantages that is, future as opposed to current comparative advantages are sometimes cited as a justification for industrial policies. Industrial policies may be warranted if the advantage includes learning or increasing returns to scale, which require support at an early stage. The idea is that developing a comparative advantage in an activity can depend on another activity in the region or country. Some industries are international rent shifting characterized by fixed costs or indivisibilities limiting the number of entrants and creating oligopolies, with significant rents for installed businesses. Industrial policies are frequently used to promote regional balance and stimulate job growth and other economic

activity where unemployment is worse, the population poorer, or a geopolitical reason exists to promote production in an area. Industrial policies are also used to smooth economic transitions.

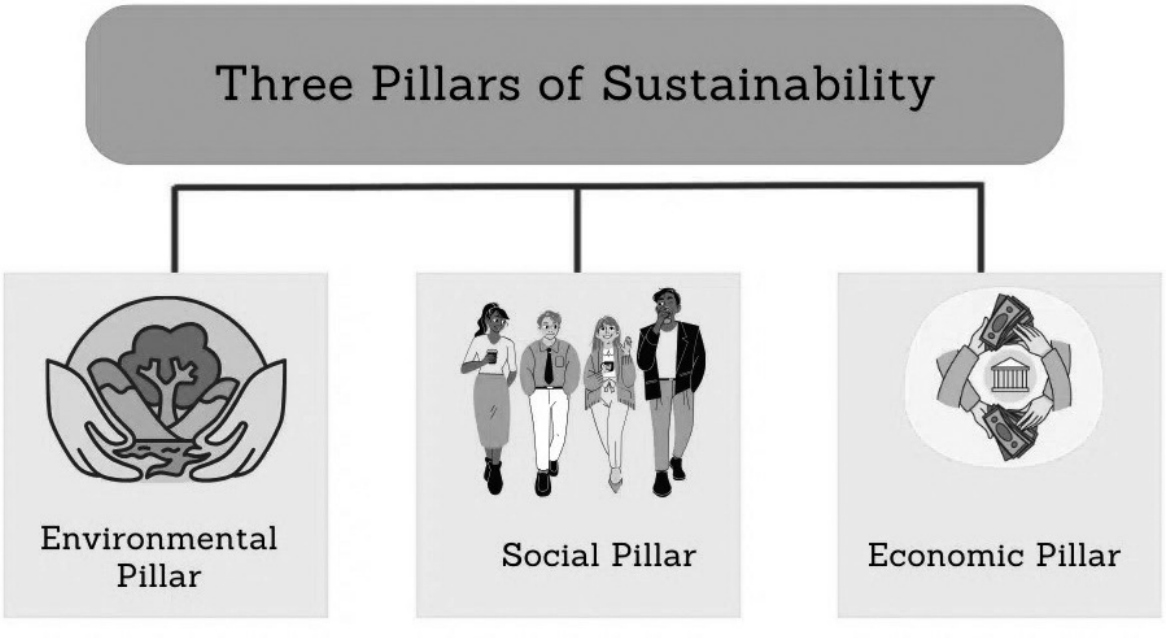
SHEDDING LIGHT ON GREEN INNOVATION, TECHNOLOGIES, AND INDUSTRIAL POLICIES

Green innovation is the development and commercialization of new ways to solve environmental problems through improvements in technology, with a wide interpretation of technology as encompassing product, process, organizational, and marketing improvements. In addition to frontier (new-to-the world) innovations, this definition includes catchup (new-to-the-firm) innovations also known as absorption which covers the diffusion (both across and within countries), adoption, adaptation (to local contexts), and use of green technologies. Green technologies comprise many fundamentally different technologies to achieve more resourceeffi cient, clean, and resilient growth. They include technologies needed to achieve the following goals: Reduce pollution and achieve greater resource efficiency in buildings (thermal insulation and new materials, heating, energy-efficient lighting); production processes (new uses of waste and other by-products from firms); agriculture (from improved and resilient crop and livestock breeds, water management, and farming systems to mechanical irrigation and farming techniques); and infrastructure and urban design (such as land use zoning). Mitigate climate change through a cleaner energy supply (wind, solar, geothermal, marine energy, biomass, hydropower, waste-to-energy, hydrogen fuels); low-carbon end use (electric and hybrid vehicles, climate-friendly cement); and carbon capture and storage. Reduce vulnerability and adapt to climate change with tools for understanding climate risks, better early warning systems, and climate-resistant technologies. Support wealth creation from the more productive and sustainable uses of biodiversity, including natural cosmetics, pharmaceutical products, other sustainable bioprospecting, nature-based tourism, more sustainable production of plants and livestock, and ecosystem protection. Green innovation policies are policies seeking to trigger green innovation by encouraging innovation broadly (horizontal policies) or supporting a specific technology (vertical policies). Green industrial policies are policies aiming to green the productive structure of the economy by targeting specific industries or firms.

IMPLICATIONS OF GREEN GROWTH POLICIES FOR LABOR MARKETS AND JOB CREATION

Green growth cannot substitute for good growth policies, and employment is no exception: shortcomings in labor markets will not disappear with the adoption of environmental policies. But even if green jobs will not be a panacea, environmental regulation need not kill jobs either, and the net balance can be positive. To smooth the impacts on labor markets of the transition to green growth, policy makers need to tackle potential skill shortages and impediments to worker mobility both of which have constituted barriers to other types of economic adjustment, such as trade liberalization.

The effect of green policies on employment depends on labor market structure and the specific policy considered the problem



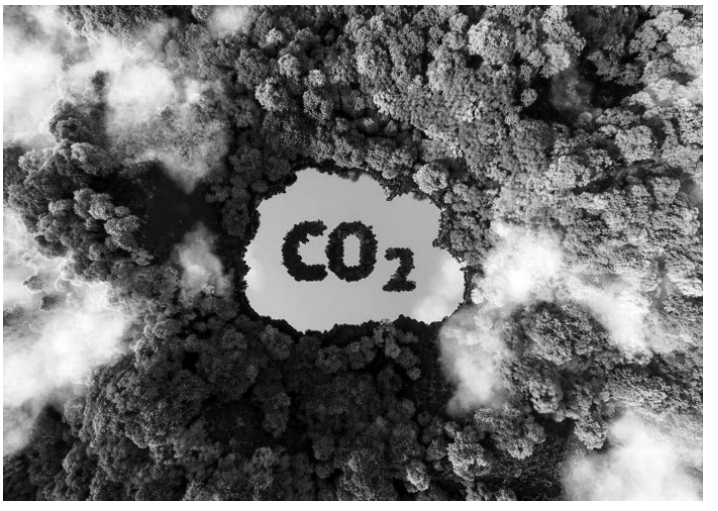
with studies that discuss job markets is that they tend to either model them as perfectly competitive, and thus adapting instantly to all shocks with no involuntary unemployment or as having involuntary unemployment that could be cleared with a fiscal stimulus. The first set of assumptions implies that green jobs are likely to displace as many jobs elsewhere in the economy. The second, that there will be no crowding out of jobs by green fiscal stimuli. Neither approach is realistic. Most developing countries have surplus labor economies, so estimates limited to direct employment creation in the green jobs literature might be less misleading for developing countries than for industrial economies closer to full employment.

Fears that environmental regulations will lead to massive job losses or loss of competitiveness are probably as unfounded as the hope that green jobs will single-handedly solve countries' employment problems.

MANAGING RESOURCES FOR SUSTAINABLE GROWTH

Sustainable management of natural capital underlies green growth in key sectors such as agriculture, manufacturing, and energy and is vital for resilience and welfare gains. Different resources require different types of policies. For extractable but renewable resources, policy should center on defining property rights and helping firms move up the value chain. For cultivated renewable resources, policy should focus on innovation, efficiency gains, sustainable intensification, and "integrated landscape" approaches. The elements of natural capital cannot be regarded in isolation. Integrated landscape approaches can increase production of both "regulating" and "provisioning" services of natural capital. In some cases, growth and green outcomes such as cleaner air, cleaner water, less solid waste, and more biodiversity will involve tradeoffs. But not all of these tradeoffs are inevitable: innovation, which can be supported through smart subsidies, can help minimize or eliminate some of them.

Managing natural capital can promote green growth. It looks at four broad categories: extractable renewable resources (capture fisheries, natural forests, soil, and water); cultivated renewable resources (crops, livestock, aquaculture, and forest plantations; nonrenewable resources (oil, gas, coal, and minerals); and ecosystems that



provide regulating services (watershed management, climate regulating services, and nature-based tourism). The first three categories provide "provisioning" services (those that directly produce goods and services, such as food and water); the fourth embraces "nonprovisioning" services (those that provide regulating services, supporting services, and cultural services).

Infrastructure policies are central to green growth strategies, because of the huge potential for regret (given the massive infrastructure investments required and the inertia they create) and substantial potential for co-benefi ts (given the current gap in infrastructure service provision). The infrastructure gap offers opportunities to "build right" and leapfrog; but huge unmet needs also can imply diffi cult trade-offs between "building right" and "building more," particularly given fi nancing and fi scal constraints. A framework for green infrastructure must build on efforts to address overall constraints on infrastructure finance (including cost recovery issues) and must develop strategies to both minimize the potential for regrets and maximize short-term co-benefi ts to address social and political acceptability constraints.

The pathway to sustainable development makes the case that greening growth is necessary, efficient, and affordable. Yet spurring growth without ensuring equity will thwart efforts to reduce poverty and improve access to health, education, and infrastructure services. Countries must make strategic investments and farsighted policy changes that acknowledge natural resource constraints and enable the world's poorest and most vulnerable to benefit from efficient, clean, and resilient growth. Like other forms of capital, natural assets are limited and require accounting, investment, and maintenance in order to be properly harnessed and deployed. By maximizing co-benefits and avoiding lock-in, by promoting smarter decisions in industry and society, and by developing innovative financing tools for green investment, we can afford to do the things we must ▪

LAN PHƯƠNG

(Source: worldbank.org; doi.org)

Organic farming - solution for sustainable agricultural development

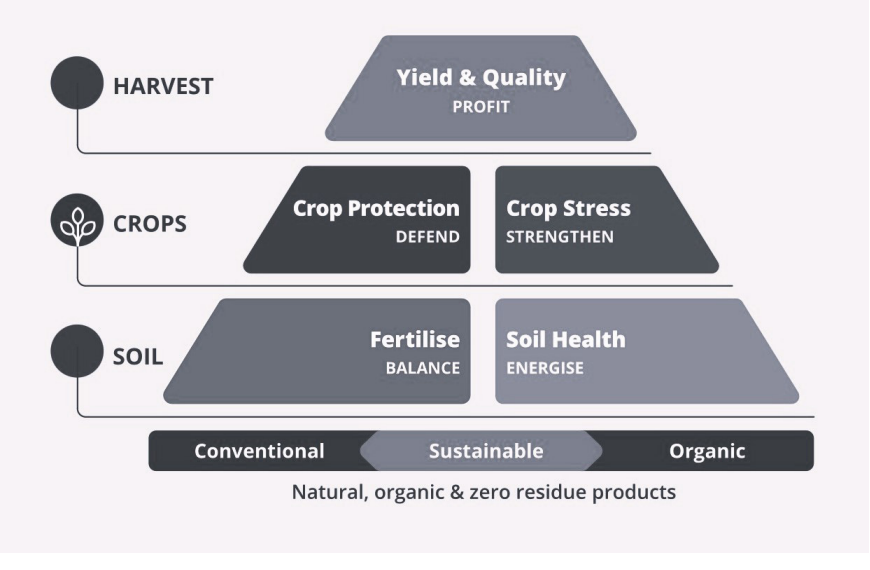
Organic farming stands as a beacon of sustainable agriculture, emphasizing natural processes and environmental stewardship. Organic farming methods have existed for a long time, before the appearance of inorganic farming methods. However, in the process of production development, the appearance of inorganic farming methods brings many immediate benefits such as: increasing productivity, reducing the labor of caring for crops and livestock... But in the long run, inorganic farming methods destroy the environment and production efficiency decreases due to polluted production environment, polluted agricultural products have a negative impact on human health... Therefore, organic farming methods have returned with the application of scientific and technological advances and mechanization in production, bringing high efficiency, providing safe products. This is a sustainable farming solution to protect human health, protect the environment and improve agricultural production efficiency.

Development of organic agriculture

The organic agriculture sector is currently the fastest growing food sector. Growth rates in organic food sales have been in the range of 20-25 percent per year for over a decade. Globally, certified organic agriculture occupies less than 1 percent of lands and 1-2 percent of food sales. In some cases, the growth may reflect the entry of land long farmed organically into a certification programme rather than an actual switch in farming systems.

The recognition of the role of organic agriculture in achieving environmental objectives, including sustainable use of land set aside, led to the adoption of agri-environmental measures to encourage organic agriculture. Consumers concerned with food quality, as well as the protection of the environment, were the first to stimulate demand. New market opportunities have developed as part of a business strategy to address consumer concerns, particularly in the European Union and the United States. Major food companies see the processing, handling, stocking, and promoting of organic foods as part of a positive public image. Retailers of all sizes now aggressively promote and market organic food, with major food retailing chains now accounting for a major share of the retail markets for fresh as well as processed foods.

Consumers are increasingly sceptical on the safety of conventional foods and the soundness of industrial agriculture. The use of growth regulators stimulated interest in organic food. The crisis over dioxin-contaminated food and livestock diseases further increased demand for organic food. Consumer surveys in almost every country show a segment that demands an alternative to genetically modified foods. Governments have responded to these concerns by setting targets for the expansion of organic production. Thus, the concern of consumers and governments with the quality and safety of food has become the major driving force in the development of organic agriculture in industrialized countries. These concerns have also opened possible markets for developing country exporters, enabling them to enhance foreign exchange earnings and diversify their exports. Price premiums of between 10-50 percent over prices for non-organic products, as well as more secure markets for organic commodities, can help counter-balance the loss of preferential trade arrangements, falling food prices and withdrawal of government support to agricultural inputs and other services. Major northern markets offer good prospects for suppliers of organic products not domestically produced. These include coffee, tea, cocoa, spices, sugar cane, tropical fruits and beverages, as well as fresh produce in the off-season. Increasingly, governments in developing countries are creating conditions in support of organic exports.



Non-certified organic agriculture is of particular importance for meeting local food requirements while providing protection and sustainable use of natural resources. Organic management makes it possible to save on production costs (especially important when cash is needed to purchase synthetic inputs) and to promote economic and/or food self-reliance. In market marginalized and resource-poor areas where farmers have no access to modern inputs and technologies, organic agriculture can also raise the productivity of traditional systems by optimizing the use of local resources.

Challenges faced by organic farmers

Organic farming abstains from synthetic herbicides, making weed management a significant challenge. However, employing techniques such as mulching, cover cropping, and regular manual weeding proves effective in suppressing weeds.

Organic farming discourages the use of chemical pesticides, necessitating alternative pest management strategies. These include natural predators, insect-repelling companion plants, and the use of organic pest control methods like neem oil. The biggest harm of using chemical fertilizers and pesticides in agriculture is pollution of soil, water resources, air environment... Chemicals from fertilizers and pesticides seep into the soil, causing the soil to become hard, depleted of nutrients, leading to slow plant growth. Over time, toxic chemicals from inorganic fertilizers and pesticides seep into water sources, polluting rivers and lakes and affecting aquatic ecosystems. Chemical pesticides kill pests and also kill beneficial organisms such as beneficial insects, birds and other animals. The use of chemical fertilizers and pesticides in agriculture can lead to greenhouse gas emissions...

Maintaining optimal soil health without the use of synthetic fertilizers is paramount in organic farming. Regular application of compost, well-rotted manure, and cover cropping aids in enriching soil fertility and structure. Organic farming emphasizes biodiversity and crop rotation to minimize soil degradation and disease pressure. Planning a diverse crop rotation schedule is essential in this regard.

Connecting organic farmers with consumers who value and support their produce can be challenging. This necessitates robust marketing strategies, partnerships with local markets, and educating consumers on the benefits of organic produce.

Solutions to overcome challenges

Organic farming methods apply farming measures such as: using organic fertilizers, crop rotation and intercropping, deep plowing, using biological control measures... This method applies to both crop and livestock farming. In farming, organic farming methods instead of using chemical fertilizers use manure, fertilizers made from plants to provide nutrients for plants and improve soil fertility. Combined with deep plowing helps improve soil structure, making the soil loose, rich in nutrients, easily retaining water and organic matter for the soil, protecting long-term fertility.

Use natural pest control measures such as natural enemies, biological products or herbal pesticides, do not use pesticides made from toxic chemicals. Organic fertilizers and biological control measures do not harm the soil and water sources. In animal husbandry, the organic farming method is not to use foods containing growth stimulants, lean meat additives...

Organic farming helps maintain and enhance biodiversity by minimizing the use of chemical pesticides. The use of biological control measures such as natural enemies or natural pesticides not only helps protect the environment but also maintains ecological balance in agriculture. Rotating and intercropping crops helps prevent soil nutrient depletion and minimizes the development of pests and diseases, increasing biodiversity.

Implementing organic farming methods protects the production environment and ecological environment well, such as: increasing soil porosity and humus, reducing soil and water pollution, protecting biodiversity, reducing greenhouse gas emissions, protecting soil and preventing erosion...

At the same time, the application of crop rotation and

intercropping helps create a more diverse environment for beneficial animals and insects, thereby creating natural resistance for crops, thereby minimizing pests. Cover crops, use of organic fertilizers and sustainable farming help maintain soil porosity and limit erosion, especially in mountainous areas, helping to protect the soil for long-term cultivation.

Propagating and mobilizing farmers to change their farming methods through agricultural extension channels and mass media has a wide influence, thereby accelerating the process of changing farmers' farming methods. By building on local knowledge, organic agriculture approaches revitalize traditional customs and local self-reliance. Employment opportunities and higher returns on labour encourage people to remain in agriculture, reinvigorating rural communities. Strengthened social cohesion and partnerships within the organic community make for better connections with external institutions. Organized groups, such as producer cooperatives, have better access to markets and can negotiate their needs as equal partners in the food supply chain.

Together with the production system, the social environment of those engaged in organic agriculture generally improves: in fact, many organic systems incorporate fair trade principles which improve working conditions. The IFOAM Basic Standards includes a chapter on Social Justice Standards. These refer to and are based upon the conventions of the International Labour Organisation on labour welfare and to the human rights charters of the United Nations.

A growing number of certified organic agriculture commodities produced by small-scale farmers organized in democratic cooperatives meet fair trade requirements: farmers are paid adequately to cover costs of production and a social premium to improve the quality of life. Although the organic movement shares a consensus that social requirements are necessary, specific standards are controversial. Standard-setting bodies are sensitive to national sovereignty and the cultural context governing social and economic relations. Such standards might create trade barriers to some developing countries organic exports, but this pressure may trigger social and economic reform in many countries. When farmers widely apply organic farming methods, they create safety in production, protect land and water resources, and create a cleaner and more sustainable agriculture.

Switching to organic farming methods that apply scientific and technical measures in agricultural production is a farming solution that brings many economic benefits, is environmentally friendly and protects human health.

Implementing Integrated Pest Management (IPM) combines various strategies like biological control, cultural practices, and natural enemies of pests. This approach minimizes the impact of pests while preserving the ecological balance. Embracing regenerative practices like no-till farming, agroforestry, and incorporating perennial crops can significantly enhance soil health and long-term sustainability.

Exploring various market channels, including farmers' markets, community-supported agriculture (CSA), and online platforms, can help expand the reach and accessibility of organic produce.

Offering training and workshops to farmers on organic farming techniques, soil health management, and sustainable practices ensures a knowledgeable and empowered farming community.

While organic farming presents its own unique challenges, the benefits far outweigh the hurdles. By adopting innovative techniques, leveraging the power of regenerative agriculture, and fostering strong community connections, organic farmers can not only overcome these challenges but also thrive in their commitment to sustainable and environmentally conscious farming practices ▪

XUÂN THẮNG

(Source: https://www.fao.org)

Hanns Seidel Foundation

Vietnam Office

Về tổ chức Hanns Seidel Foundation

Tổ chức Hanns Seidel Foundation (HSF) là một tổ chức phi chính phủ của CHLB Đức được thành lập năm 1967 với trụ sở chính tại thành phố Munich, CHLB Đức. Tôn chỉ của HSF là thúc đẩy điều kiện sống của người dân và đóng góp vào mục tiêu phát triển bền vững qua việc củng cố hòa bình, dân chủ và mô hình kinh tế thị trường xã hội. HSF liên kết với đảng Liên minh Xã hội Thiên chúa giáo (CSU), và có trọng tâm hoạt động tập trung vào phát triển nhân cách, lòng khoan dung, sự hỗ trợ, tính bền vững cũng như tự do và đoàn kết. Với các dự án được triển khai trên 71 quốc gia, HSF hợp tác chặt chẽ với mạng lưới đối tác rộng khắp và các tổ chức có cùng chí hướng. Kể từ khi thành lập văn phòng đại diện tại Hà Nội vào năm 2011, HSF đã hợp tác chặt chẽ với Viện Chiến lược, Chính sách tài nguyên và môi trường (ISPONRE) thuộc Bộ TN&MT. Các hoạt động hợp tác giữa 2 bên tập trung vào vấn đề bảo vệ môi trường, phát triển bền vững và xây dựng năng lực thể chế.

Hãy theo dõi HSF Việt Nam trên Facebook để cập nhật những thông tin về hoạt động của chúng tôi tại:

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Mặc dù Tổ chức Hanns Seidel Foundation tài trợ cho ấn phẩm này, các ý kiến thể hiện trong các bài viết chỉ phản ánh quan điểm cá nhân của các tác giả và không hoàn toàn phản ánh quan điểm chính thức của Hanns Seidel Foundation.

About the Hanns Seidel Foundation

The Hanns Seidel Foundation (HSF) is a German political foundation established in 1967. Headquartered in Munich, HSF aims to promote humane living conditions and to contribute to sustainable development by strengthening peace, democracy, and the social market economy. The foundation is affiliated to the Christian Social Union (CSU) and the cornerstone of our work includes a strong emphasis on human dignity and tolerance, subsidiarity, sustainability as well as on freedom and solidarity. With projects in 71 countries worldwide, HSF cooperates closely with a broad network of partners and like-minded institutions. Since the establishment of a representative office in Hanoi in 2011, HSF has collaborated closely with ISPONRE under MONRE. This partnership has focused on environmental protection, sustainable development and institutional capacity building.

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환경부
Ministry of Environment

KEITI
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Center of Global Green Network

KEITI creates a clean and green world by disseminating eco-friendly technologies and establishing global cooperation networks so that every country can enjoy the benefits that the environment offers.

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■Manage funding sources to support cooperation and investment promotion, technology transfer in the field of environmental infrastructure development and new energy (water supply, wastewater treatment, renewable energy, emissions management, …);

■Support Korean and Vietnamese enterprises to promote investment in the field of environmental industry in Vietnam;

■Research and explore the technology market in order to serve the promotion and cooperation development, investment and technology transfer in the field of environment and sustainable development.

For more information about our activities, please refer to:
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