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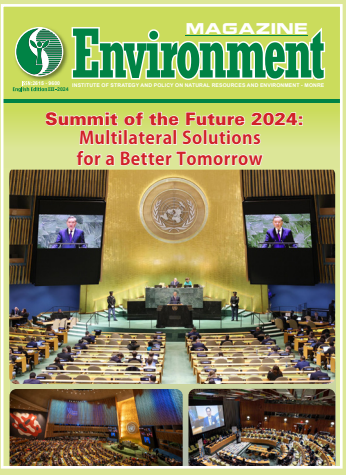

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Assessment of heavy metals contamination in water in Dong Mai craft village

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Abstract

Industrialization, climate change and craft village production activities produce a variety of water pollutants in Vietnam. Classical multivariate statistical analysis was used to evaluate the characteristics of As, Cu, Zn, Pb contamination in water in Dong Mai village, Hung Yen province, by using the evaluation indicators such as the metal index (MI), the enrichment factor (EF), the potential ecological risk factor (ERF) and the potential ecological risk index (ERI). This research showed that the classical statiscal analysis was significant to identify contamination sources and origin. It was notabled that high loading of (As, Cu, Zn) and Pb in water in principal components (PC1 and PC2) with seasonal variations was indicative of both geogenic and anthropogenic pollution as primary sources in terms of MI and EF. The ERF and ERI of heavy metals in Dong Mai's surface water as well as the ground water were at the low level (ERF<40 & ERI < 150). The result of the assessment highlights the need for a comprehensive and detailed study program on heavy metal content in the water resources in a wider area to identify the magnitude and details of the problem associated with heavy metal contamination for the development of a remediation plan and more effective pollution preventing measures.

Keywords: *Heavy metal, Pb battery - recycling, enrichment factor, the potential ecological risk index, the potential ecological risk factor.*

JEL Classifications: *Q51, Q52, Q53.*

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1. INTRODUCTION

Trace elements in water have been difficult to degrade and highly toxic, especially the excessive accumulation of toxic trace elements which not only threaten safety of invertebrates and fish ecosystems, but also cause serious health effects on human beings [2, 19]. Some trace elements are extremely toxic even at low concentrations, such as arsenic (As) and lead (Pb) [4]. Exposure to Pb could seriously damage the kidney, liver, central nervous system and blood system [14], Pb has been one of the 67 important risk factors leading to global diseases [18].

Vietnam recorded the eighth highest economic growth in Asia [15], and has high resource demands. In Vietnam, so called "craft village", which is defined as rural villages with existing craft and non-farming activities drawing the participation of at least 30% of all households and making at least 50% of the village's total income. It was estimated that ninety waste recycling craft villages are distributed across the country, mainly in the Northern part [29]. However, in most craft villages, production activities develop spontaneously, with household size and outdated production technology, thus creating environmental pollution problems, directly affecting the environment. The craft village of recycling lead from batteries at Dong Mai village is not an exception.

Dong Mai is a village in the Northern part of Vietnam, and has been recycling Pb-acid battery for many years. A local news report suggested that of 715 households in the village, at least 61 were involved in Pb recycling, total more than 500 workers [26]. The General Department of Environment's report in 2008 warned that Dong Mai villagers can lose up to 10 years of their lifespan due to environmental pollution. The metal concentrations in water and related health risk in Dong Mai battery recycling village have not been well reported previously. Considering the situation in Dong Mai, characteristics assessment of exposure status in the village residents is necessary.

The specific objectives include to study the distribution of As, Pb, Cu, Zn in the water environment and characteristics assessment of heavy metals pollution in Dong Mai craft village aim to get an overall view of the pollution situation as well as help the policy makers for implementing policies to improve the better environment and raising the people's awareness of the environment in the production as well as living process locally. Within the grassroots research project 2024, Dong Mai is one of the study areas, where heavy metals in the water were under study, an attempt of application of metal quality indices to identify the source of heavy metals and their concentration distribution characteristics is carried out. The

results of the assessment would assist to make a decision on farther comprehensive and detailed study programs on heavy metal contents in different water resources in the craft villages in particular as well as the other heavy metal pollution areas of Vietnam in general.

2. MATERIALS AND METHODS

2.1. Site description

The Pb recycling area is located in the Dong Mai village, Chi Dao commune, Van Lam district, Hung Yen province, northern Viet Nam. Since the 1970s, the traditional village of Dong Mai has been developing a professional Pb recycling program, which involves processing old batteries, Pb smelting and slag sifting. Initially, Pb smelting was performed by individual households within the home and garden areas. In 2000, the village started to use a self-contained Pb dust suction system consisting of hundreds of large bags. The suction capacity of this system was 7 tons of Pb dust per one night per one smelter. This groundbreaking technology was very efficient at minimizing the amount of Pb released to the air. Since 2015, Pb smelting has occurred in 2 new smelter systems operated by two companies located approximately 1km away from the residential area in Dong Mai village because the old smelters were closed [7].

2.2. Method for sampling and analysis

Sampling in Dong Mai was carried out in high precipitation season (HPS) and low precipitation season (LPS) in 2015. The possible wastewater outflows, tributaries, irrigation canals, upstream locations and other human-ecological interactions were taken into account in choosing the targeted sampling locations. Water sample collection two times a day (8-9am, 16-17pm) was recommended to observe diurnal (24h) concentration patterns of heavy metal. Average amount of water sample was 500ml and filled to the top of the sample bottle to remove air that may be left in the bottle, avoiding chemical reactions such as oxidation to ensure accuracy and reliability for sample. The general information including well depth and capacity of each well was supported by well's owner. The samples were measured of pH using pH meter (Horiba U52) as well as electrical conductivity EC, redox potential Eh on-site (measured values were recorded in the field-diary); and then preserved by HNO_3 (0.2%) to ensure the retention of metal ions in the water. In the laboratory, samples were shaken well and filtered with specialized water filter paper. The filtered samples were treated with 1% HNO_3 acid in a 100ml volumetric vial.

Heavy metal elements were analyzed by inductively coupled plasma-mass spectrometer on Varian Ultramass 700 ICP-MS. Inductively Coupled Plasma (ICP) Mass Spectrometry (MS) (ICP-MS) is a multi-element technique that uses an ICP plasma source to dissociate the sample substance into its constituent atoms or ions. The analysis detection limit by quadrupole analyzer is from 100ppt (part per trillion) for Fe to 0.1ppt for Cd and Pb. The short-term precision (measurements in the period of 5-10 minutes) is 0.5-2% and long-term precision (measurements in the period of several hours) is 2-4% [28].

2.3. Data analysis by using metal quality indices (MQI) in water

2.3.1. The metal index (MI)

The metal index (*MI*) was applied to analyze the metal content of the water samples in comparison to the maximum allowable concentrations from the Vietnamese National Water Regulation [21, 22, 23].

The metal index (*MI*) was applied to analyze the quality of drinking water [24], canal water [12] and river water [3]. Based on *Tamasi and Cini, 2004* [27], *MI* is calculated as follows: $MI = \sum [C_i / (MAC)_i]$

where C_i is the concentration of each heavy metal in each sample, and *MAC* is the maximum allowable concentration based on the standards of Vietnamese. *MI* is considered the contemporary aggregate tendency of the quality status [12], which provides an overall understanding of the water quality for policymakers as well as the community. The higher the concentration of a metal compared to its respective *MAC* value, the worse the quality of water. *MI*> 1 is a threshold of warning [3], even though the C_i may be less than $(MAC)_i$ for certain metals [27]. *Table 1* shows the water quality classification categories of *MI*.

Table 1. Classification of water quality based on the Metal Index (MI) [24]

MI	Class	Nature of water quality	MI	Class	Nature of water quality
< 0.3	I	Very pure	2.0-4.0	IV	Moderately affected
0.3-1.0	II	Pure	4.0-6.0	V	Strongly affected
1.0-2.0	III	Slightly affected	>6.0	VI	Seriously affected

2.3.2. The enrichment of trace elements (EF)

In order to understand the enrichment status of metal elements in the study area, enrichment factor (*EF*) was used for analysis. The enrichment factor was the ratio of the metal element content in the water body of the study area to the average river content in the world [9]. According to the enrichment factor, the enrichment conditions could be divided into 6 categories: when *EF*>100, it was abnormal enrichment; 10<*EF*<*100,* indicating super enrichment; 5<*EF*<10, indicating significant enrichment; 1.5<*EF*<5, indicating slight enrichment; 0.5<*EF*<1.5, indicating that it is not enriched. If *EF*<0.5, this indicates a loss [17].

2.3.3. The ecological risk factor (ERF)

The potential ecological risk factor (*ERF*) of a given single heavy metal was calculated according to the methods of *Hakanson, 1980* [13] as follows:

$E^i_{r=} T^i_r x\, C^i_{f=} T^i_r x\, (C^i_0 / C^i_r)$

where E^i_r is the potential ecological risk factor of substance "*i*"; T^i_r is the toxic response factor of substance "*i*" (which is 10 for As, 5 for Cu and Pb, and 1 for Zn [13]); C^i_f is the contamination factor of substance "*i*"; C^i_0 is the measured concentrations in the water of substance "*i*", and C^i_r is the background reference level for substance "*i*" (Vietnam's national technical regulation on surface water and groundwater quality (QCVN 08:2023/BTNMT & QCVN 09:2023/BTNMT) [21, 22] was adopted as C^i_r in this study As = 0.01 (mg/l), Cu = 0.1 (mg/l), Zn = 0.5 (mg/l) and Pb = 0.02 (mg/l) for surface water; As = 0.05 (mg/l), Cu = 1 (mg/l), Zn = 3 (mg/l) and Pb = 0.01 (mg/l) for ground water).

The *ERF* was calculated for each replicate sample, and subsequently, the minimum, maximum, and mean values were determined to summarize the results. According to *Hakanson, 1980* [13], the ecological risks were classified into five terminologies based on the *ERF* values: (1) *ERF*<40, low potential ecological risk; (2) 40≤ *ERF*<80, moderate potential ecological risk; (3) 80≤ *ERF*<160, considerable potential ecological risk; (4) 160≤ *ERF*<320, high potential ecological risk; and *ERF*≥320, very high ecological risk.

2.3.4. The potential ecological risk index (ERI)

The potential ecological risk index (*ERI*) proposed by *Hakanson, 1980* [13] has been widely used to assess the potential ecological risk of heavy metals in aquatic ecosystems [31]. In this study, the *ERI* was used to evaluate the ecological risks of heavy metals in the surface water of both villages. The *ERI* was calculated by the following equation: $ERI = \sum [(ERF)_i]$; where *i* is the number of studied elements.

Based on the *ERI* values, the potential ecological risk was classified into 4 terminologies: *ERI*<150, low ecological risk; 150≤ *ERI*<300, moderate ecological risk; 300≤ *ERI*<600, considerable ecological risk; and *ERI*≥600, very high ecological risk.

2.4. Statistical analysis

Principal component analysis (PCA), together with correlation analysis (CA) and hierarchical cluster analysis, has proven to be a useful multivariate statistical technique for disclosing the origins of heavy metal contamination [25]. In this study, Spearman's correlation analysis was conducted to analyze the correlations between the variables, the sign of the correlation coefcient value shows whether the relationship is positive or negative, while the absolute value of correlation coefcient reveals the linear relationship's strength. PCA is often used in data reduction to identify common factors (principal components and PCs) that explain most of the variance observed in a large number of manifest variables. The reduced, new set of orthogonal (non-corrected) PCs by PCA is arranged in decreasing order of merit. PCA was made with varimax rotation of standardized component loadings for maximizing the variation among the variables under each factor [1]. The eigenvalue for the factor represents the strength of variance for the interpretive variables, and only eigenvalues ≥ 1.0 were considered in this study. The hierarchical cluster analysis (HCA) can be used for grouping data into classes according to characteristics, sources, and features that are similar or dissimilar. The HCA can be obtained by employing the most widely used data clustering method and application of Ward's method of linkage. Dendrogram is a pictorial representation of the HCA result based on either the analyzed parameters or sampling locations [5]. According to the dendrogram, in this study, we used the grouping data that lying in the CD (>0) & (≤10) to distinguish and arrange all the parameters which have same source, feature and characteristics in one group. The three analyses were all performed using SPSS software, version 20.0.

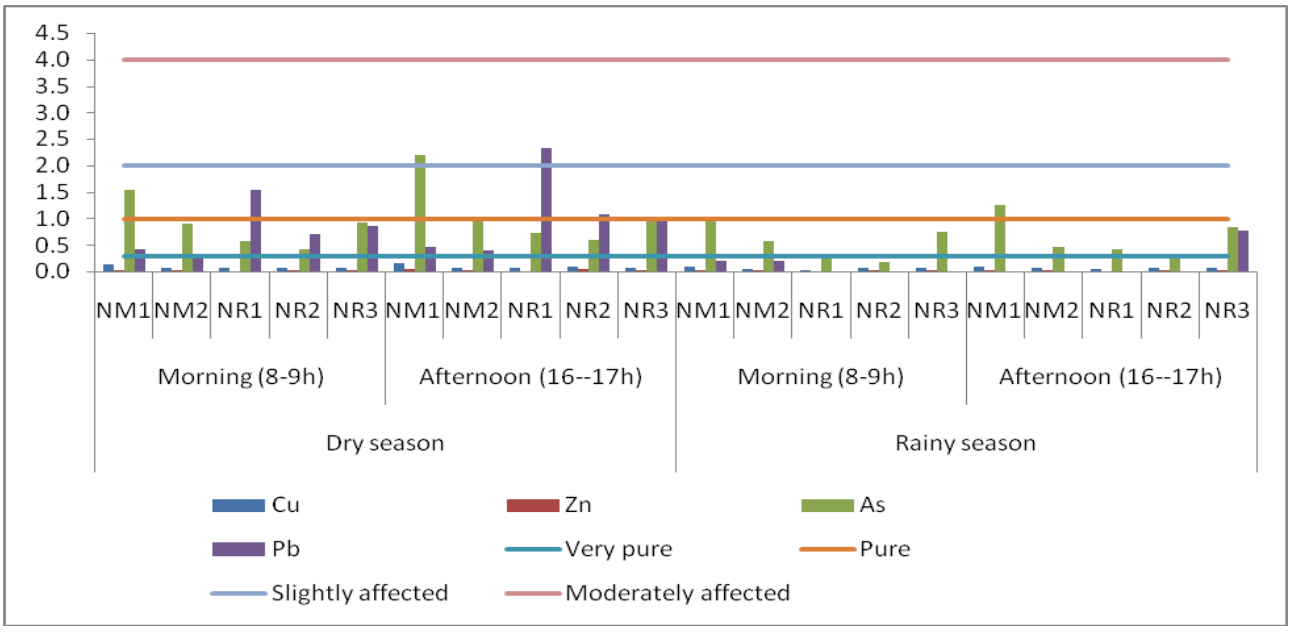
3. RESULTS AND DISCUSSIONS

3.1. Environment of surface water in the craft villages by using metal quality indices (MQI) in water

3.1.1. The metal index (MI)

Based on the *MI*, the following sequence was observed: average *MI* [As (0.978) > Pb (0.908) > Cu (0.086) > Zn (0.037) in LPS and Pb (0.626) > As (0.606) > Cu (0.060) > Zn (0.033) in HPS] in the surface water in Dong Mai village. According to the percentage of samples with *MI* >1, the selected sites around Dong Mai village were slightly to moderately threatened by As and Pb pollution for aquatic life usage (MI>1). *Fig.1* demonstrated the *MI* for the morning and evening for both seasons.

In general, the contents of Cu, Zn, As and Pb in the water body of the Dong Mai village in the dry season were higher than those in the wet season, mainly because the water amount in the wet season was larger and the trace elements in the water body diluted. The



▲ *Fig.1. Seasonal variations of the metal index (MI) value of the surface water*

metal concentrations in the dry season were greater than those in the rainy season, which may be related to the dilution effect of rainfall in the rainy season. Electrical conductivity (EC) is a measure of water capability to transmit electric current. Electrical conductivity was within range 264 to 662 (µS/cm) in LPS and 182 to 532 (µS/cm) in HPS.

The results of principal component analysis and correlation analysis were shown in *Table 2*. In order to verify the applicability of the principal component analysis, Kaiser-Meyer-Olkin (KMO) and Bartlett tests were conducted on the data of heavy metal concentrations. In general, the KMO value is > 0.5 when the Bartlett's detection significance is $p < 0.05$, indicating that the principal component analysis was effective [6]. The KMO and Bartlett (p) test values of the Dong Mai's surface water were 0.529 and 0.00, respectively, showing that the principal component analysis was effective for our data. The principal components analysis (PCA) was the uncorrelated variables, obtained by multiplying the original correlated variables with the eigenvalues. Surface water samples exhibited 77.33% in total sample variance, was reflected by two principal components, with characteristic values greater than one, respectively, indicating that the principal component factor model can explain the variabilities of most variables [30]. In general, absolute load values > 0.75, 0.75–0.5, and 0.5–0.3 are considered as strong, medium, and weak loads, respectively [10].

For the surface water in Dong Mai village, PC1 explained 52.56% of variance and showed medium to strong positive loads related to EC, Eh, *MI2* and strong negative loads related to *MI4*. EC represented the levels of surface water's ion concentrations, reflecting the combination of rock weathering and human activities in the water body. The EC value was positively correlated with *MI2* (r= 0.790) that standed for metal index of Zn element. Zn is usually believed to come from urban sewage [11], agricultural combustion, or fungicides [8, 20], and it may also come from rock weathering [16, 25]. The inverse relationships between the loads of (Eh, EC, *MI2*) and *MI4* as well as the negative SC between [(Eh, *MI4)* (r= -0.525), (EC, *MI4) (r*= -0.713), (*MI2, MI4*), (r= -0.509), respectively] indicated that Zn and Pb had different sources. The cluster of EC & *MI2* had the shortest cluster distance (CD) (<5) (*Fig.2a*) which represented strong linkage with minimum CD that indicated those parameters had influencing power during seasonal variations. Therefore PC1 indicated that the metal index of Pb element (*MI4*) came from the lead-recycled activities in Dong Mai village but the metal index of Zn element (*MI2*) may come from rock weathering here.

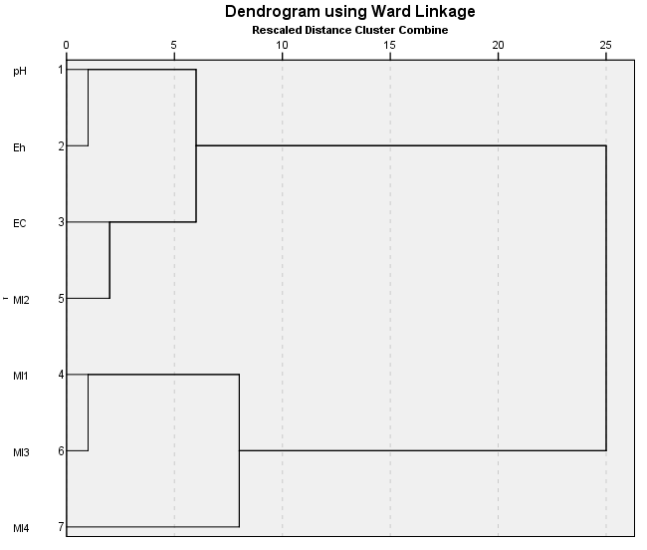
PC2 explained 24.54% of variance and showed weak to strong positive loads related to *MI2*, EC, *MI3*, *MI1* and strong negative loads related to pH (*Table 2*). For surface water of Dong Mai village, pH & Eh and *MI1* & *MI3* formed a cluster with the shortest CD (<5) (*Fig.2a*) which represented strong linkage with minimum CD that indicated those parameters had influencing power during seasonal variations. The metal index of Cu element (*MI1*) and the metal index of As element (*MI3*) were clustered in one main group with the shortest CD (<5); at the same time, they had positive significant correlation (SC) (r= 0.722), indicating that they had similar patterns and sources in the groundwater in Dong Mai village. Heavy metals Cu, Zn and As that were assembled together in less distance had a higher attraction with similar identical behavior during temporal variations and also exerted a possible effect on each other.

Table 2. Rotated principal component loadings of metal index (MI), pH, Eh and EC values in the Dong Mai's surface water.

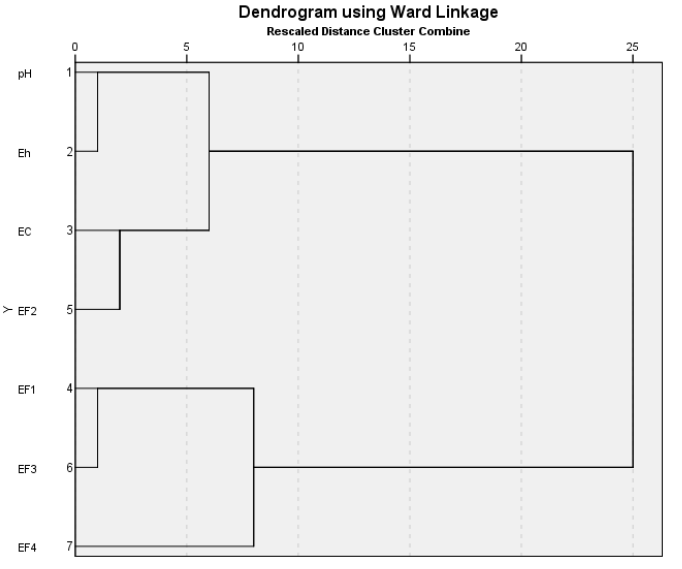
Variables	PC1	PC2	Variables	PC1	PC2
Eh	0.783		MI3		0.852
pH		-0.753	MI4	-0.962	
EC	0.639	0.594	Eigenvalue	3.68	1.73
MI1		0.907	% of variance	52.56	24.77
MI2	0.803	0.415	Cumulative %	52.56	77.33

Note: The load values > 0.50 or < -0.5 were shown in bold italics. MI1, MI2, MI3, MI4 stands for metal index of Cu, Zn, As, Pb element, respectively.

By observing the raw data (before calculation of mean values), notable oscillations in the concentrations of some heavy metals between morning and evening were identified. *Fig. 3* summarized these diurnal as well as seasonal changes in the selected sample sites where considerable changes were observed.



▲ *Fig.2a. Hierarchical cluster tree of grouping ph, Eh, EC and metal index (MI) in surface water by cluster analysis*

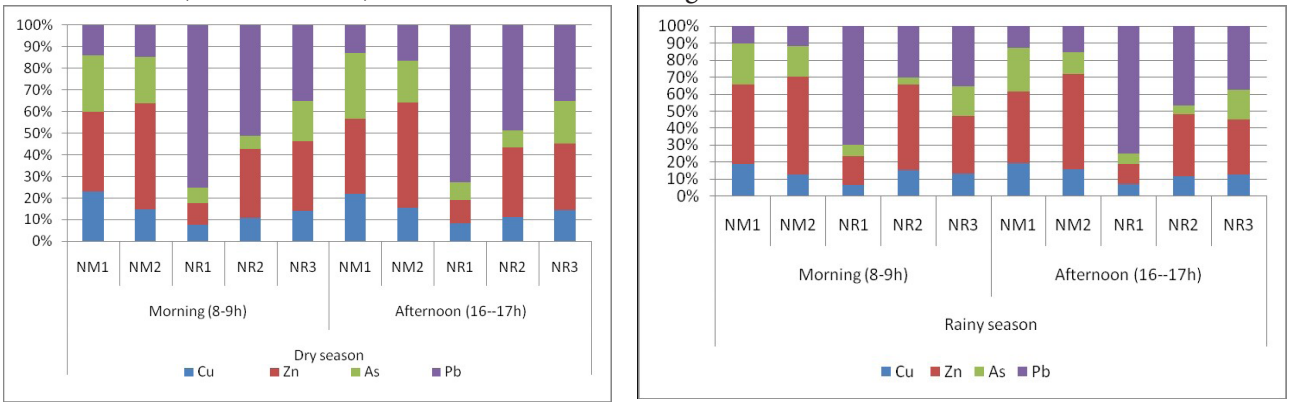


▲ *Fig.2b. Hierarchical cluster tree of grouping pH, Eh, EC and enrichment factor of trace elements (EF) in the surface water by cluster analysis*

The cluster of [*MI1*, *MI3*] along with *MI4* also formed a cluster had strong linkage (>5, <10), indicated their moderate relatedness but contributed largely to the surface water and significantly impacted to each other. Moreover, they had a negative SC between pH & the metal index of Cu, As element (*MI1, MI3*) (r= -0.557 and r= -0.478, respectively) and a positive SC between [EC & (*MI1*, *MI2, MI3*)] (0.639, 0.790, 0.525, respectively) as well as the positive SC between [(*MI1*, *MI2*) & (*MI1*, *MI3*)] (0.691, 0.722, respectively), indicating that the metal index of Cu, Zn, As had same source from rock weathering. Therefore PC2 indicated that the metal index of Cu, Zn, As element (*MI1, MI2, MI3*) came from rock weathering here.

3.1.2. The enrichment factor of trace elements (EF)

Based on the enrichment factor *EF*, the following sequence was observed: average *EF* [Pb (229.873) > Zn (31.033) > As (15.774) > Cu (5.791) in LPS and Pb (158.378) > Zn (27.416) > As (9.779) > Cu (4.033) in HPS] in the surface water in Dong Mai village. *Fig.4* demonstrated the *EF* for the morning and evening for both seasons.

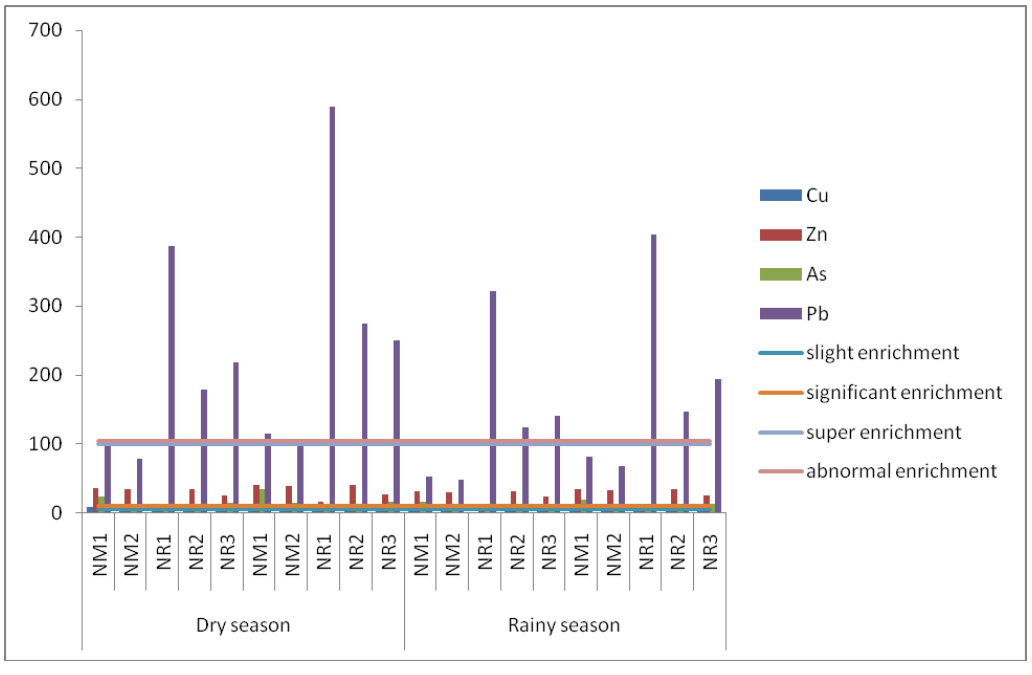


▲ *Fig.3. Diurnal trends in heavy metal concentration for selected sample sites*

The KMO and Bartlett (p) test values of the Dong Mai's surface water were 0.545 and 0.00, respectively, showing that the principal component analysis between pH, Eh, EC and the enrichment factor of trace elements (*EF*) was effective for our data. Surface water samples exhibited 77.37% in total sample variance, was reflected by two principal components, with characteristic values greater than one, respectively.

In the case of surface water of Dong Mai, PC1 explained 52.58% of variance and showed medium to strong positive loads related to EC, Eh, *EF2* and strong negative loads related to *EF4* (*Table 3*). Furthermore, [EC, *EF2*] formed a cluster with the shortest CD (<5) (*Fig.2b*) which represented strong linkage with minimum CD that indicated those parameters had influencing power during seasonal variations. The cluster of [(pH & Eh) along with EC] also formed a cluster had strong linkage (>5, <10) but lesser than cluster [pH & Eh] (<5), contributed largely to the environment, which had positive signinficant correlation between EC & *EF2* represented the enrichment factor of Zn element had the linear relationship with EC (0.796), so that the *EF2* originated from rock weathering source.

PC2 explained 24.79% of variance and showed weak, medium to strong positive loads related to *EF2*, EC, *EF3*, *EF1* as well as strong negative loads related to pH, which had positive SC between (EC, *EF1*), (EC, *EF2*) and (EC, *EF3*) (r= 0.638, 0.706, 0.528, respectively) and (pH & Eh], [EC, *EF2*], [*EF1*, *EF3*] formed a cluster with the shortest CD (<5) which represented strong linkage with minimum CD that indicated those parameters had influencing power during seasonal variations. Heavy metals included Cu, Zn, As that were assembled together in less distance had a higher attraction with similar identical behavior during temporal variations and also exerted a possible effect on each other. The cluster of [(pH & Eh) along with EC] also formed a cluster had strong linkage (>5, <10) but lesser than cluster [pH & Eh] (<5), but contributed largely to the environment. It was thus concluded that the enrichment factor of Cu, Zn & As had a same source. The cluster of [(EF1, EF3) along with EF4] also formed a cluster (>5, <10) had strong linkage but lesser than cluster [pH, Eh, EC], which had positive SC between (*EF1*, *EF2*), (*EF1*, *EF3*) (r= 0.705, 0.714, respectively) as well as negative SC between (*EF2*, *EF4*) r= -0.512), indicating



▲ *Fig.4. The enrichment factor of trace elements (EF) value of the surface water in Dong Mai.*

Table 3. Rotated principal component loadings of the enrichment factor of trace elements (EF), pH, Eh and EC values in the Dong Mai's surface water

Variables	PC1	PC2	Variables	PC1	PC2
Eh	0.783		EF1		0.907
pH		-0.753	EF3		0.852
EC	0.639	0.594	Eigenvalue	3.680	1.735
EF2	0.806	0.412	% of variance	52.58	24.79
EF4	-0.961		Cumulative %	52.58	77.37

Note: The load values > 0.50 or < -0.5 were shown in bold italics. EF1, EF2, EF3, EF4 stands for enrichment factor of Cu, Zn, As, Pb element, respectively.

that PC2 represented the combination of rock weathering related to Cu, Zn, As and the enrichment factor of Pb element had the source from human activities.

3.1.3 The ecological risk factor (ERF)

Fig.5 represented the potential ecological risk factor of Cu, Zn, As and Pb in the surface water of Dong Mai village. The *ERFs* of Dong Mai's suface water were at the low level (ERF<40).

3.1.4. The potential ecological risk index (ERI)

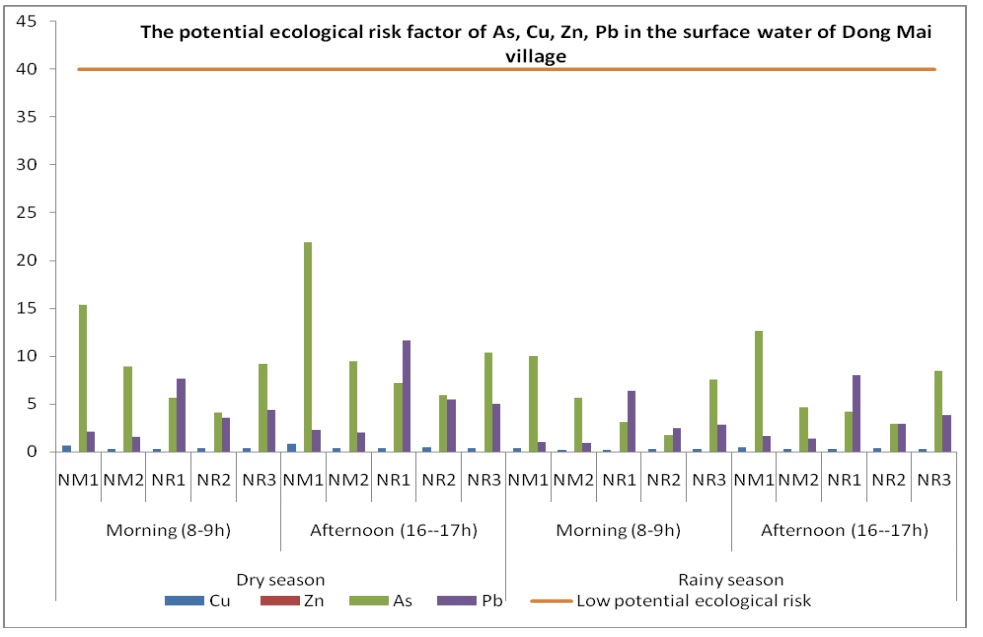
In this study, the *ERI* was used to evaluate the ecological risks of heavy metals in the surface water. The potential ecological risk indexes of heavy metals in the surface water were all in the low level (*Fig.6*).

3.2. Environment of groundwater of the craft villages by using metal quality indices (MQI) in water

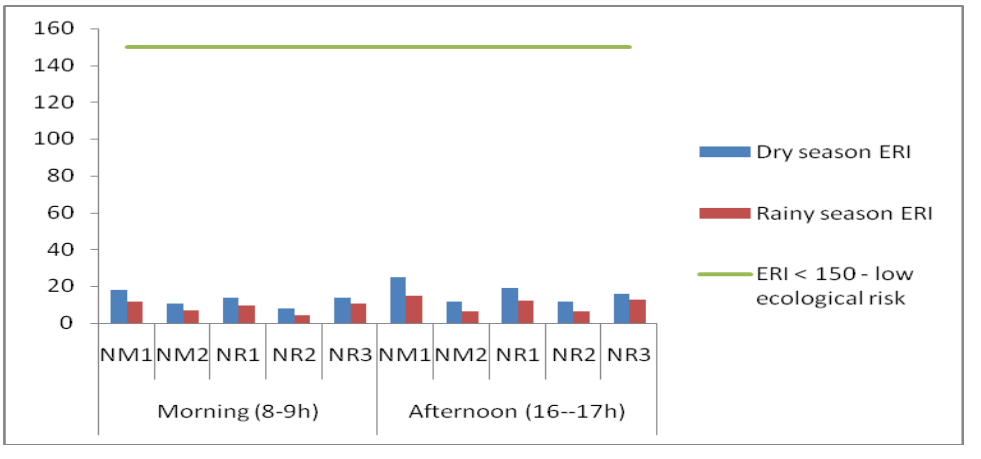
3.2.1. The metal index (MI)

Based on the *MI*, the following sequence was observed: average *MI* [Cu (0.0034) < Zn (0.0107) < As (0.1453) < Pb (0.1964) in LPS and Cu (0.0028) < Zn (0.0094) < As (0.1183) < Pb (0.1359) in HPS] in the groundwater in Dong Mai village. The selected sites around Dong Mai village were very pure by As and Pb. and *Fig.7* demonstrated the *MI* for both seasons.

For the groundwater in Dong Mai village, the weak negative SC between (pH, EC) (r= -0.546, p<0.05), (pH, Eh) (r= -0.477, p<0.05) and (*MI1*, *MI3*) (r= -0.462, p<0.05),

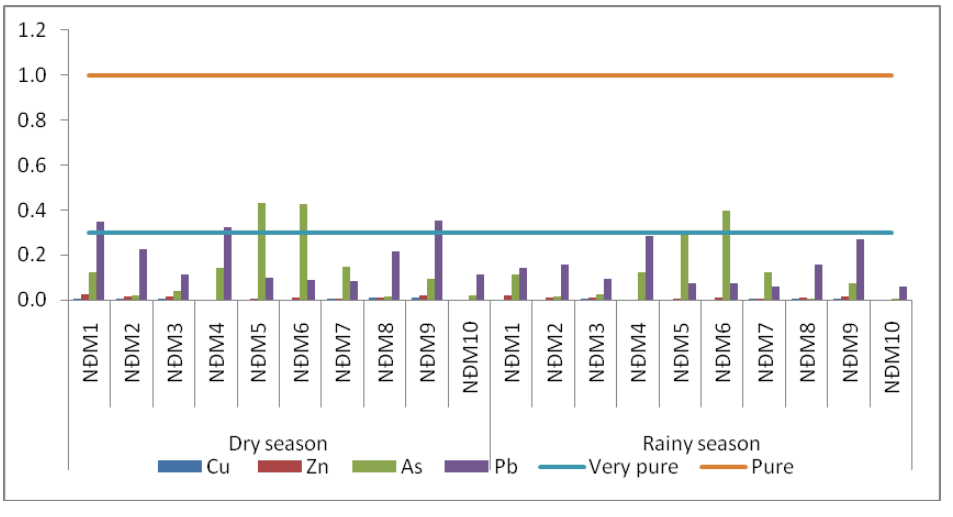


▲ *Fig.5. The potential ecological risk factor of As, Cu, Zn, Pb in the surface water.*



▲ *Fig.6. The potential ecological risk index (ERI) of heavy metals in the surface water*

so that an increase in the level of pH may lead in the decrease of EC & Eh as well as an increase in the level of the metal index of Cu element (*MI1*) may lead in the decrease of the metal index of As element (*MI3*). The metal index of Zn element (*MI2*) and the metal index of Pb element (*MI4*) were clustered in one main group



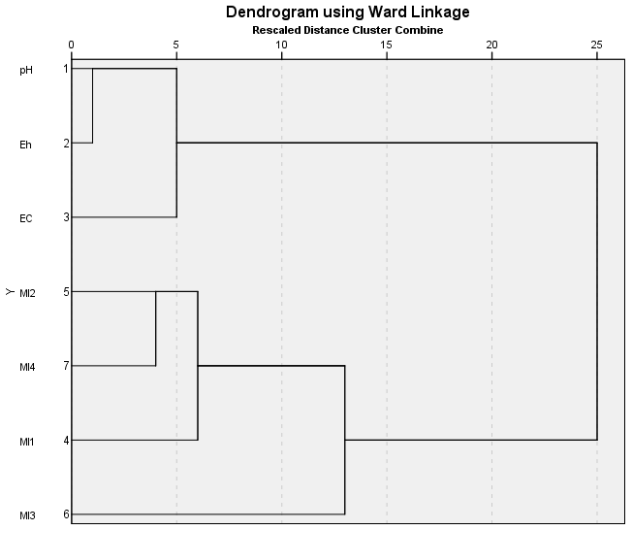
▲ *Fig.7. Seasonal variations of the metal index (MI) value of the groundwater*

with the shortest CD (<5) (*Fig.8a*); at the same time, they had positive SC (r= 0.469, p<0.05), indicating that they had similar patterns and sources in the groundwater in Dong Mai village. The cluster of [*MI2*, *MI4*] along with *MI1* also formed a cluster had strong linkage (>5, <10), but contributed largely to the groundwater, furthermore, the metal index of Cu element (*MI1*) and the metal index of Zn element (*MI2*) also had a same source by rock weathering and human activities (r= 0.605, p<0.01).

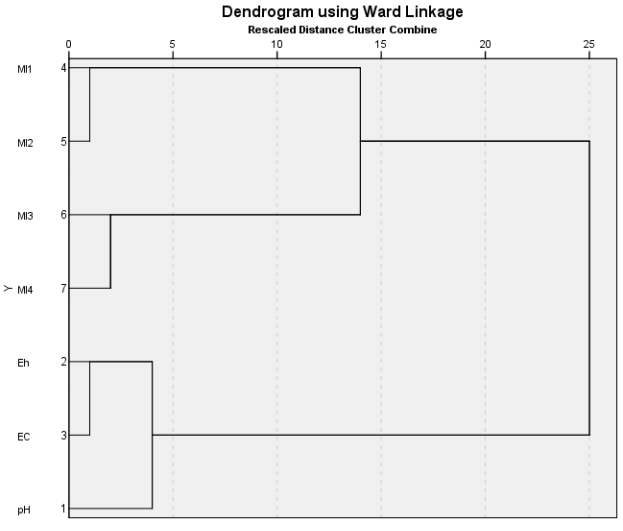
3.3. Environment of wastewater of the craft villages by using metal quality indices (MQI) in water

3.3.1. The metal index (MI)

Based on the *MI*, the following sequence was observed: average *MI* [As (0.014) < Cu (0.076) < Zn (0.244) < Pb (3.075) in HPS and As (0.073) < Cu (0.136) < Zn (0.369) < Pb (4.096) in LPS] in the wastewater in Dong Mai village. The selected sites around Dong Mai village were very pure and seriously affected by Cu, Zn, As and Pb, respectively, in HPS. In LPS, the selected sites around here were very pure to seriously affected by Cu, Zn, As and Pb, respectively and *Fig.10* demonstrated the *MI* for both seasons.



▲ *Fig.8a. Hierarchical cluster tree of grouping pH, Eh, EC and metal index (MI) of groundwater by cluster analysis*

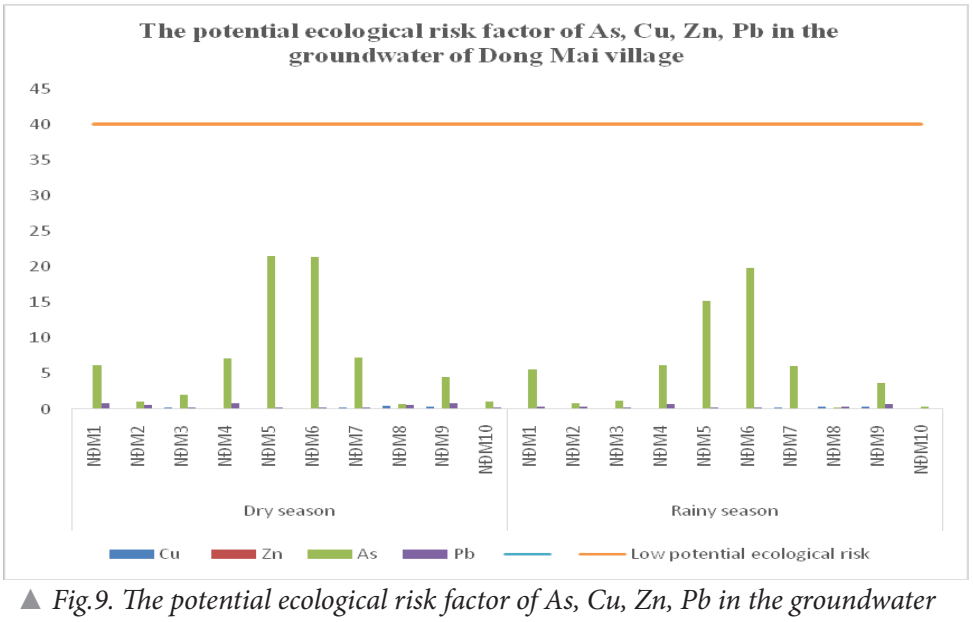


▲ *Fig.8b. Hierarchical cluster tree of grouping pH, Eh, EC and metal index (MI) of wastewater by cluster analysis*

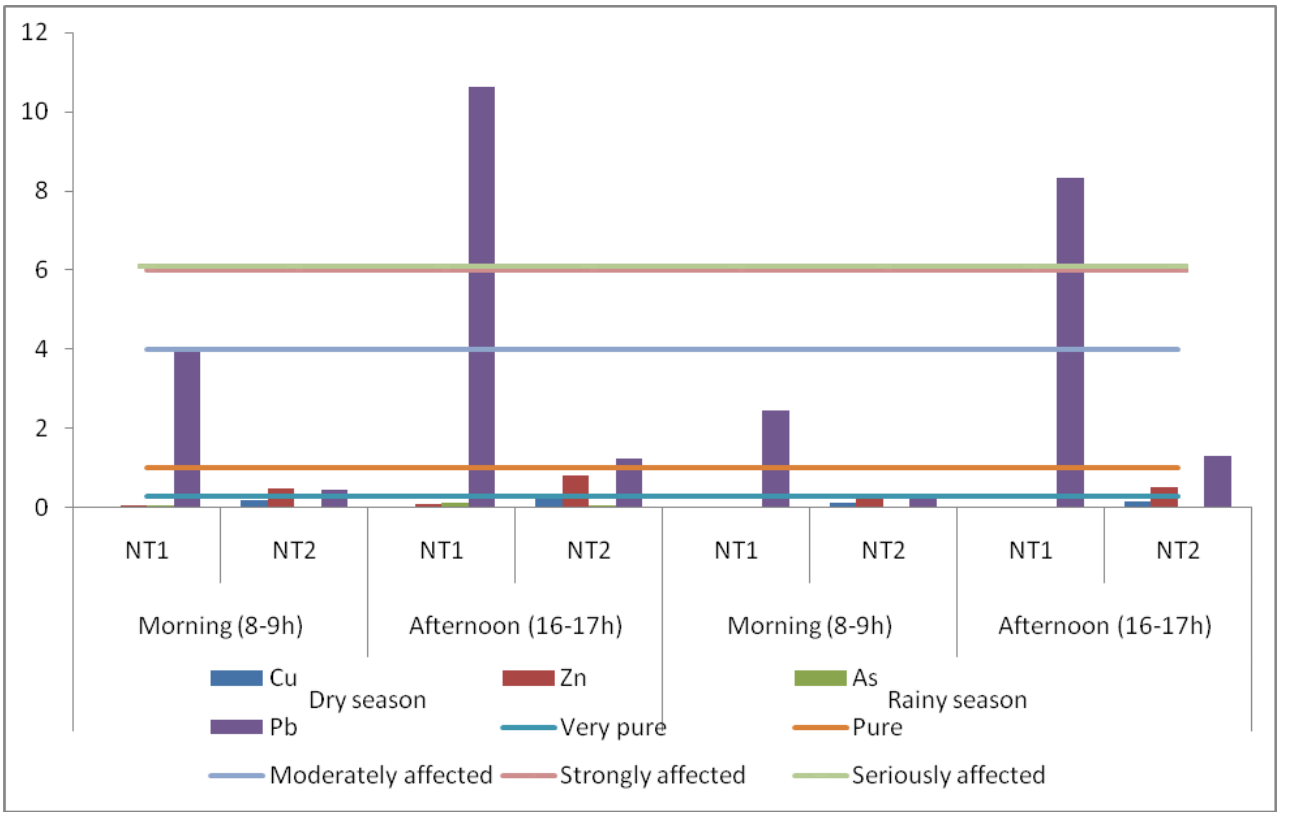
3.2.2. The ecological risk factor (ERF)

Fig.9 represented the potential ecological risk factor of Cu, Zn, As and Pb in the groundwater of Dong Mai village. The *ERFs* of Cu, Zn, As and Pb of the groundwater were at the low level (*ERF*<40).

For the wastewater in Dong Mai village, the metal index of Cu element (*MI1*) and the metal index of Zn element (*MI2*) were clustered in one main group with the shortest CD (<5) (*Fig.8b*); they had strong positive SC (r= 0.976, p<0.01), indicating that they had similar patterns and sources in the wastewater in Dong Mai village. The strong positive SC between (pH, *MI1*) (r= 0.802, p<0.05), (pH, *MI2*) (r= 0.731, p<0.05), an increase in the level of pH may lead in the increase in the level of metal index of Cu and Zn element. The cluster of [*MI3*, *MI4*] also formed a cluster had strong linkage (<5) and the strong negative SC between pH and metal index of Pb element (r= -0.898), therefore, the metal index of As element (*MI3*) and the metal index of Pb element (*MI4*) also had



▲ *Fig.9. The potential ecological risk factor of As, Cu, Zn, Pb in the groundwater*



▲ *Fig.10. Metal index (MI) value of the wastewater of Dong Mai village*

a same source but contributed largely to the wastewater, an increase in the level of pH may lead in the decrease of the level of the metal index of Pb element (*MI4*) and vice versa.

5. CONCLUSION

In this study, the characteristics of As, Cu, Zn, Pb contamination in water Dong Mai (Hung Yen) handicraft village was avaluated. The main conclusions were obtained as follows.

Principal component analysis (PCA) was conducted separately for each type of water environment. PCA had eigenvalue >1 focused on 2 components. PCA suggested that the contribution of metals in water was derived from the anthropogenic in addition to lithogenic sources. High loading of Pb in surface water came from the lead-recycled activities in Dong Mai village but Zn, Cu, As may come from rock weathering in terms of the metal index (*MI*) and the enrichment factor (*EF*). The potential ecological risk factor and the potential ecological risk index of Dong Mai's surface water were at the low level (ERF<40 & ERI < 150).

For the groundwater in Dong Mai village, Cu & As, Zn & Pb, Cu & Zn had the same pattern and source by rock weathering and human activities by an increase in the level of pH may lead in the decrease of EC and Eh as well as an increase in the level of one of heavy metals may lead in the decrease of each other metal and vice versa in terms of metal index (*MI*). The potential ecological risk factor of Cu, Zn, As, Pb of Dong Mai's groundwater were at the low level (ERF <40).

Cu & Zn, As & Pb also had same source, but contributed hugely to the wastewater and an increase in the level of pH may lead in the decrease of the level of Pb and vice versa in terms of metal index (*MI*).

A more comprehensive program of water sampling and analysis of Cu, Zn, As, Pb and other heavy metals is needed to be carried out for Dong Mai village in particular and in a wider area in Hung Yen province in general since the results of this study have shown an ecological risk of heavy metals concentration in the surface as well as ground water.

Acknowledgements: This research has been supported by a grant for the grassroots research project from Institute of Geological Sciences - Vietnam Academy of Science and Technology. The Author will also like to acknowledge the staff of Devision of Geological Chronology, Center of Environment as well as Institute of Geological Sciences for their technical advice and support ▪

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Calcination-hydrothermal treament of fly ash for methylene blue adsorption

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Abstract

Due to its high surface area, porous structure, small particle size and rich in mineral composition, fly ash has been widely studied as a potential adsorbent material (AM), which exhibits a significant capacity to adsorb pollutants from the environment and can be effectively used in wastewater treatment. However, current researches on the use of fly ash for methylene blue (MB) removal from wastewater are still limited. Therefore, this study aims to evaluate the MB adsorption capacity of modified fly ash (MFA) with 96% solid NaOH at 600°C for 1 hour. The static adsorption study has been conducted on the adsorption of MB solution of different concentrations on MFA at varying pH, contact time and initial concentration of dye solution. Research results show that the adsorption capacity of MFA is much greater than that of the original raw fly ash sample (FA); the equilibrium time of MFA is about 90 minutes; the optimal pH value is 7 with the adsorption efficiency of 98.53% and MB concentration is 100 mg/l. The highest adsorption capacity is 16.87 mg/g. Therefore, using MFA for MB adsorption can not only solve environmental problems, utilizing waste resources but also bring many technical and economic benefits, contributing to the sustainable development of related industries.

Keywords: *Adsorption, modified fly ash, methylene blue.*
JEL Classifications*: Q50, Q55, Q57.*
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1. INTRODUCTION

Water pollution caused by organic substances and industrial dyes has become a critical environmental issue these days. Among the dyes, MB is one of the most commonly used in textile, paper and leather industries. However, the presence of MB in wastewater poses significant environmental and health risks, particularly when it is present in high concentration. One of the effective methods to remove dyes from wastewater is adsorption. Among adsorbents, fly ash – a by-product of coal combustion at thermal power plants – has gained significant attention as a potential adsorbent due to its availability, cost-effectiveness, and adsorption properties.

According to data from Vietnam Electricity, Vietnam Oil and Gas Group, Vietnam National Coal - Mineral Industries Group and other thermal power plants, currently, Vietnam has 29 coal-fired thermal power plants in operation. In 2021, the total amount of ash and slag emitted from coal-fired thermal power plants across Vietnam was approximately 16 million tons. This waste was primarily concentrated in the Northern region, which accounted for 64% of the total emissions, while the Central and Southern regions accounted for 25% and 11%, respectively (Vietnam Electricity, 2022). By the end of 2021, the total amount of ash and slag consumed by thermal power plants nationwide was about 48.4 million tons, accounting for approximately 48% of the total emissions to date. In Vietnam, ash is mainly used in the construction sector such as landfilling, concrete additive or mineral additive for cement…; in the plastics processing industry or agriculture (Vietnam Electricity, 2022).

Most fly ash is composed of silicate compounds, mainly including silicon dioxide (SiO_2), aluminium oxide (Al_2O_3), iron (III) oxide (Fe_2O_3) and some other metal oxides such as CaO, MgO and TiO_2. The unburned coal generally constitutes a small percentage of the total fly ash. In addition, fly ash can contain trace amounts of heavy metals such as Cd, Ba, Pb, Cu and Zn... The chemical composition of fly ash depends on the source of coal used for combustion and the combustion conditions in thermal power plants (Luong Nhu Hai, 2020).

Fly ash, with its large surface area, porous structure, small particle size and diverse chemical composition, is increasingly being studied by scientists and considered an effective material for pollutant adsorption and wastewater treatment.

Numerous studies have explored the use of fly ash as a adsorbent material for removing toxic metal ions from wastewater (Marisa Nascimento et al., 2012), (Dasmahapatra et al., 1996), air pollutants (Anand Srinivasan et al., 1999), organic and inorganic compounds (Jakkapong Sasithorn et al., 2010), (Haribhau E. et al., 1993) and dyes from wastewater (Nityanand Singh Maurya et al., 2008), (Debabrata Chatterjee et al., 2010). However,

in fly ash, SiO_2 and Al_2O_3 often exist in different crystalline forms, of which mullite ($3Al_2O_3 \cdot 2SiO_2$) and quartz (SiO_2) are two main crystalline phases. The presence of quartz and mullite in fly ash can reduce its overall adsorption capacity since they have low surface areas, highly stable and non-reactive (Bakkali H. et al., 2016). So research often focuses on enhancing the adsorption capacity of fly ash by modifying or treating it to increase the proportion of reactive amorphous phases. Techniques such as chemical activation, thermal treatment and physical modification can be employed to improve fly ash's performance as an adsorbent (Z. Sarbak et al., 2002), (Ubolluk Rattanasaka et al., 2009), (Xiaojing Chen et al., 2018). Z. Sarbak et al. (2002) treated the surface of fly ash with NaOH, $NaOH/NH_4HCO_3$, EDTA and HCl solutions to change the surface area, porous structure and chemical composition of fly ash. In all cases, the surface area of the treated fly ash was larger than that of the original fly ash sample. Xiaojing Chen et al. modified fly ash by the hydrothermal fusion method with NaOH. The research results showed that the modified fly ash sample significantly increased its surface area from 0.15 m^2/g to 270 m^2/g, and the maximum adsorption capacity for NH_4^+ ions was up to 139 mg/g (Xiaojing Chen et al., 2018).

Compared to acid modification method, alkaline modification of fly ash has been shown to significantly enhance its structure, surface properties, and adsorption efficiency due to the chemical reactions that occur during the alkaline treatment.

Firstly, the quartz (SiO_2) and mullite ($3Al_2O_3$ $2SiO_2$) compounds in fly ash can react with alkali to form soluble compounds:

$SiO_2 + 2NaOH \rightarrow Na_2SiO_3 + H_2O$

$3Al_2O_3 \,.\, 2SiO_2 + 10NaOH \rightarrow 2Na_2SiO_3 + 6NaAlO_2 + 5H_2O$

These reactions reduce the amount of SiO_2 and Al_2O_3, leading to structural destruction, increasing the porosity and surface area of the fly ash. The newly formed pores increase the adsorption capacity of the fly ash (Bakkali H. et al., 2016), (Tifa Paramitha, 2020).

Calcination hydrothermal method with solid NaOH is performed at higher temperatures (550-600°C) and offers distinct advantages over the conventional hydrothermal method. High temperature is necessary which can stimulate the quartz and mullite in fly ash, destroy their crystal structure, thus release more active forms of SiO_2 and Al_2O_3. These substances react with NaOH and generate amorphous aluminosilicate, which then recombine to form three-dimensional aluminosilicate structures (called geopolymers) on the fly ash particle surface during the hydrothermal phase. Moreover, high temperature calcination can remove organic impurities and amorphous carbon in fly ash, which improves the purity of raw materials. In addition, alkali melting of fly ash provides a larger amount of NaOH for the following hydrothermal process than NaOH in solution. These factors significantly enhance the efficiency and quality of the resulting geopolymer, which improve the adsorption capacity of fly ash compared to the traditional thermal hydrolysis method in NaOH solution (Minghua Wang et al., 2019), (Vegere K. et al., 2020).

Secondly, the alkali treatment of fly ash can generate hydroxyl groups (-OH) on its surface. Hydroxyl groups can form hydrogen bonds with polar substances, enhancing the adsorption of molecules such as dyes and organic pollutants. Fourier transform infrared spectroscopy (FTIR) analysis showed the formation of O–H bonds of silanol (Si–OH) on the fly ash particle surface through absorption peaks at 3400-3500 cm^{-1} (Khoa Dang Nguyen et al., 2022).

In Vietnam, studies on the application of modified fly ash are still relatively limited. Some notable studies include: Evaluation of the adsorption capacity of Cu^{2+} in electroplating wastewater using modified fly ash (Lu Thi Yen et al., 2020); modification of Pha Lai fly ash with functional polymers to increase chromium adsorption capacity in wastewater treatment (Tran Minh Huyen, 2012); research coal fly ash-slag and slag-based geopolymer as an absorbent for the removal of methylene blue in wastewater (Khoa Dang Nguyen et al., 2022). Currently, there is no study on the adsorption capacity of MB using fly ash with solid NaOH calcination hydrothermal treatment. Therefore, this study is necessary because the research results could serve as a crucial basis for applying modified fly ash in the treatment of colored wastewater containing MB.

2. MATERIALS AND METHODS

2.1. Equipment, materials and chemicals

2.1.1. Equipment

Experimental studies were conducted at the Environmental Laboratory - University of Transport Technology. Experimental equipments are shown in Table 1.

2.1.2. Materials and chemicals

Chemicals used in this study include:

- Methylene blue $C_{16}H_{18}ClN_3S$
- Solid sodium hydroxide NaOH 96%
- HCl solution (36 - 38%)

Fly ash used in this study was gotten from Pha Lai Thermal Power Plant in Hai Duong province which was pre-qualified by air separation technology. The fly ash sample has a surface area of 8.169 cm^2/cm^3, most of the particles are 30 μm in size (accounting for 95%). The results of chemical composition analysis of fly ash at the Vietnam Academy of Science and Technology are shown in Table 2. According to chemical composition, fly ash of Pha Lai Thermal Power Plant belongs to group F according to ASTM C618-03 standard (Lu Thi Yen et al., 2020).

Table 1: Experimental equipments

No	Equipment	Product Code/Origin	Main function
1	Spectrophotometer	Tintometer/France	Analysis of chemical components in water using spectroscopy
2	Drying oven	Memmert/Germany	Dry samples at 20 - 300°C
3	Muffle furnace	LH 15/14 Nabertherm/Germany	Heat samples up to 1.400°C
4	pH meter	HI 2211 Hanna/Rumania	Measure the pH of solutions
5	Analytical balance	Sartorius/Germany	Determine the exact weight of samples (± 0,1mg)
6	Ducted fume hood	Esco/Singapore-Indonesia	Provide personnel protection against toxic fumes, vapors, and dust
7	Heating magnetic stirrer	IKA/Germany - China -Malaysia	Heat and stirr solution samples

(Source: Environmental Laboratory - University of Transport Technology)

Table 2: Chemical composition of fly ash (mass fraction, %)

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	SO_3	MKN*
51,74	24,53	5,59	0,81	1,95	4,42	0,11	0,76	0,31	8,98

(*) Loss on heating
(Source: Lu Thi Yen et al., 2020)

2.2. Modification of fly ash

The modification method used in this study was carried out according to the research of Lu Thi Yen et al. (2020). The preparation process of the modified fly ash was as follows:

A certain amount of fine fly ash was mixed with NaOH powder with a mass ratio of 1:1,2. The mixture was transferred to a crucible cup which was calcinated at 600°C in a muffle furnace for 1 hour.

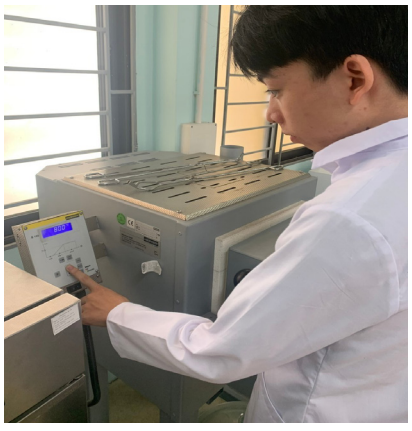
After cooling down to room temperature, the solid mixture was ground. Then distilled water was added at a ratio of 1:5 and stirred continuously on the heating magnetic stirrer at 70°C for 2 hours to form an aluminosilicate gel. The mixture was then heated to 100°C for 4 hours to crystallize the aluminosilicate gel on the fly ash particle surface.

The mixture was then filtered off and washed with distilled water until pH = 7. The obtained material was dried at 105°C to constant mass. Figures 1 to 6 illustrate the key steps involved in the fly ash modification procedure. The fly ash sample obtained after the modification process is shown in Figure 7.

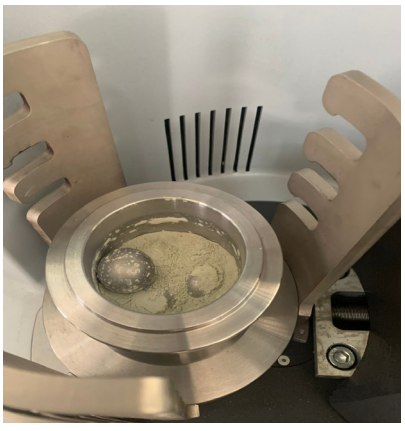
2.3. Determination of MB concentration in solutions using spectroscopy

Standard solutions of MB with the following concentrations of 0,5 mg/l; 0,75 mg/l; 1 mg/l; 1,5 mg/l; 2 mg/l; 3 mg/l were prepared. The absorbance of each standard solution was measured at 664 nm using the UV-Vis spectrophotometer. The measurement of each solution was repeated three times and then, the average of these three values was calculated. Base on the absorbance data, the standard solution calibration curve A - C (MB) is built by Excel and presented in Figure 8.

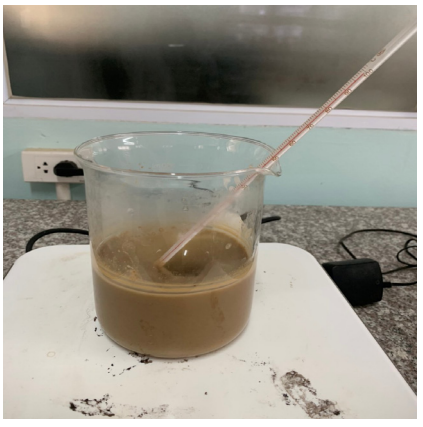
Based on these data, a linear regression equation y = 0,9827x + 0,0452 was obtained with a coefficient of determination R^2 = 0,9949 so that the linearity of the standard solution with a range of 0,5-3,0 mg/l is more than 99%. By having a correlation coefficient ≥ 0,99, the calibration curve meets the requirements of linearity acceptance so that the test results on the standard solution used are proportional to the concentration of analytes in the sample working in the range of linear area (0,5-3,0 mg/l). Because the MB standard curve equation has high linearity in the low concentration range from 0,5 ÷ 3,0 mg/l, the determination of MB concentrations in the higher value range was performed by diluting.



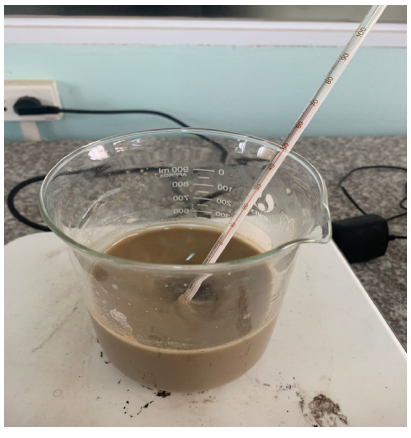
▲ *Fig.1. Heating the mixture of fly ash and NaOH at 600°C*



▲ *Fig.2. Grinding the mixture of fly ash and NaOH*



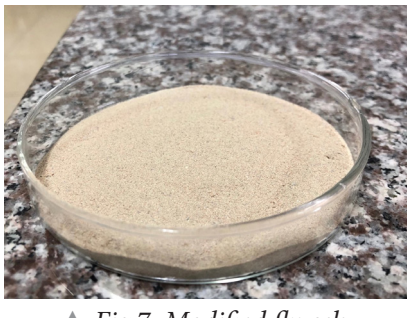
▲ *Fig.3. Adding distilled water at a ratio of 1:5 and stirring at 70°C*



▲ *Fig.4. Stirring at 100°C*

▲ *Fig.5. Washing fly ash*

▲ *Fig.6. Drying fly ash at 105°C in the drying oven*



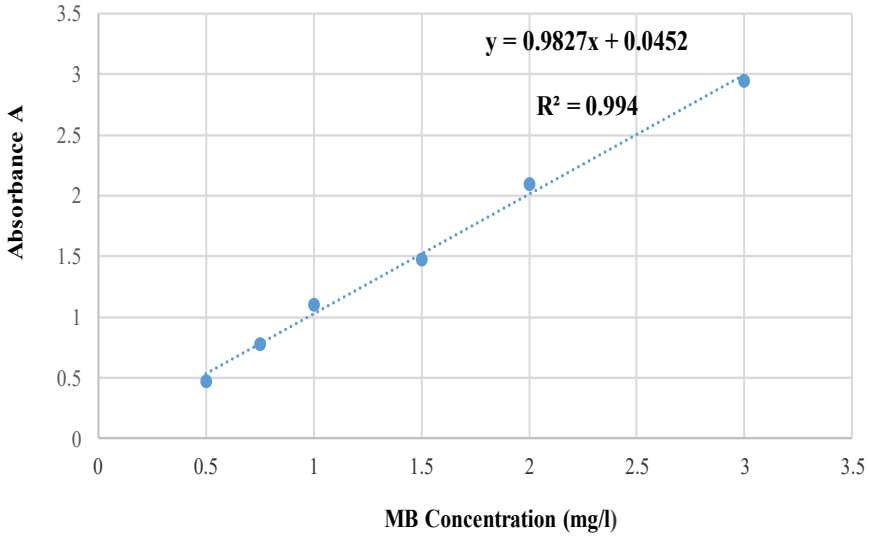
▲ *Fig.7. Modified fly ash sample after drying*

2.4. MB adsorption experiments using modified fly ash

2.4.1. Experiments of the effect of time on MB adsorption capacity

a. MB adsorption by raw fly ash sample

MB adsorption experiments were carried out in a series of batch experiments. Firstly, 7 beakers with a capacity of 500 ml, containing 250 ml of MB with a concentration of 40 mg/l were taken. 1 gram of raw fly ash (untreated) was put into each beaker, and then these beakers were shaken for different time intervals (5, 10, 20, 30, 60, 90 and 120 minutes). At the end of each contact time interval, the fly ash was separated from the solution using filtration. The absorbance of the filtrate from each sample was measured using the UV-Vis spectrophotometer at 664 nm. The remaining MB concentration was calculated using the calibration curve A - C (MB).



▲ *Fig.8. Methylene blue standard solution calibration curve*

b. MB adsorption by modified fly ash sample

The experiment was conducted similarly to the raw fly ash sample, except that the adsorbent material was 1g of modified fly ash.

2.4.2. Experiments of the effect of pH on MB adsorption capacity

The optimal adsorption time of MB onto modified fly ash was determined by the result of experiments studying the effect of contact time on MB adsorption capacity.

5 beakers with a capacity of 500 ml, containing 250 ml of MB with a concentration of 40 mg/l were taken. pH adsorptions (with the values of 3, 5, 7, 9, 11) were adjusted using HCl or NaOH solution. Then 1 g of modified ash sample was added to the solution. The solution was shaken for the adsorption equilibrium time determined in the above experiment. After separating the ash from the solution by filtration, the concentration of MB in the solutions was then determined using UV-Vis spectrophotometer at 664 nm (solution may be diluted before measurement if required). The remaining MB concentration was calculated using the calibration curve A - C (MB).

2.4.3. Experimental study on the effect of initial MB concentration on adsorption capacity

7 beakers containing 250 ml of MB with concentrations of 40 mg/l, 50 mg/l, 75 mg/l, 100 mg/l, 150 mg/l, 200 mg/l, 250 mg/l were prepared. 1g of modified ash sample was added to the solutions, and then the solutions were shaken for the adsorption equilibrium time determined in the above experiment. The determination of the remaining MB concentration was carried out similarly to the experiment 2.4.2.

2.5. Calculation of results

- Calculation of adsorption capacity

The adsorption capacity at equilibrium (q, mg/g) can be calculated using the equation:

$$q = \frac{(C_o - C_t).V}{m}$$

where C_0 is the initial MB concentration (mg/l), C_t is the retained MB concentration (mg/l) in solution at time t, V is the solution volume (ml), and m is the weight of the adsorbent (g).

- Calculation of adsorption efficiency

Adsorption efficiency (H, %) was calculated using the following formula:

$$H = \frac{(C_o - C_t)}{C_o}.100\%$$

3. RESULTS AND DISCUSSIONS

3.1. Effect of contact time on MB adsorption

The effect of contact time on the adsorption of MB from aqueous solution by raw fly ash and modified fly ash was performed. The adsorbents were added at a ratio of 1g for 250 ml of MB solution with the initial concentration of 40 mg/l.

The results of determining the retained MB concentration and adsorption efficiency after certain time intervals are presented in Table 3, Fig.9 and Fig.10.

The results showed that the initial raw fly ash sample had the ability to adsorb MB in solution, however the adsorption efficiency was not high, just about 30% - 58%. The adsorption efficiency gradually increased with increasing contact time ranging from 5 to 120 min. From 90 to 120 mins, the adsorption efficiency was almost stable and reached nearly 58%. The MB adsorption capacity also increased gradually over time from 2,96 mg/g to 5,76 mg/g (in 90 min) and beyond 90 mins, the capacity was almost stable.

Unlike the raw fly ash sample, the modified fly ash showed a much higher and faster increase in adsorption efficiency. Rapid adsorption of MB took place in the first 5 mins with 95,4% of MB being removed from the solution. From 60 to 120 mins, the adsorption efficiency of the modified fly ash began to plateau, indicating that equilibrium was approaching. The adsorption capacity of MB on the modified fly ash increased significantly compared to the initial raw fly ash sample, reaching 9,84 mg/g after 120 minutes and corresponding to a significant higher adsorption efficiency of 98,25% at equilibrium.

The significant improvement in adsorption capacity and efficiency for the modified fly ash can be attributed to the modification process with NaOH. This process changes the morphology and increases the surface area of fly ash particles. The increased surface area enhances the contact and interaction ability of MB with the adsorption centers on the surface of fly ash particles, leading to a significant increase in adsorption efficiency compared to the original raw fly ash sample (Sarbak Z. et al., 2002), (Xiaojing Chen et al., 2018), (Lu Thi Yen and partners, 2020). Therefore, the next MB adsorption experiments were investigated only on modified fly ash.

On the basis of this result, it was determined that the time for the adsorption process of MB on modified fly ash to reach equilibrium was approximately 90 minutes. This result is similar to the study of Cu^{2+} adsorption on fly ash samples modified by the fusion-hydrothermal method (Lu Thi Yen et al., 2020) and is half the time of MB adsorption on ash and coal slag samples modified by NaOH/Na_2SiO_3 solution at 60°C in 24 hours (Khoa Dang Nguyen et al., 2022). The shortened time to reach equilibrium for the adsorption process is particularly meaningful by reducing the overall time required for wastewater treatment in the adsorption stage.

The rest of the adsorption studies was conducted with adsorption time of 90 mins.

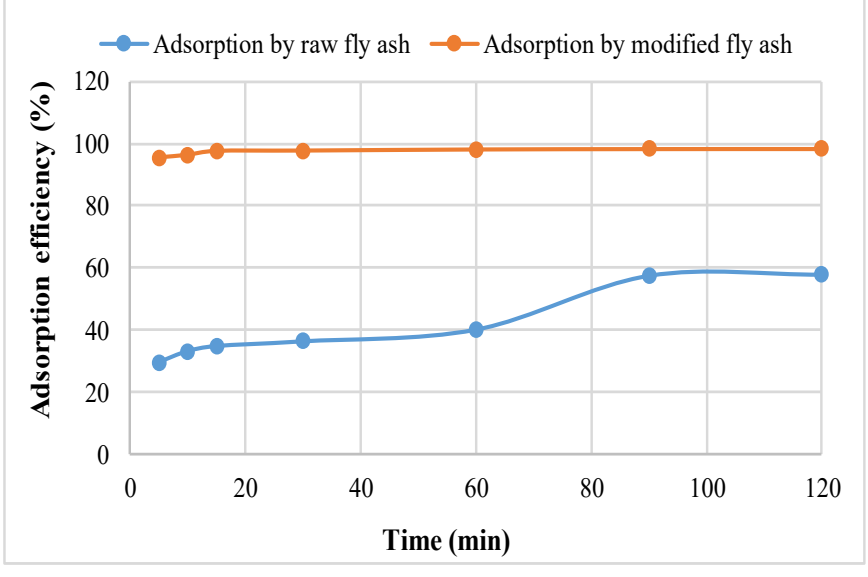
3.2. Effect of solution pH on MB adsorption

The experiments were carried out with the following parameters: The mass of modified fly ash was 1g; the volume of MB solution was 250 ml; the concentration of MB was 40 mg/l; the adsorption time was 90 min; the pH range was 3÷11, including values 3, 5, 7, 9 and 11. MB solutions after adsorption by modified fly ash at different pH values is shown in Figure 11.

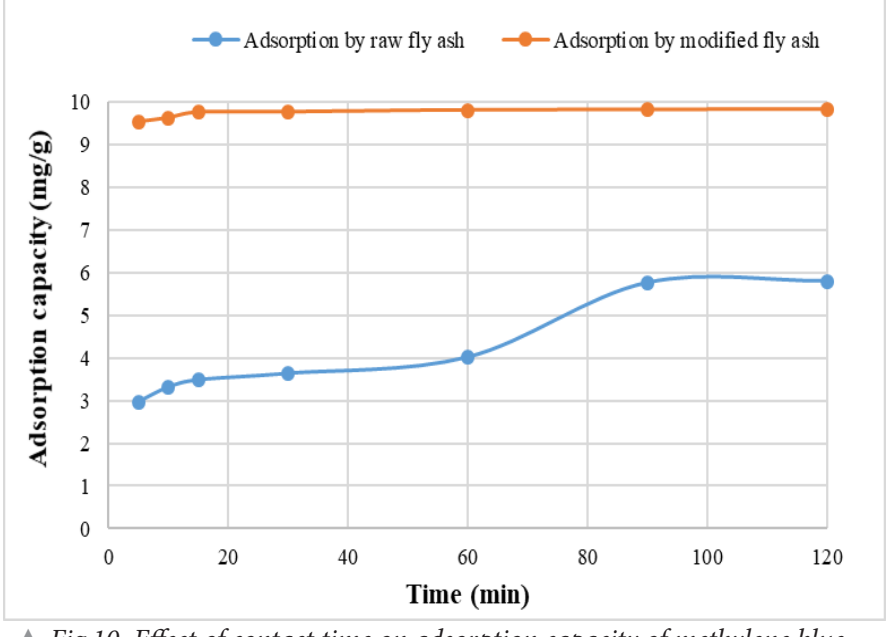
Table 3. Results of effect of contact time on MB adsorption

Time, (min)	Initial MB concentration, C_0 (mg/l)	Adsorption by raw fly ash			Adsorption by modified fly ash		
		Retained MB concentration, C_t (mg/l)	Adsorption efficiency, H (%)	Adsorption capacity, q (mg/g)	Retained MB concentration, C_t (mg/l)	Adsorption efficiency, H (%)	Adsorption capacity, q (mg/g)
5	40	28,18	29,55	2,96	1,84	95,40	9,54
10	40	26,75	33,13	3,31	1,49	96,28	9,63
15	40	26,09	34,78	3,48	0,95	97,63	9,76
30	40	25,48	36,30	3,63	0,91	97,73	9,77
60	40	23,97	40,08	4,01	0,76	98,10	9,81
90	40	16,97	57,58	5,76	0,71	98,23	9,82
120	40	16,82	57,95	5,80	0,70	98,25	9,83

(Source: Results of the research team)



▲ *Fig.9. Effect of contact time on adsorption efficiency of methylene blue*



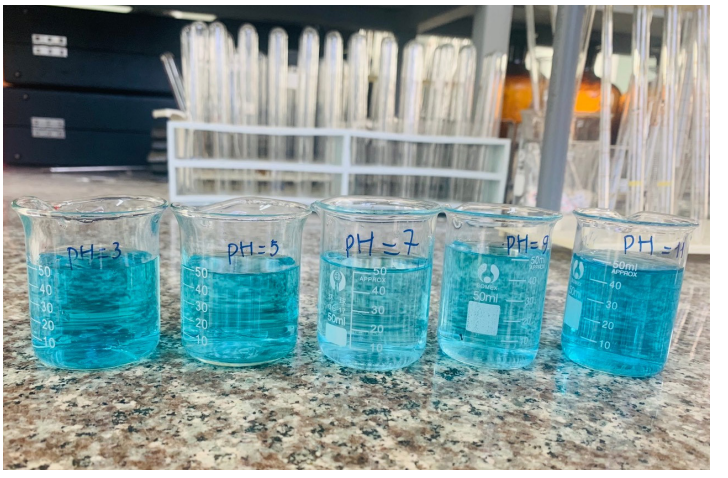
▲ *Fig.10. Effect of contact time on adsorption capacity of methylene blue*

The results of MB adsorption efficiency depending on different pH are summarized in Table 4 and represented in Figures 12 and 13.

The results in Table 4 show that the adsorption efficiency and capacity of MB on modified fly ash vary with pH, with the highest efficiency observed at pH 7. At this optimal pH, the adsorption efficiency reached 98,53%, and the adsorption capacity was 9,85 mg/g. The adsorption efficiency and capacity increased as the pH changed from acidic to neutral and slightly alkaline conditions. However, when the pH increased too high, the adsorption efficiency decreased to 93.23% at pH = 11. This result is different from the study (Lu Thi Yen et al., 2020) when the adsorption efficiency of Cu^{2+} by modified fly ash reached the highest efficiency at pH = 6 (H = 95%). This is because at low pH, the functional groups on the fly ash surface, such as hydroxyl (-OH) groups, can become protonated, leading to a positively charged surface. This causes electrostatic repulsion between the positively charged surface and the cationic MB dye, resulting in low adsorption capacity. At neutral pH (pH = 7), the fly ash surface charge is nearly neutral or may have some negatively charged sites, which facilitate better adsorption of MB due to the balance between electrostatic

forces and Vander Waals interactions. At slightly alkaline pH, the functional groups on the fly ash surface can be deprotonated, resulting in a negatively charged surface and facilitating the adsorption of MB^+ cations due to stronger electrostatic attraction. However, if the pH continues to increase (pH = 11), there will be competition from OH^- ions in the solution, so the adsorption efficiency will gradually decrease.

Although pH affects the adsorption efficiency, it is insignificant and the adsorption efficiency is still very high in the pH range from 3 to 11, which is very meaningful in practice because it can effectively treat water sources contaminated with MB color with different pH ranges.

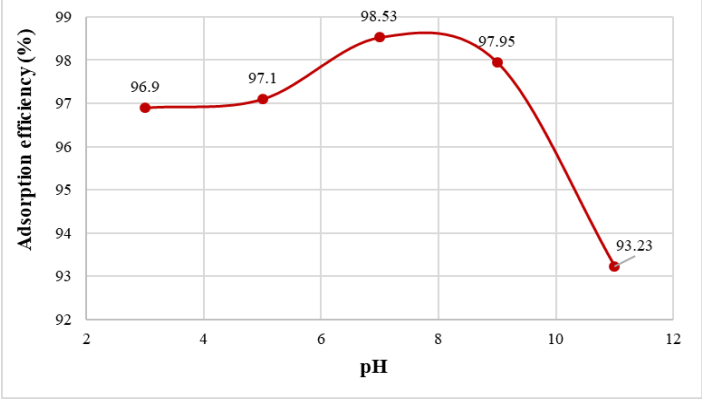


▲ *Fig.11. MB solutions after adsorption by modified fly ash at different pH values*

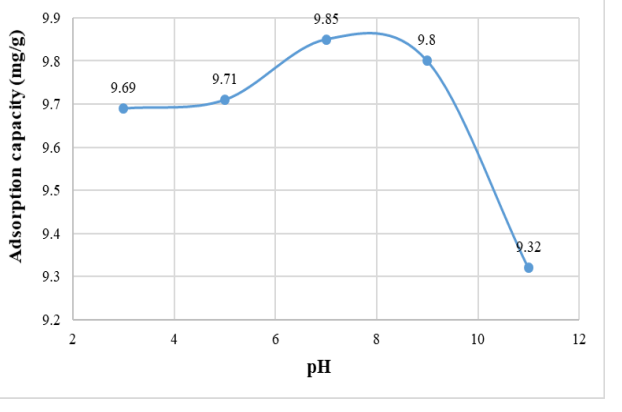
Table 4. Effect of pH on MB adsorption by modified fly ash

pH	Initial concentration of MB solution, C_0 (mg/l)	Retained concentration of MB solution, C_t (mg/l)	Adsorption efficiency, H (%)	Adsorption capacity, q (mg/g)
3	40	1,24	96,90	9,69
5	40	1,16	97,10	9,71
7	40	0,59	98,53	9,85
9	40	0,82	97,95	9,80
11	40	2,71	93,23	9,32

(Source: Results of the research team)



▲ *Fig.12. Effect of pH on MB adsorption efficiency of modified fly ash*



▲ *Fig.13. Effect of pH on MB adsorption capacity of modified fly ash*

3.3. Effect of initial MB concentration on adsorption capacity of modified fly ash

The effect of MB concentration on adsorption efficiency and capacity at constant pH of 7, adsorbent mass of 1 g, contact time of 90 min and the volume solution of 250 ml. The effect of MB concentration in the range of 40 –250 mg/l (40 mg/l, 50 mg/l, 75 mg/l, 100 mg/l, 150 mg/l, 200 mg/l, 250 mg/l) was selected. The results are shown in Table 5, Figure 14 and Figure 15.

As shown in Figure 14, by increasing the concentration from 40 to 250 mg/l, the adsorption efficiency decreases. In case of low concentration (C_0 = 40 mg/l), the adsorption efficiency reaches 98,53%, but when increasing the concentration of MB solution to 250 mg/l, the efficiency decreases to 26,42%.

On the other hand, as shown in Figure 15, by increasing the concentration from 40 to 250 mg/l, the adsorption capacity (q) is increasing. The adsorption capacity increases from 9,85 mg/g to 16,87 mg/g when the concentration increases from 40 mg/l to 100 mg/l. And when the MB concentration increases to 150 mg/L, 200 mg/L, and 250 mg/L, the adsorption capacity almost remains unchanged, indicating

that the fly ash adsorption sites are saturated. In this case, by increasing dye concentration, the amount of MB molecules available to interact with adsorption sites on the fly ash surface also increases. MB molecules in the aqueous solution increases relatively to the adsorbent dose and there are fewer adsorption sites for methylene blue dyes to be placed on the adsorbent surface, and as a result, the removal efficiency decreases. However, when all the adsorption sites on the fly ash surface are occupied, the adsorption process will reach equilibrium, and after this point, increasing the MB concentration will not significantly increase the amount of MB adsorbed.

3.4. Adsorption isotherm model for MB adsorption on modified fly ash

The two widely used adsorption isotherm models such as Langmuir and Freundlich were used to determine the adsorption behaviour of MB modified fly ash (Yuan N. et al., 2029).

The Langmuir isotherm model assumes monolayer adsorption onto a surface with a finite number of identical sites. Equation of Langmuir isotherms is given as follows:

$$q = q_{max} \frac{K_L C}{1+K_L C}$$

where: q is the amount of MB adsorbed per unit mass of adsorbent (mg/g); C is the equilibrium concentration of MB in the solution (mg/l); Q_{max} is the maximum adsorption capacity (mg/g); K_L is the Langmuir constant related to the affinity of the binding sites (l/mg).

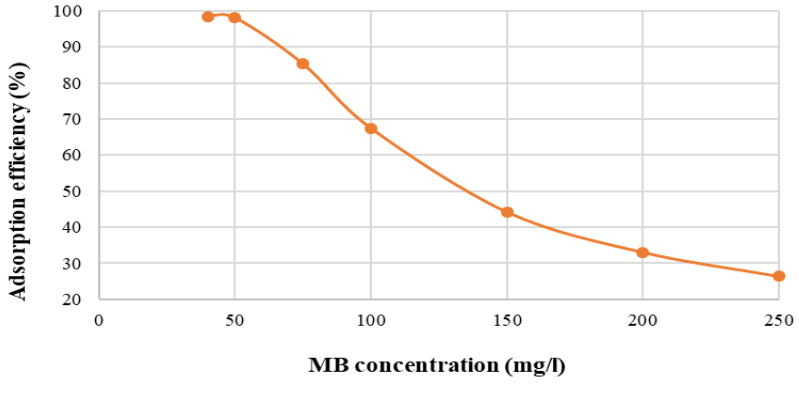
The linear form of the Langmuir isotherm can be expressed as:

$$\frac{1}{q} = \frac{1}{K_L q_{max}} \frac{1}{C} + \frac{1}{q_{max}}$$

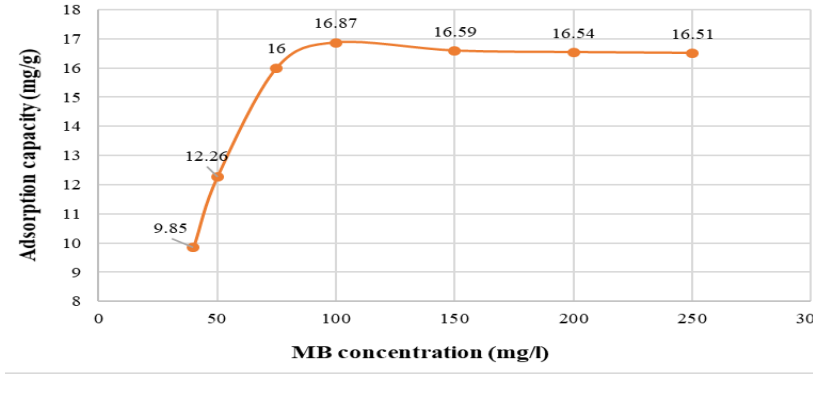
Table 5. Results of effect of initial concentration on MB adsorption

Mass of modified fly ash, m (g)	Volumn of MB solution, V(ml)	Initial concentration of MB solution, C_o (mg/l)	Retained concentration of MB solution, C_t (mg/l)	Adsorption efficiency, H (%)	Adsorption capacity, q (mg/g)
1	250	40	0,59	98,53	9,85
1	250	50	0,96	98,08	12,26
1	250	75	11,01	85,32	16,00
1	250	100	32,53	67,47	16,87
1	250	150	83,64	44,24	16,59
1	250	200	133,84	33,08	16,54
1	250	250	183,96	26,42	16,51

(Source: Results of the research team)



▲ *Fig.14. Effect of initial MB concentration on adsorption efficiency of modified fly ash*



▲ *Fig.15. Effect of initial MB concentration on adsorption capacity of modified fly ash*

The Freundlich isotherm model describes adsorption on heterogeneous surfaces and is represented by the following equation:

$$q = K_F C^{\frac{1}{n}}$$

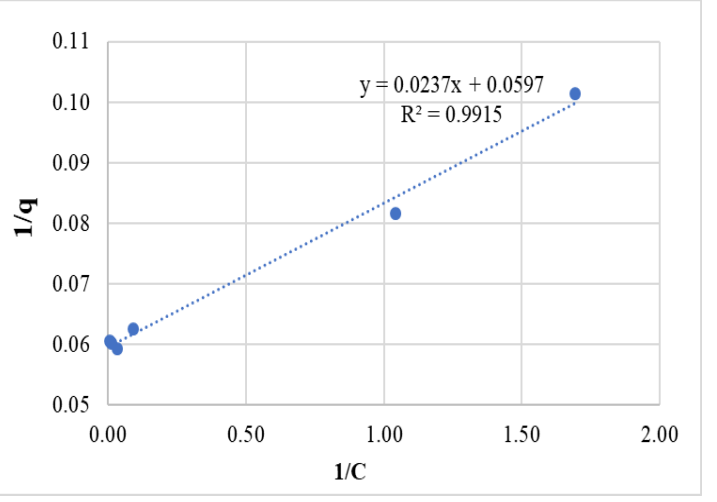
The linear form of the Freundlich isotherm is:

$$\ln q = \ln K_F + \frac{1}{n}\ln C$$

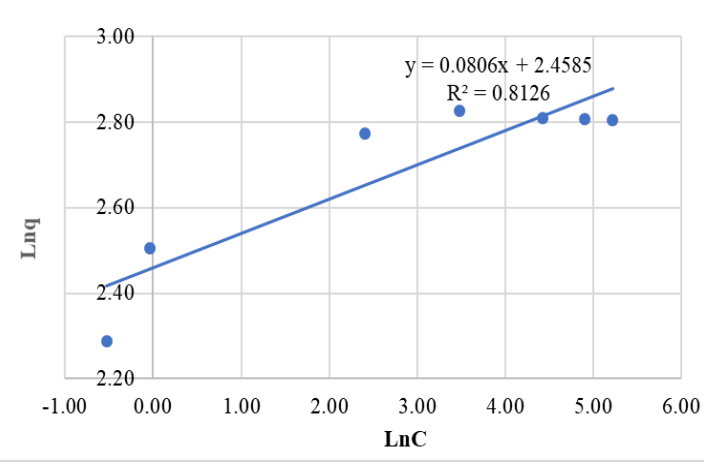
where: K_F is the Freundlich constant indicative of the adsorption capacity (mg/g); n is related to the adsorption capacity and heterogeneity of the adsorbent surface sites. Values of n > 1 indicate that the adsorption process is favorable.

Since K_L, q_{max}, K_F and n are constants, equations (2) and (4) have the form of the straight line y = ax+b. The linear forms of Langmuir and Freundlich isotherm models are plotted in Figure 16 and Figure 17 respectively. Their constant values are given in Table 6.

From the data of Table 6, it is observed that R^2 value of the Langmuir model is much closer to unity (R^2 = 0,9915) and higher than the R^2 value of the Freundlich model. So the Langmuir model is better than the Freundlich model in fitting the experimental isotherms, which might be due to homogenous distribution of active sites on the surface of the modified fly ash. The maximum adsorption capacity of the modified fly ash obtained was 16,8 mg/g (Table 6). This result is quite similar to the maximum adsorption capacity of Cu^{2+} on modified fly ash (q_{max} = 16,4 mg/g) in a previous study (Lu Thi Yen et al., 2020).



▲ *Fig.16. Dependence of 1/q on 1/C according to the Langmuir isotherm model*



▲ *Fig.17. Dependence of lnq on lnC according to the Freundlich isotherm model*

Table 6. Calculated constants and statistical parameters of selected isotherm models for MB adsorption onto modified fly ash

Langmuir isotherm model			Freundlich isotherm model		
q_{max}	K_L	R^2	n	K_L	R^2
16,8	2,5	0,9915	12,4	11,7	0,8126

(Source: Results of the research team)

4. CONCLUSION

Based on the experimental research results, the following conclusions can be given about the MB adsorption capacity of modified fly ash:

1. Fly ash of Pha Lai thermal power plant (Hai Duong province) after treating with 96% solid NaOH at 600°C for 1 hour has much better MB adsorption capacity than unmodified TB.

2. Several factors affecting the MB adsorption capacity of modified fly ash by static adsorption method were studied. According to the experimental results, the time for the adsorption process of MB on modified fly ash to reach equilibrium was approximately 90 minutes. High adsorption efficiency (over 93%) of MB on modified fly ash was achieved at pH range from 3 to 11 and best at pH = 7 (adsorption efficiency 98,53%). The adsorption efficiency was high (over 98%) at initial MB concentrations of 40 mg/l and 50 mg/l. The adsorption efficiency gradually decreased with incresing of MB concentration and was only 26,42% when the MB concentration was 250 mg/l. The adsorption capacity gradually increased with increasing MB concentration, however, the adsorption capacity only increased to 16,87 mg/g (when the MB concentration was 100 mg/l) and then gradually stabilized.

3. Isotherm study indicated that the Langmuir model fitted best with experimental data and revealed the monolayer adsorption on a surface with a finite number of identical sites. The maximum adsorption capacity calculated from the Langmuir isotherm is 16,8 mg/g.

In summary, the research results demonstrated that modified fly ash is a highly effective adsorbent material for methylene blue that it can be utilized in wastewater treatment systems to remove organic dyes. However, the research primarily focused on the static adsorption process and MB solutions used in the experiments were prepared in the laboratory. Another notable limitation of the research is the absence of regeneration experiments for the modified fly ash. So further studies on dynamic adsorption and regeneration of adsorbent using real wastewater samples are essential to assess the effectiveness of the modified fly ash in practical conditions ▪

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Risk zonation and assessment of environmental pollution in coastal area of Quang Tri province

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Abstract

The coastal area of Quang Tri province is less affected by socio-economic development but it was affected by oil spill environmental incidents and the Formosa in the period 2015 - 2019. For risk zonation and environmental risk assessment on coastal area of Quang Tri province, quantitative research method and approaches of Circular 26/2016/TT-BTNMT have been applied. Within the coastal area of Quang Tri province, 1,631 cell of near the shore and 83 cell of coastal areas have been identified, classified and zoned risk and assessed environmental risk. The results show that the environmental risk in the coastal area of Quang Tri province is medium – small level, 84% for near the shore and 99% for coastal areas. Besides, the number of locations with small levels of pollution or low environmental risk is significantly high compared to locations with high environmental risk.

Keywords: *Environmental risk zonation, environmental risk assessment, Quang Tri province.*
JEL Classifications: *Q51, Q56, P48.*
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1. INTRODUCTION

Quang Tri is a coastal province in the North Central region, with a coastline of about 75 km and zone of over 8,400 km^2. According to the synthesis of research results (Phuoc 2023) on marine biodiversity in coral reef ecosystems and the coastal area of Con Co island is very diverse and rich. 954 species of marine life were recorded, including: 133 species of phytoplankton; 97 species of plankton; 137 species of corals (144 species of hard corals, 23 species of soft corals); 182 species of reef fish; 302 species of benthic animals (186 species of mollusks, 49 species of echinoderms, 48 species of arthropods, 19 species of arthropods); 96 species of seaweed; 1 species of seagrass and 6 species of mangrove plants. Of which, 12 precious species were identified and endangered species that need to be prioritized for protection, restoration and development.

In the coastal waters of Quang Tri province, there are three main types of environmental pollution in coastal and estuarine areas (Anderson 2013): (i) Nitrogen-phosphorus pollution from agriculture, wastewater, urban wastewater and industrial wastewater and with average of about 20% of nitrogen fertilizers lost from agricultural production and up to 60% can evaporate into the atmosphere, some of which will fall into the ocean; (ii) Chemical pollution. This type of pollution is mainly from oil spills and statistics show that the volume still accounts for more than 10% of the oil entering the ocean (Anderson 2013); (iii) Plastic waste pollution. Therefore assessment and zoning of coastal environmental pollution risks in Quang Tri province with the guidance on coastal environmental risk zoning (Monre 2016), assessment and communication of environmental risks in coastal (GESAMP 2008) is important and necessary. In this study, the quantitative research methodology (Rana, Gutierrez and Oldroyd 2021) was used. The values of the risk quotient (RQ) are calculated and shown on the risk zoning map. The results of this study are a practical basis to help local management agencies implement measures to control, mitigate and coastal environmental risks in water of coastal of Quang Tri province.

2. MATERIALS AND METHODS

2.1. Study area

For risk zonation and assessment of environmental pollution in coastal of Quang Tri province, the study area is the coastal which include coastal and near the shore waters shown in *Figure 1.* The coastal area is 1,337.91 km^2 and the outer limit of coastal is 6 nautical milesaway (Decision N0.853/QĐ-BTNMT). The coastal include 11 commune belongs to 4 districts and Con Co island, natural area is about 142.94 km^2.

2.2. Methodology

2.2.1. Methods of computational grid for risk zonation of environmental pollution

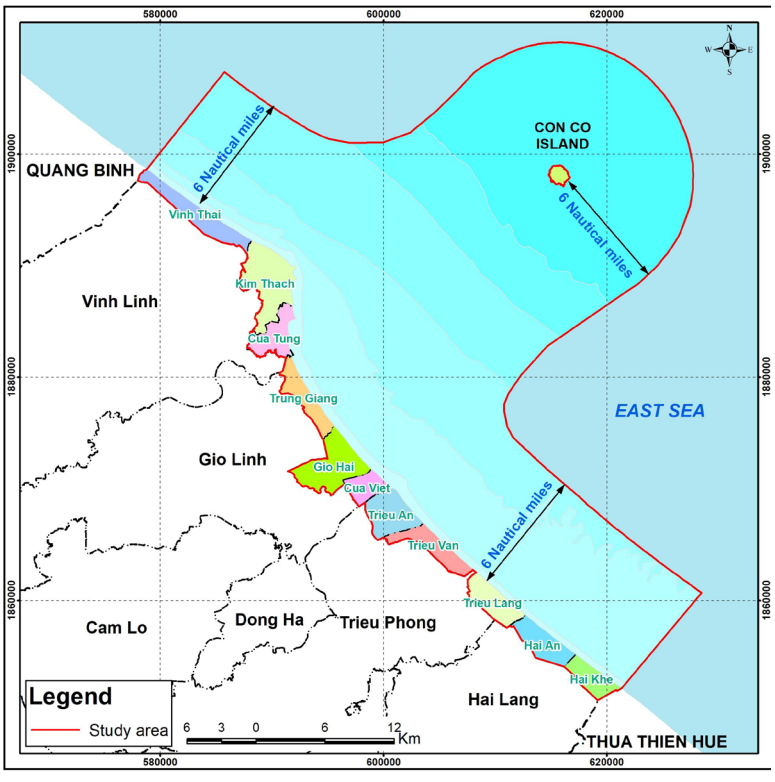
Arcgis softwave were used for computational grid of near the shore and coastal areas. The grids have dimensions of 40 x 60 and are consistent with the characteristics of the research area and regulations (Monre 2016).

Computational grid of near the shore area: Implemented with the following criteria: (i) The distance between the high tide and low tide lines is ranging from 70 to 120 m, especially in areas near the estuary such as in Cua Tung and Cua Viet, this distance is from 150 to 200 m; (ii) Combining cells with a very small area (less than 0.001 km^2).

The total number of coastal cells in Quang Tri province was calculated 1,631 cells, including 2 cells with area of ≤ 0.001 km^2, 11 cells with area between 0.001 - 0.0014 km^2, 342 cells with area of 0.0014 - 0.0024 km^2, 966 cells with area of 0.0024 - 0.0036 km^2 and 310 cells with area between 0.0036 - 0.0048 km^2.

Computational grid of coastal area: Implemented with the following criteria: (i) The size of coastal cells of 4 x 5 km and the total area of 1,338 km^2; (ii) The inner boundary of the coastal cell area with a small area of 1 - 14 km^2 which is maintained. These coastal cells was changed due to fluctuations in the range of the multi-year average high tide line to the 6 nautical mile line.

The total number of coastal cells in Quang Tri province are calculated as 83 coastal cells. In which, the number of coastal cells has area of about 20 km^2 accounting for the highest number of 66 cells, the number of cells with area of 19 km^2 is 7 cells and the number of coastal cells with area is in the range of 7 - 18 km, there are 8 cells and the number of coastal cells with area of 15 km^2 is 2 cells.



▲ *Figure 1. Study area*

2.2.2. Methodology of calculation of risk quotient and coastal environmental pollution risk assessment

Calculation of Risk Quotient (RQ): The risk quotients and total risk quotients are shown in formula 1 (Z. Vryzas, et al. 2011) and in formula 2 (Monre 2016), respectively.

$$RQ = \frac{PEC}{PNEC} \quad (1) \qquad RQ = \frac{\sum_{j=1}^{n} W_j \left(\frac{PEC}{PNEC}\right)}{\sum_{j=1}^{n} W_j} \quad (2)$$

Notes:

RQ: Risk Quotient for parameter j.

PEC: Concentration of pollutant jin coastal water of Quang Tri province.

PNEC: Maximum allowable value concentration of pollutant j according to QCVN 10-MT:2015/BTNMT.

m: Total number of parameters for zoning and risk assessment (12 parameters).

W_j: The weight for pollutants j as prescribed in Article 11, Circular 26/2016/TT-BTNMT (Monre 2016) such as BOD, COD, DO are 1.5; pH, ammonia (N-NH_4^+), phosphate (PO_4^{3-}) are 1.7; arsenic (As), iron (Fe), manganese (Mn) are 2.0; fluoride (F^-) is 1.0 and coliforms is 1.3.

Environmental pollution risk assessment of coastal area: The criteria for risk rating were used in this study (Hernando, et al. 2006): RQ < 0.01, no risk; 0.01 ≤ RQ < 0.1, low risk; 0.1 ≤ RQ <1, medium risk; and RQ ≥ 1, high risk or as directed (Monre 2016): RQtb > 1.5 very high risk; 1.25 < RQ_{tb} ≤ 1.5 high risk; 1 <RQ_{tb} ≤ 1.25 medium risk and RQ_{tb} ≤ 1 low risk.

2.2.3. Model method to measure predict pollutant concentrations in the coastal water

In this study, the MIKE21/3 Coupled FM model set with HD and SW modules (using a flexible and suitable unstructured mesh).

2.2.4. Model calibration and validation

Model calibration is carried out by comparing the actual measured data and the data calculated by the model at hydrological stations. Nash-Sutcliffe coefficient is used to validate the accuracy of model.

Nash-Sutcliffe coefficient was calculated according to formula (3):

$$NSE = 1 - \frac{\sum_{t=1}^{T}(H_0^t - H_m^t)^2}{\sum_{t=1}^{T}(H_0^t - \overline{H_0})^2}$$

where:

- H_{0t}: Measured data.
- H_{mt}: Simulation data.
- NSE: Error between measured data and simulation data according to Nash-Sutcliffe.

Table 1. Sensitivity level classification of simulation model according to Nash-Sutcliffe

Sensitivity level	Nash-Sutcliffe (NSE)
Very High	0.75 ÷ 1.0
High	0.65 ÷ 0.75
Medium	0.50 ÷ 0.65
Small	≤ 0.50

In this study, the calibration and validation of the simulation model was quite good accuracy, the Nash balance coefficient was quite high and met the regulations for determining the concentration of pollutants at each near the shore and coastal by simulation model.

Calibration and validation for water concentration: The parameters of TSS, NH_4^+, Florua, PO_4, Fe, As, Mn is used for calibration and validation of the pollutants propagation model and were samled at 11 locations in the estuary and coastal areas of Quang Tri province in the period of May 2018, June 2020 and November 2020 (Donre 2020). Sampling sites coastal of Quang Tri province for model calibration of are shown in Figure 2. The results of calibration and validation of the mass propagation model showed a negligible difference between the measurement and the simulation. Thereby, the simulation results ensure reliability and the set of parameters of the model can be used to calculate the pollutants propagation.

Table 2. Results of calibration and validation for depth

Hydrogies station and measurement duration	Nash-Sutcliffe coefficient		R2
	NSE	Notes	
Cua Viet: since May 2018	0.675	High	0.827
Cua Viet: since June 2020	0.683	High	0.831
Con Co: since May 2018	0.601	Medium	0.776
Con Co: since June 2020	0.591	Medium	0.876

Table 3. Results of calibration and validation for flow velocity simulation

Hydrogies station	Nash-Sutcliffe coefficient		R2
	NSE	Notes	
S1 Station: since June 2023	0.543	Medium	0.675
S2 Station: since June 2023	0.557	Medium	0.712
S3 Station: since May 2018	0.638	Medium	0.745
S3 Station: since June 2020	0.686	High	0.826
S3 Station: since November 2020	0.606	Medium	0.740

Table 4. Results of calibration and validation for waves

Name of Station	Nash-Sutcliffe coefficient		R2
	NSE	Notes	
S1 Station: since June 2023	0.678	High	0.778
S2 Station: since June 2023	0.629	Medium	0.748
S3 Station: since June 2020	0.516	Medium	0.672

2.2.5. Method of simulation model

East-sea model: The main boundaries of the aimulation model was used be the Taiwan Strait, Luzon, Mindoro, Babalac, and Malacca. With the HD hydrodynamic module, these boundaries are water level boundaries and tidal water level data calculated from conditioning constants. With the SW spectrum module, these boundaries are assumed to be "lateral boundaries". The coastal area from Quang Binh to Da Nang is updated with a fine coastal net.

Detailed model: The grid resolution is set to be very detailed with a grid pitch of about 1m to 5m. The simulation range is also set to be large enough to minimize the effects of boundaries on the study area. (Figure 3).

▲ *Figure 2. Sampling sites for model calibration*

▲ *Figure 3. Computational grid and calculation scope of detailed model*

3. RESULTS AND DISCUSSIONS

3.1. Simulation of pollutants concentration in coastal water

The parameters used for study of environmental pollution zoning and assessment in coastal of Quang Tri province include: Dissolved oxygen (DO), biochemical oxygen demand $(BOD)_5$), chemical oxygen demand (COD), pH, ammonium ($N\text{-}NH_4^+$), phosphate (PO_4^{3-}), suspended solids (TSS), Fluoride (F), coliform, arsenic (As), dissolved iron (Fe), manganese (Mn)... The summary results of the concentration of pollutants are shown in Table 5.

The simulative results of pollution concentrations in near the shore waters of Quang Tri provinve showed:

The concentration of dissolved oxygen (DO) is high and relatively stable, with a monthly average of approximately 5.1 - 8.0 mg/l and average of the typical climatic year per of 7.14 mg/L. Concentrations of DO is no significant difference between the rainy season and dry season, the trend of the Northeast monsoon period is more scattered. In the compared to the DO concentration in coastal waters of Quang Tri province in recent years, 5.6 - 6.2 mg/L (Donre Quang Tri 2023), the dissolved oxygen concentration is forecasted to be significantly higher.

Concentration BOD_5 in water of coastal of Quang Tri provine is unstable over time and spatially (standard deviation > mean), concentration of BOD_5 has a large variation, about 0.5 - 13.8 m/L (the average is low, 1.5 mg/L). The reason is due to effect of the Northeast monsoon and the Southwest monsoon. Concentration of BOD_5 was the

Table 5. Summary of calculation results of predicted concentration of pollutants in the coastal of Quang Tri province

Parameters	Descriptive Statistics						
	Mean	Standard Error	Median	Standard Deviation	Min	Max	Confidence Level (95.0%)
DO (mg/L)	7.14	0.01	7.12	0.54	5.12	8.02	0.03
BOD_5 (mg/L)	1.48	0.05	1.08	2.00	0.50	13.76	0.10
COD (mg/L)	5.18	0.06	4.51	2.49	2.88	14.88	0.12
pH	7.95	0.00	7.98	0.09	7.41	8.00	0.00
NH_4^+ (mg/L)	0.24	0.00	0.20	0.17	0.05	0.89	0.01
PO_4^{3-} (mg/L)	0.09	0.00	0.08	0.06	0.02	0.31	0.00
TSS (mg/L)	6.48	0.07	5.88	3.00	5.00	24.92	0.15
Floridemg/L)	1.09	0.00	1.06	0.10	1.00	1.50	0.00
Coliform (MPN100mL)	159	10	30	397	0	2.716	19
As (mg/L)	0.02	0.00	0.02	0.01	0.01	0.05	0.00
Fe (mg/L)	0.68	0.01	0.63	0.20	0.50	1.50	0.01
Mn (mg/L)	0.17	0.00	0.15	0.08	0.10	0.50	0.00

largest value in December and the lowest in January. Concentration of BOD_5 at locations from Cua Tung to Cua Viet are higher than the average and the point locations along the coast of Quang Tri province.

Concentration of COD in coastal water tends to change according to the monsoon mode, with a small fluctuation amplitude and only approximately 2.5 - 4.0 mg/L. During the Northeast monsoon, concentration of COD is highest value of the year (ranging from 2.9 - 14.9 mg/L) at all locations and concentration of COD is the lowest of the year (ranging from 2.0 - 3.0 mg/L) during the Southwest monsoon period.

The pH value in the waters of Quang Tri province is relatively stable, in the range of 7.4 - 8.0 and has seasonal fluctuations but not significantly. These results are lower than the pH coastal water quality monitoring results of Quang Tri province (Donre Quang Tri 2023), the pH value ranges from 7.6 - 8.3 (at the foot of the tide) and 7.7 - 8.1 (at the peak of the tide).

Concentration of ammonium (NH_4^+) in water of coastal is about 0.24 mg/L and little change in the whole region. These values are significantly different when compared to the results of coastal water quality monitoring of Quang Tri province, ranging from undetected to 0.15 mg/L (tidal peak) and ranging from undetected to 0.19 mg/L (tidal peak) (Donre Quang Tri 2023).

Concentration of phosphate (PO_4^{3-}) in water of coastal tends to vary markedly seasonally and is relatively stable and concentrations of phosphate approximately 0.04 - 0.09 mg/L.

Average concentration of total suspended solids in the study area ranged from 5.0 to 24.9 mg/L, with an average of about 6.5 mg/L and little major variation between regions and seasons under typical 1-year climatic conditions. At the estuary locations (Cua Tung, Cua Viet), total suspended solids tends to disperse stronger, the largest concentration can range from 20 to 30 mg/L or greater. Concentration of TSS is forecasted to be significantly smaller when compared to the monitoring results of coastal water quality in Quang Tri province, the average TSS concentration is about 5.2 - 47.9 mg/L (at the foot of the tide) and 4.4 - 46.0 mg/L (at the peak of the tide) (Donre Quang Tri 2023). This contributes to reducing the coastal environmental risk vulnerability index.

Concentration of fluoride in water of coastal is relatively stable, varies from 1.0 mg/L (minimum) to 1.5 mg/L (maximum), with an average of about 1.1 mg/L.

Concentrations of Coliform in water of coastal are quite stable and the only change is the difference in the near the shore and the river area. The forecast concentration of coliform in water of coastal area of Quang Tri province is in the range of 0 - 2,700 MPN/100mL, the average is about 160 MPN/100mL and this value is very low compared to QCVN 10-MT:2015/BTNMT.

The concentration of As in water of coastal tends to vary seasonally and spatially. The highest value appears in the flood season months (November and December), approximately 0.02 mg/L in the coastal area from Cua Tung to Cua Viet and varies from 0.015 - 0.050 mg/L in other areas. The concentration of As is relatively stable, about 0.01 - 0.015 mg/L and the lowest in the dry months (June, July) with a concentration of less than 0.012 mg/L.

Concentrations of Fe in water of coastal tend to vary seasonally and spatially. The highest concentration of Fe appears in the flood season months (November and December), approximately about 0.80 mg/L in the coastal area from Cua Tung to Cua Viet and varies from 0.60 to 0.75 mg/L in other areas, the average is 0.68 mg/L.

Concentration of Mn in water of coatal is low and insignificantly chanes in seasonally and spatially. The highest value appears in the flood season months (November and December) with a concentration of approximately 0.17 mg/L in the coastal area from Cua Tung to Cua Viet and the concentration of Mn fluctuates between 0.1 - 0.50 mg/L in other areas. Most of the concentrations of metals (As, Fe, Mn) with is lower than the limit value of QCVN 10-MT:2015/BTNMT.

In general, the concentration of pollutants in coastal of Quang Tri province is quite stable except for the BOD5, COD due to the influence of changes in wind direction in the area. Overall, concentration of pollutants in water of near the shore is small and the dispersion of pollutants concentration is small and relative standard deviation (RSD) in near the shore cells (n = 1631) < 20%, which is acceptable in environmental analysis.

3.2. Risk zonation and environmental risk assessment in coastal area of Quang Tri province

3.2.1. Calculation results of risk quotient $I_ô$ for cells of near the shore

In this study, Environmental risks zonation of coastal area was only considered in the Northeast monsoon scenario and shown in Figure 4. Environmental risk zonation results are classified and risk assessed according to 3 levels: medium, high and very high risk.

Area of very high environmental risk ($I_ô \geq 3.5$) accounting for 78/1,631 cells (corresponding to 5%) of the number of cells of near the shore, these cells of very high environmental risk were main distributed in area of Trung Giang commune, Cua Viet commune (Gio Linh district), Trieu An commune (Trieu Phong district). Because of very high environmental risk in these areas and therefore, it is necessary to have appropriate risk mitigation solutions for these areas. The reason is due to the impact of high density living activities and socio-economic development in the areas. For example, in 02

communes Gio Hai and Trung Giang, the population rate accounts for 61.59%, the aquaculture area (32.7 hectares) accounts for 93.69% and the number of boats accounts for 63.5% of the Gio Linh district (Phuoc 2023).

Area of high environmental risk (2.5 ≤ $I_ô$ < 3.5) accounting for 190/1,631 cells (corresponding to 12%) of the number of cells of near the shore and concentrated mainly in Gio Hai commune and a part of Trung Giang commune, a part of Trung Giang commune and Cua Viet commune (Gio Linh), a part of Trieu An (Trieu Lang district).

Area of medium environmental risk (1.5 ≤ $I_ô$ < 2.5), accounting for 1,363/1,631 cells (corresponding to 84%) of the number of cells of near the shore.

3.2.2. Calculation results of risk quotient $I_ô$ for cells of coastal

The results of environmental risk zonation show that environmental risk level in the coastal area of Quang Tri province is medium - low, as follows:

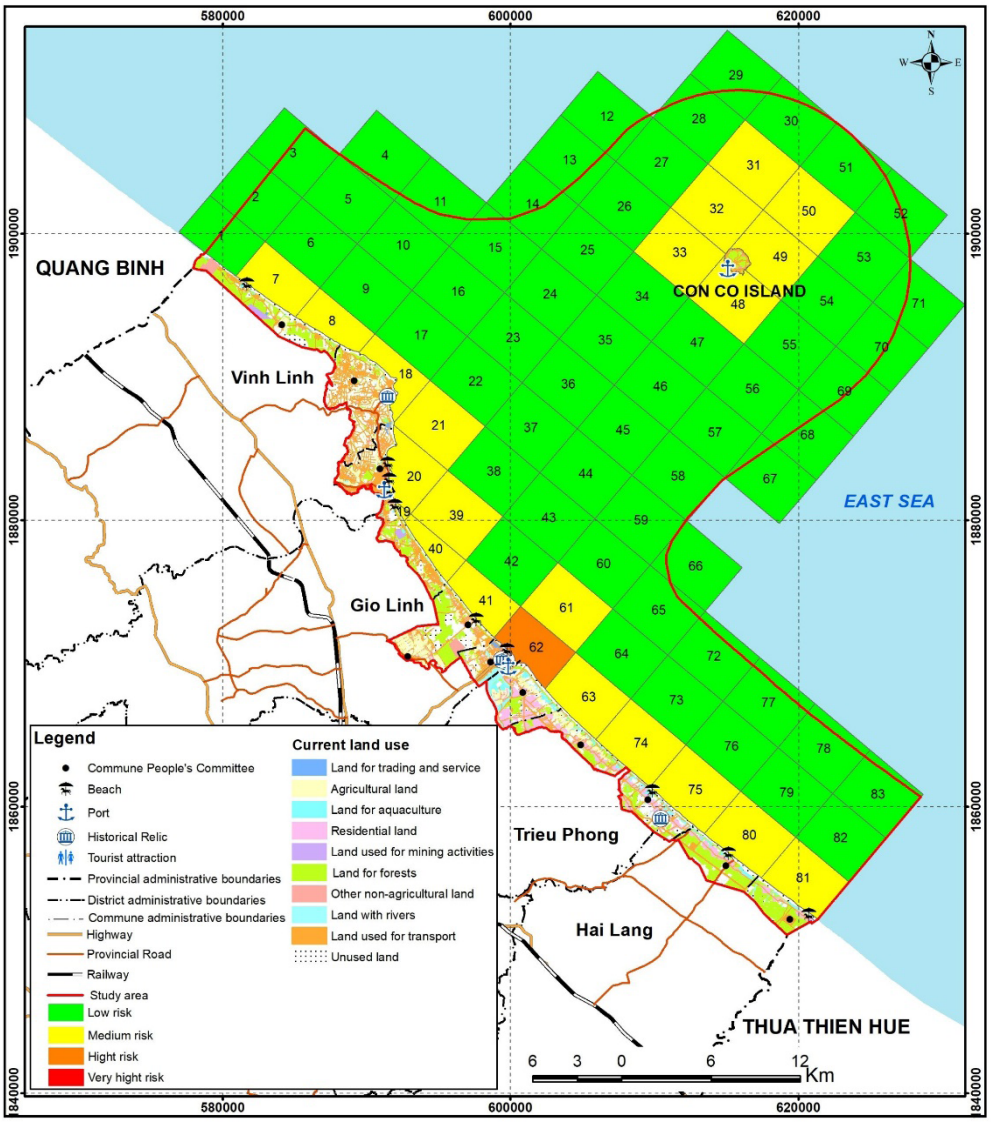
Area of high environmental risk (2.5 ≤ $I_ô$ < 3.5) is only concentrated in 62 cell (Cua Viet port), accounts for 1% of the number of coastal cells. The cause of high environmental risk in this area is due to the activities of Cua Viet port such as ships gathering, activition of fishing boats and importing seafood, provision of seafood logistics... A lot of waste was generated from these activities but have not been treated and managed strictly.

Area of medium environmental risk (1.5 ≤ $I_ô$ < 2.5) is concentrated in the area adjacent to the near the shore and and in the area around Con Co island where there is a marine conservation area that needs to be strictly protected, accounts for 25% of the number of coastal cells.

The cells of coastal have low environmental risk ($I_ô$ ≤ 1.5), accounts for about 74%.

General, environmental risk in coastal area of Quang Tri province was medium – low ($I_ô$ ≤ 1.5) of about 84% for near the shore and 99% coastal. This shows that natural factors, human activities, and socio -economic development activities have negligible impacts on the coastal waters of Quang Tri province.

The summary results of the calculation of risk quotients for coastal waters areas of Quang Tri province are shown in Table 6. For the coastal area, because the area of the cells is quite large (7 - 20 km2/cell), so the cells are divided into 4,281 points for 83 coastal cells. For near the shore cells, because the area of the cells is small, the risk quotient of each cell only calculates of 1 location, so RQj = RQtb.



▲ *Figure 4. The risk zonation map of environmental pollution in coastal of Quang Tri province*

Table 6. Summary of calculation results of risk quotient (RQ) in the coastal of Quang Tri province

Descriptive Statistics	Risk Quotient of near the shore area (n = 1631 cell)	Risk Quotient of coastal area (n = 4281 point/83 cell)	
	$RQ_j = RQ_{tb}$	RQ_j	RQ_{tb}
Mean	0.867	0.585	0.590
Standard Error	0.009	0.002	0.010
Median	0.776	0.549	0.549
Standard Deviation	0.350	0.108	0.090
Minimum	0.541	0.543	0.546
Maximum	2.291	2.489	1.012
Confidence Level (95.0%)	0.017	0.003	0.020

It can be seen that the level of pollution and environmental risk in the near the shore area is greater than that in the coastal area when both the average risk quotient of each cell or the whole the near the shore area is higher than that of the coastal area. The reason can be easily seen is the activities of people's livelihood, production and aquaculture in the near the shore area of Quang Tri province.

The statistics (Table 6) also show that the number of locations with low environmental pollution risk levels is higher because the median value is smaller than the average value. Comparing with the current state of the coastal waters environment quality in recent years in the Central region (MONRE 2021), it shows that the level of coastal waters environmental risks in Quang Tri province is significantly higher, 6-8 times higher than in Dong Hoi, Quang Binh waters (RQ = 0.10 in the 2018 rainy season) and Thuan An, Hue waters (RQ = 0.12 in the 2018 rainy season) and only equivalent to the waters of Sam Son, Thanh Hoa province (RQ = 0.43) and lower than that of Phan Thiet waters (RQ = 2.66).

For minimization of the hight risk of environmental pollution areas in coastal waters of Quang Tri province, some solutions for integrated management of coastal are proposed:

i) Building a management tools for sustainable development in coastal of Quang Tri province, including regulations of technical, environmental, economic and social…

ii) There is a need for an economic tool, in which the costs/benefits and minimum costs are analyzed and calculated in detail for management of high environmental pollution risks.

iii) Community consultation should be implemented to manage effectively coastal pollution and ensure the common interests of management and community.

iv) The main cause of the environmental pollution risk were high and very high level in coastal areas of Quang Tri province, that conflicts of interest between stakeholders have not been resolved. Therefore, it is necessary to solve or have appropriate technical solutions to solve these causes.

4. CONCLUSION

The results of risk regional zonation and assessment of coastal environmental pollution in Quang Tri province have been carried out according to the guidance of Circular No. 26/2016/TT-BTNMT and are referenced in studies of environmental risk assessment. The results of the study have shown, coastal environmental risks in Quang Tri province is medium and low with theRQ_{tb}rate <1.25 accounted for coastal areas 84% and coastal areas 99%; The level of environmental risk in the coastal waters of Quang Tri province has the tendency of leaning towards a medium and low level and was significantly higher than in the waters of the Central region.

In this study, the risk of environmental pollution assessment coastal water of in Quang Tri province are have only been based on the limited concentration of some physicochemical parameters in coastal water according to QCVN 10-MT:2015/BTNMT and the corresponding weights proposed in Article 11 in Circular No. 26/2016/TT-BTNMT. Therefore, there is a need for further research on the effect limit concentrations and risk weights for sensitive ecological objects because each coastal area has different sensitivities. In addition, coastal environmental pollution risk assessment for persistent organic pollutants (POPs), microplastics and sediments is needed ▪

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1. INTRODUCTION

Open burning of rice straw in the fields is a method of cleaning the fields after harvest, preparing for the next crop in Vietnam. Emissions from the burning of rice straw contribute greatly to air pollution in Vietnam, negatively affecting human health, contributing to increasing the greenhouse effect and acid rain. The results of calculating the air pollution load [01] due to open burning show that in 2020, open burning of rice straw in Vietnam emitted 905,544.6 tons of $PM_{2.5}$, 1,017,802.2 tons of PM_{10}, 104,773.8 tons of SO_2, 97,289.9 tons of NO_2, 170,631.6 tons of NO_x, 2,596,892.0 tons of CO. By 2030, open burning of rice straw in Vietnam will emit 258,062.1 tons of $PM_{2.5}$, 290,053.3 tons of PM_{10}, 29,858.4 tons of SO_2, 27,725.7 tons of NO_2, 48,626.6 tons of NO_x, and 740,062.4 tons of CO.

During the period 2022-2025, the Vietnam Association for Conservation of Nature and Environment (VACNE) has coordinated with the Global Alliance for Pollution and Health (GAHP) to implement the project "Reducion of risks of open burning practices and unsafe use of pesticides to the environment and human health in Vietnam" funded by the UK Department of Environment, Food and Rural Affaire (DEFRA).

Within the framework of this project, some demonstration models on straw open burning alternatives were implemented, including rice-straw composting, rice-straw fermented for cattle feed, and straw mushroom production in Chau Thanh district, An Giang province [02],[03], models of in-field microbiological decomposing straw in Khanh Thanh commune, Yen Khanh district, Ninh Binh province [04] and in Song Ray commune, Cam My district, Dong Nai province [05].

The implementation of the above mentioned open burning alternative models brings many economic benefits (i.e. enhancing the value chain of the rice production sector), social benefits (i.e. creating new jobs, improving farmers' lives) and environmental benefits (i.e. reducing environmental pollution, reducing greenhouse gas (GHG) emissions).

The purpose of this study is to assess the potentials of GHG emission reduction due to open burning alternatives. The applied methods are rapid assessment based on investigation, survey, data collection and application of GHG emission factors [06].

2. METHODOLOGY

2.1. Study Subjects

This study focused on some straw open burning alternative models, including:

- Three technical models utilizing rice straw in some selected communes of Chau Thanh district, An Giang province such as rice straw mushroom production, rice straw composting and rice straw fermented for cattle feed.
- One model of in-field decomposing straw in Khanh Thanh commune, Yen Khanh district, Ninh Binh province.
- One model of in-field decomposing straw in Song Ray commune, Cam My district, Dong Nai province.

2.2. Study methods

2.2.1. Data collection

Data were collected in the selected communes, Chau Thanh district, An Giang province including area of rice cultivation, mass of rice straw generated, mass of straw transported and used for the open burning alternative models.

Assessment of greenhouse gas emission reduction of rice straw open burning alternative methods in some selected areas in Vietnam

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Abstract

Rice straw open burning has been quite popular in Vietnam and caused pollution and greenhouse gases emission. There have been several alternative methods to replace the open burning including rice-straw composting, rice-straw fermented for cattle feed, straw mushroom production and models of in-field microbiological decomposing straw. This study aims to investigate GHG reduction of the straw open burning alternative models in Vietnam, including An Giang, Ninh Binh and Dong Nai provinces. Results showed that, the models contribute to reducing GHG emissions in selected communes in Chau Thanh district, Khanh Thanh, Song Ray communes including 64.3, 328.1, 45.1 tons, respectively. If the research results of the models are replicated, GHG emissions in Khanh Thanh, Song Ray communes can be reduced by 3,065.9, 3,635.6 tons/year, respectively. The potentials for GHG emission reduction in 2022 in Chau Thanh, Yen Khanh, Cam My districts are 2,644.2, 8,772.6, 821.8tons/year, respectively. Those in An Giang, Ninh Binh, Dong Nai provinces are 5,530.5, 112,885.1, 56,140.0 tons/year, respectively. By 2030, the potentials for GHG emission reduction in Chau Thanh, Yen Khanh, Cam My districts will be 13,098.9, 14,474.8, 1,355.9 tons/year, respectively. Those in An Giang, Ninh Binh, Dong Nai provinces will be 27,358.6, 56,410.9, 26,853.1 tons/year, respectively.

Keywords: *Open burning alternatives, greenhouse gases, potential reduction.*
JEL Classifications: *Q51, Q53, Q55.*
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Data were collected in Khanh Thanh commune, Yen Khanh district, Ninh Binh province and Song Ray commune, Cam My district, Dong Nai province, including area of rice cultivation, mass of rice straw generated, rate of straw in-field decomposting.

2.2.2. Emission factors

This study applied the emission factor (EF) to estimate the total GHG emission from rice straw open-burning and compare them with those from the open burning alternative models (See tables 1).

The GHG emission from the models will be calculated based on the total GHG emission from harvesting, rolling and transporting the rice straw plus the GHG emission of applied open burning alternative models.

Total GHG emission from straw burning is calculated as follows:

GHG emission (kg/year) = MB×CF×EF_i (1)

of which MB: Straw production (ton dry weight/ha), CF: burning efficiency = 0,80%, EF_i: emission factors (kg/ton of burned straw).

Total GHG emissions from machinery straw rolling, transportation, open burning alternatives are calculated as follows:

GHG emissions = Mass of rolled straw × EF_i (2)

of which: EF_i is emission factors (kg/ton rice straw), i changes from 1 to 7.

3. RESULTS AND DISCUSSIONS

3.1. Technical models utilizing rice straw in Chau Thanh district, An Giang province

3.1.1. Reduction of GHG emissions due to the open burning alternatives models in selected communes, Chau Thanh District

The mushroom production models were implemented in 4 communes (Can Dang, Vinh An, Vinh Binh, Binh Thanh, Vinh Hanh), the composting models were implemented in 07 communes (Can Dang, An Chau, An Hoa, Vinh Hanh, Vinh An, Vinh Nhuan, Vinh Loi), the straw fermented models for cattle feed were implemented

Table 1. GHG emission factors [03], [06], [07]

No	Activities	Unit	CO_2	CH_4	N_2O	CO_{2e}
01	Straw burning (EF_1)	kg/ton rice straw	1,489.5	2.7	0.07	1,577.9
02	Machinery straw rolling (EF_2)	kg/ton rice straw				4.378
03	Transportation (EF_3)	kg/ton rice straw				740.0
04	Straw mushroom production (EF_4)	kg/ton rice straw				222.0
05	Ricestraw composting (EF_5)	kg/ton rice straw		4.0	0.24	171.5
06	Ricestraw fermented for cattle feed (EF_6)	kg/ton rice straw				60.0
07	Decomposting wet straw/ stubble (EF_7)	kg/ton rice straw/stubble		4.0	0.24	171.5

Note: CH_4 and N_2O emission were converted to CO_2 equivalent (CO_{2e}) by applying global warming potentials (GWP) such as: $1CO_2 = CO_{2e}$; $1CH_4 = 25\ CO_{2e}$; $1N_2O = 298\ CO_{2e}$.

in 5 communes (Vinh Nhuan, Vinh Loi, An Chau, An Hoa, Vinh An) in Chau Thanh district, An Giang province. Based on the mass of rice straw used for the alternative models [02], emission factors in table 1, one can estimate the GHG emissions reduction due to the alternatives models in the selected communes of Chau Thanh District (See table 2).

Table 2.GHG emissions reduction due to the open burning alternatives in the selected communes of Chau Thanh District

Alternative models	Emisson factor ($kgCO_{2e}$/ton rice straw)	Mass of rice straw used for models (ton/year)	GHG emission (kg/year)
1. Straw open burning	1,577.9	177.6	224,188
2. Open burning alternatives			159,904
Machinery straw rolling	*4.378*	*177.6*	*778*
Transportation	*740.0*	*177.6*	*131,424*
Straw mushroom production	*222.0*	*88.0*	*19,536*
Rice straw composting	*171.5*	*32.0*	*5,488*
Rice straw fermented for cattle feed	*60.0*	*57.6*	*3,456*
3. GHG emissions reduction			64,286

Table 2 shown that the open burning alternative models will reduce 64,286 kg CO_{2e}/year or 64.3 tons CO_{2e}/year.

3.1.2. Potentials of GHG emission reduction in Chau Thanh district and An Giang province

According to research results [03], the mass of straw generated in 2022 in Chau Thanh district is 146,669 tons/year, in An Giang province is 1,451,908 tons/year. From 2014 to 2022, about 37-40% of straw in Chau Thanh district was collected and transported to households for reuse. The collection and reuse rate increased by about 5%/year [08]. The mass collected for reuse in Chau Thanh district is 58,667 tons/year, in An Giang province is 290,382 tons/year. Among those, about 70% of the straw volume is used to produce straw mushrooms (15%), for fermented feeds (5%), for composting (50%) and for stump cover of vegetables and orchards (the remaining 30%) (See Table 3).

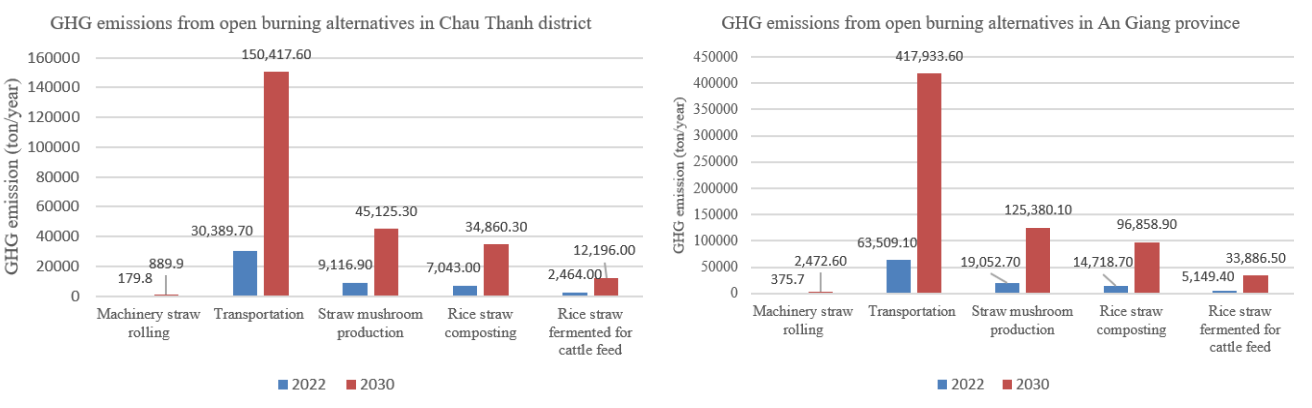
Based on rice cultivation area [10], it is forecasted that by 2030, the mass of straw generated in Chau Thanh district will be 143,039 tons/year, and in An Giang province will be 1,411,938 tons/year. Rice straw collection rate in 2030 should increase to 60% (85,823 tons/year) in Chau Thanh and 40% (564,775 tons/year) in An Giang, respectively [08], and the rate of mushroom: compost: feed model was planned as 35:50:15 in 2030 (See Table 3).

Based on the potential volume of straw that can be collected to produce straw mushrooms, compost, and animal feed in 2022 (Chau Thanh district 41,067 tons/year, An Giang province 203,267 tons/year) and forecast to 2030 (Chau Thanh district 85,823 tons/year, An Giang province 564,775 tons/year) (Table 3), the GHG emission factor (Table 1), CO_{2e} emissions in 2022 and 2030 from open burning alternatives in Chau Thanh district and An Giang province can be estimated (Figure 1).

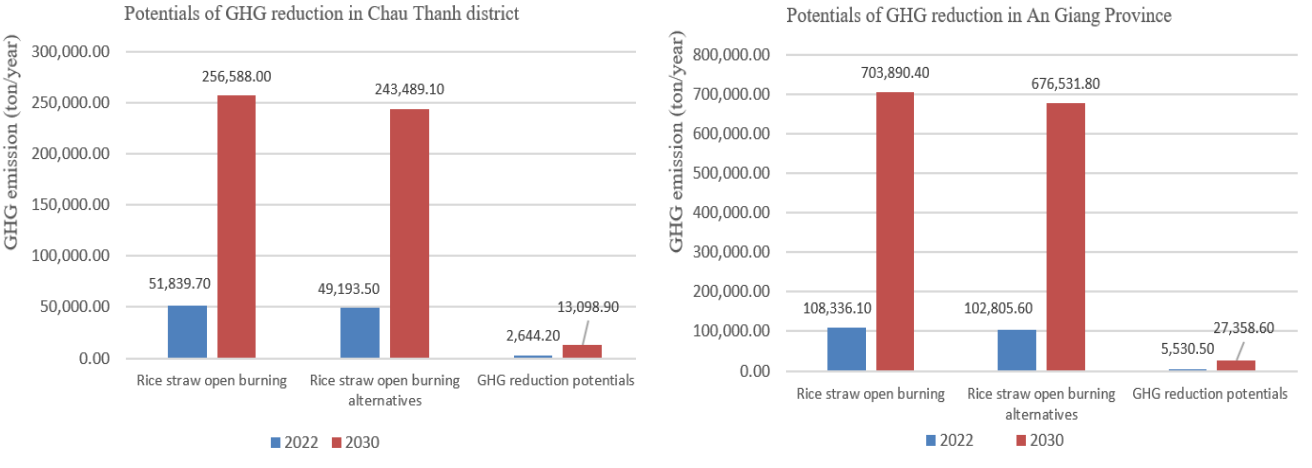
Table 3. The mass of straw generated in Chau Thanh district and An Giang province

Straw utilization	Chau Thanh District (ton/year)		An Giang Province (tone year)	
	2022	2030	2022	2030
Total mass of straw generated	146,669	143,039	1,451,908	1,411,938
Total mass of straw collected	58,667	85,823	290,382	564,775
Total mass of straw used for the alternative models	41,067	85,823	203,267	564,775
- Straw mushroom production	*8,800*	*30,038*	*43,557*	*197,671*
- Rice straw composting	*29,334*	*42,912*	*145,191*	*282,388*
- Rice straw fermented for cattle feed	*2,933*	*12,873*	*14,519*	*84,716*

Calculation of GHG emissions from open burning of rice straw is based on formula (1) in section 2.2.2 above. The mass of rice straw used to calculate GHG emissions from open burning is equivalent to the mass of rice straw used for open burning alternatives (i.e. straw mushroom production, composting, animal feed fermentation). Calculation of potentials of GHG reduction is based on the difference between the GHG emissions generated from open burning of rice straw and the GHG emissions generated from open burning alternatives (see Figure 2).



▲ *Figure 1. GHG emissions from the open burning alternatives in Chau Thanh and An Giang Province*



▲ *Figure 2. Potentials of GHG reduction due to the open burning alternatives in Chau Thanh and An Giang Province*

The results of Figure 2 show that the potential for GHG emission reduction due to the implementation of open burning alternatives in 2022 in Chau Thanh district is 2,644.2 tons/year, in An Giang province is 5,530.5 tons/year. Those by 2030 in Chau Thanh district will be 13,098.9 tons/year and in An Giang province will be 27,358.6 tons/year.

3.2. Model of in-field decomposing straw in Khanh Thanh commune, Yen Khanh district, Ninh Binh province

3.2.1. Reduction of GHG emissions due to the open burning alternative models in Khanh Thanh commune

Based on the mass of rice straw/stabble used for the alternative models (i.e. in-field decomposting) [04], emission factors in table 1, one can estimate the GHG emissions redution from the alternatives models in Khanh Thanh commune (See table 4).

Calculation of potentials of GHG emission reduction is based on the difference between the GHG emission generated from rice straw open burning and the GHG emission generated from in-field composting (see Figure 3).

The results of Figure 3 show that the potentials for GHG emission reduction due to the implementation of in-field decomposting in 2022 in Yen Khanh district is 19,436.0 tons/year, in Ninh Binh province is 112,885.1 tons/year. Those by 2030 in Yen Khanh district will be 8,772.6 tons/year and in Ninh Binh province will be 56,410.9 tons/year.

Table 4. GHG emission reduction due to the alternative models in Khanh Thanh commune

Alternative models	Emisson factor ($kgCO_{2e}$/ton rice straw/ stubble)	Mass of rice straw/ stubble used for decomposting (ton/ year)	GHG emission (kg/year)
Straw open burning	1,577.9	233.26	368,061
Decomposting straw/stubble	171.5	233.26	40,004
GHG reduction potentials due to in-field decomposting straw/stubble			328,057

Table 4 shown that, the reduction in GHG emission due to in-field decomposting will be: 328,057 kg of CO_{2e}/year or 328.1 tons of CO_{2e}/year.

During the project implementation, the expert team provided microbial products to decompose rice straw/ stubble on an area of 400 hectares of rice/year, those generate 2,180 tons of rice straw/stubble per year. The GHG emitted due to in-field decomposting will be 373.9 tons of CO_{2e}/year. The GHG emitted due to burning is (2,180x1,577.9 = 3,439.8 tons/year. The GHG emission is reduced: 3,439.8 - 373.9 = 3,065.9 tons/year.

3.2.2. Potentials of GHG emission reduction in Yen Khanh district and Ninh Binh province

Based on data on rice cultivaton area in Yen Khanh district and Ninh Binh province in 2022 [09], the plan until 2030 [10], the straw generation factor, the average ratio of in-field decomposting straw/stubble mass [04], it is possible to estimate the mass of straw/stubble generated and that decomposed in the field (see table 5).

3.3. Model of in-field decomposing straw in Song Ray commune, Cam My district, Dong Nai province

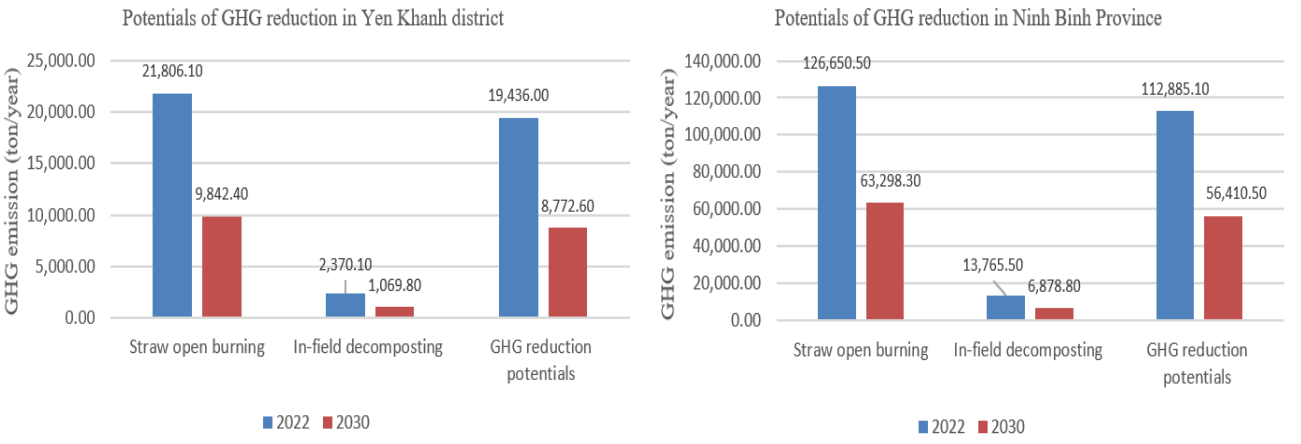
3.3.1. Reduction of GHG emissions due to the open burning alternative models in Song Ray commune

The in-fiels decomposting models were implemented in 3 sessions from August 2023 to September 2024 for 20 households with total area of 5.3 ha in Song Ray commune.

Based on the mass of rice straw/ stabble used for the alternative models (i.e. in-field decomposting) [05], emission factors in table 1, we can estimate the GHG emissions redution from the alternatives models in Song Ray commune (See table 6).

Table 5. The mass of straw generated in Yen Khanh district and Ninh Binh province

Straw utilization	Yen Khanh district (ton/year)		Ninh Binh province (tone year)	
	2022	2030	2022	2030
Total mass of straw generated	41,877.8	31,188.2	243,228.1	200,549.1
Total mass of straw/stubble decomposed	13,819.7	6,237.6	80,265.3	40,109.8



▲ *Figure 3. Potentials of GHG reduction due to the open burning alternatives in Yen Khanh and Ninh Binh province*

Table 6. GHG emission reduction due to the alternative models in Song Ray commune

Alternative models	Emisson factor ($kgCO_{2e}$/ton rice straw/stubble)	Mass of rice straw/stubble used for decomposting (ton/year)	GHG emission (kg/year)
Straw open burning	1,577.9	29.15	45,995.8
Decomposting wet straw/stubble	171.5	29.15	909.0
Potential of CO_{2e} emission reduction due to in-field decomposting straw/stubble			45,086.8

Table 6 shown that, the reduction in GHG emission due to in-field decomposting models will be 45,086.8 kg of CO_{2e}/year or 45.1 tons of CO_{2e}/year.

If this model is replicated in Song Ray commune with a total rice growing area of 470 hectares, the mass of straw generated will be 2,585 tons/year. The GHG emitted due to in-field decomposting will be 443.3 tons of CO_{2e}/year. The GHG emitted due to burning will be 4,078.9 tons/year. The GHG emissions could be reduced 4,078.9 - 443.3 = 3,635.6 tons/year.

3.3.2. Potentials of GHG emission reduction in Cam My district and Dong Nai province

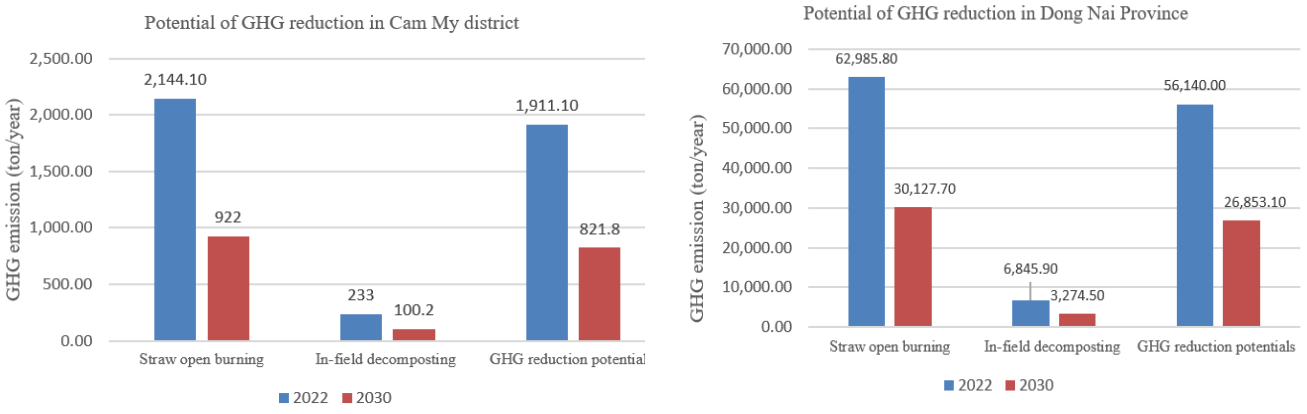
Based on data on rice cultivaton areas in Cam My district and Dong Nai province in 2022, the plan until 2030 [05][10], the straw generation factor, the average ratio of in-field decomposting straw/stubble mass, it is possible to estimate the mass of straw/stubble generated and that decomposed in the field (see table 7).

Calculation of GHG reduction potential is based on the difference between the GHG emission generated from open burning of rice straw and the GHG emission generated from open burning alternatives (i.e. in-field composting) (see Figure 4).

The results of Figure 4 show that the potential for GHG emission reduction due to the implementation of in-field decomposting in 2022 in Cam My district is 1,911.1 tons/year, in Dong Nai province is 56,140.0 tons/year. Those by 2030 in Cam My district will be 821.8 tons/year and in Dong Nai province will be 26,853.1 tons/year.

Table 7. The mass of straw generated in Cam My district and Dong Nai province

Straw utilization	Cam My district (ton/year)		Dong Nai province (tone year)	
	2022	2030	2022	2030
Total mass of straw generated	4,117.7	2,921.5	120,962.2	95,467.7
Total mass of straw/ stubble decomposed	1,358.8	584.3	39,917.5	19,093.5



▲ *Figure 4. Potentials of GHG reduction due to the open burning alternatives in Cam My and Dong Nai province*

4. CONCLUSION

Some straw open burning alternative models were implemented, including rice straw mushroom production, rice straw composting, rice straw fermented for cattle feed in the selected communes, Chau Thanh district, An Giang province, models of in-field microbiological decomposing straw in Khanh Thanh commune, Yen Khanh district, Ninh Binh province and in Song Ray commune, Cam My district, Dong Nai province.

In addition to economic, social and environmental benefits, implementing the models contributes to reducing GHG emissions in selected communes in Chau Thanh district, Khanh Thanh, Song Ray communes, including 64.3, 328.1, 45.1 tons, respectively.

If the research results of straw/stubble decomposition in the fields are replicated, the potentials of GHG emission reduction in Khanh Thanh, Song Ray communes can be 3,065.9, 635.6 tons/year, respectively. The reduction potentials in 2022 in Chau Thanh, Yen Khanh, Cam My districts are 2,644.2, 19,436.0, 1,911.1 tons/year, respectively. Those in An Giang, Ninh Binh, Dong Nai could be 5,530.5, 112,885.1, 56,140.0 tons/year, respectively. By the year of 2030, the potentials of GHG reduction in Chau Thanh, Yen Khanh, Cam My districts will be 13,098.9, 8,772.6, 821.8 tons/year, respectively. Those in An Giang, Ninh Binh, Dong Nai province will be 27,358.6, 56,410.9, 26,853.1 tons/year, respectively.

The research results show that implementing open burning alternatives significantly reduces GHG compared to open burning, so it is recommended that authorities increase propaganda on the benefits of alternative solutions, provide technical guidance and preferential funding to replicate these models, contributing to GHG emission reducing to achieve the goal of net zero.

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Assessing the wind energy potential of Hai Phong's offshore area

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Abstract
While offshore wind farms are a global reality, Vietnam remains untapped in this renewable energy sector. Hai Phong, a city experiencing rapid economic growth, faces increasing electricity demands. This study assessed the wind energy potential of Hai Phong's offshore area by calculating wind energy density at 10 meters and extrapolating to 100 meters using meteorological data and semi-empirical formulas. Results indicate significantly higher average wind energy density offshore compared to coastal areas (1.36 times at 10 meters). At 100 meters, average wind energy density fluctuates substantially (2,927 to 22,108 W/m²) with a notable difference between monsoon seasons (2.04 times higher in the Southwest monsoon than the Northeast one). This preliminary investigation seeks to evaluate the potential of Hai Phong's sea wind as a resource, laying the groundwork for comprehensive research initiatives in the future.

Keywords: *Offshore wind energy, clean energy source, wind resources, Hai Phong city.*
JEL Classifications: *O13, P18, P48.*
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1. INTRODUCTION

Wind energy has become a global phenomenon, with over 130 countries harnessing its power. The industry has experienced rapid growth, with global capacity nearly doubling from 2011 to 2020, reaching 733 GW. China and India have been key drivers of this expansion, accounting for over half of the new installations in the past decade *(WB, 2021)*.

Offshore wind energy is rapidly emerging as a promising clean energy source. The UK led the global offshore wind (WE) industry in 2016 with the largest installed capacity (8.5 GW) and lowest costs. By September 2019, global offshore wind capacity had expanded to approximately 25 GW, representing annual investments of around $26 billion. Historically, offshore wind was significantly more expensive than onshore, with 2015 levelized costs of electricity (LCOE) ranging from $150 to $200/MWh. However, a dramatic shift occurred between 2016 and 2017, as European competition drove levelized cost of energy (LCOE) below $100/MWh. This trend culminated in subsidy-free offshore wind projects in the Netherlands. The US and UK further accelerated cost reductions, with bids falling to $65/MWh and £39.65/MWh, respectively, by late 2019. Global offshore wind capacity grew by 4.8 GW in 2018, with Europe contributing 60% and China emerging as Asia's leader. Forecasts predict annual installations of 7-11 GW from 2019-2024, rising to 15-21 GW from 2025-2030. By 2030, cumulative capacity is expected to reach 190 GW, backed by $700 billion in investments. While Europe will maintain steady growth, Asia is projected to dominate installations over the next decade, with the United States capturing approximately 10% of the global market (*Du Van Toan et al., 2020*).

Vietnam boasts abundant offshore wind resources strategically located near densely populated areas. This prime positioning presents a significant opportunity to harness wind power, potentially contributing nearly 30% of the nation's electricity demand by 2050 *(WB, 2019)*. The industry is poised for substantial growth in the coming years. Offshore wind power is crucial for sustainably meeting Vietnam's rapidly increasing electricity needs, with the potential to supply 12% of the country's power by 2035. Estimates indicate a colossal offshore wind potential of up to 609 GW across 3,000 km of coastline and 150,000 km² of sea area, considering depths of up to 50m and a distance of 70 km from shore *(Teske et al., 2019)*. This study also delineates potential wind energy zones and influencing factors on power output. While Vietnam has successfully developed onshore and nearshore wind power, offshore wind remains nascent. Despite variations in wind power potential assessments due to differing scales and methodologies, studies consistently highlight Vietnam's immense wind energy prospects *(Van Khiem Mai, 2024)*.

Hai Phong city is one of the provinces and cities with important industrial clusters, the 2nd largest port in the country, with a population of over 2 million people. With these characteristics, the demand for electricity

is increasing. To further clarify the picture of the wind potential of Hai Phong waters. The paper used the method of calculating the wind energy density of the 10m floor according to the observation data of the meteorological measuring column and used a semi-experimental formula to extrapolate the wind speed of the 100m floor. The paper focuses on evaluating the reliability of existing data sources and testing the calculation of wind energy density, making policy recommendations for offshore wind power development in Hai Phong.

2. MATERIALS AND METHODS

2.1. Materials

Wind data was collected from two level, fixed base hydrometeorological stations (Hon Dau and Bach Long Vi) located along the coastal and island regions. These stations, equipped with 10-meter wind measuring poles, adhere to Level I station standards for wind data collection. Data was recorded every six hours from 1980 to 2020. Prior to analysis, raw data underwent preprocessing in Excel to remove outliers and filter maximum monthly wind speeds.

2.2. Methods

a) Calculation of wind energy density (Ministry of Natural Resources and Environment, 2022):

The average wind energy density E (W/m^2) at a specific location over a given period (year, season, month, etc.) is calculated using the following formula:

$$E = (1/2\rho)(1/N)\sum_{i=1}^{n} v_i^3 \qquad (1)$$

Where: ρ represents the air density, assumed constant at 1.225 kg/m^3, v_i is the instantaneous wind speed (m/s), N is the sample capacity.

b) Calculation of wind distribution (Ministry of Natural Resources and Environment, 2022):

$$V_z = V_1 \frac{\ln(z/z_o)}{\ln(z_1/z_o)} \qquad (2)$$

Where: V_z is the wind speed at the desired altitude, Z. For comparison, V_1 is the ground-level wind speed measured at an altitude of Z_1 = 10m. , Z_0 is the roughness of the cushion, and Z_1 is the altitude of the ground anemometer (Z_1 = 10m). Because the altitude to be calculated is usually greater than the ground wind measurement altitude ($Z > Z_1$), $V_z > V_1$ or wind speed increases with altitude. In addition, the degree of increase in wind speed with altitude depends on the roughness of the cushion (Z_o). The greater the roughness of the cushion, the faster the wind speed at the required altitude (V_z) increases.

c) Method of building wind energy density diagram

This study employed a Geographic Information System (GIS) to construct foundational data layers essential for generating wind energy density diagrams. The Inverse Distance Weighted (IDW) interpolation method, a GIS-based technique, was utilized in this process.

3. RESULTS AND DISCUSSIONS

3.1. Hai Phong coastal wind regime

Analysis of coastal wind patterns from 1980 to 2020 reveals distinct seasonal variations. Predominant wind directions shift between the rainy and dry seasons. Southerly, southeasterly, and southwesterly winds characterize the rainy season, while northeasterly, northerly, and easterly winds dominate the dry period. Easterly winds are most frequent, comprising approximately 26.93% of all observations. Southeast and north winds follow, accounting for 15.44% and 12.94%, respectively. Northeast and south winds are less common at 9.2% and 9% (Table 1).

Wind patterns in the region exhibit pronounced seasonal variability. Annually, winds typically range from 0.5 to 2.1 m/s, accounting for nearly half (47.9%) of total wind velocity. The next most common wind speeds, 3.6 to 5.7 m/s, comprise about 24% of the total (Table 1). Stronger winds exceeding 5.7 m/s occur less frequently (11.7%) and predominantly originate from easterly, southerly, south-easterly, and north-easterly directions. Notably, extreme wind events surpassing 15 m/s are concentrated between May and October, coinciding with the region's stormy season.

During the dry season, easterly winds dominate (39.5%), followed by northerly (18.2%) and north-easterly (12%) winds. Wind speeds between 0.5 and 2.1 m/s account for slightly more than half (50.3%) of the total, with 3.6-5.7 m/s winds comprising about 23.1%. High-speed winds (over 5.7 m/s) are relatively uncommon (10.3%) and primarily originate from easterly, northerly, north-easterly, and south-easterly directions.

In contrast, the rainy season is characterized by south-easterly winds as the predominant direction (20.4%), followed by northerly (17.2%) and easterly (12.1%) winds. Wind speeds in the 0.5-2.1 m/s range constitute approximately 47.4% of the total, while those between 3.6 and 5.7 m/s reach around 23.2%. Stronger winds (over 5.7 m/s) are more common during the rainy season (16%) and primarily originate from easterly, southerly, and south-easterly directions.

3.2. The sea breeze regime in Hai Phong

Hai Phong's wind regime is primarily influenced by the Gulf of Tonkin. The region experiences two distinct monsoon seasons: a northeast monsoon from October to February, characterized by cold, dry weather, and a southwest monsoon from April to August,

Table 1. Average wind frequency for years (1980 - 2020) in Hon Dau

Direction	Velocity (m/s)						Sum
	0.5 - 2.1	2.1 - 3.6	3.6 - 5.7	5.7 - 8.8	8.8 - 11.1	>11.1	
North	8.24	1.71	1.93	0.95	0.07	0.04	12.94
Northeast-North	1.44	0.46	0.39	0.06	0.01	0.00	2.37
Northeast	5.90	1.29	1.34	0.59	0.02	0.01	9.16
East-Northeast	1.09	0.32	0.48	0.24	0.01	0.02	2.16
East	10.52	4.52	7.99	3.77	0.09	0.05	26.93
East Southeast	1.50	1.11	1.55	0.53	0.01	0.02	4.73
Southeast	6.38	2.83	4.81	1.34	0.02	0.05	15.44
South Southeast	1.16	0.90	1.45	0.72	0.09	0.00	4.32
South	3.13	0.99	2.43	2.11	0.31	0.02	8.99
South-Southwest	0.53	0.12	0.32	0.54	0.05	0.01	1.56
Southwest	0.66	0.26	0.55	0.61	0.06	0.01	2.15
West-Southwest	0.16	0.01	0.04	0.01	0.01	0.00	0.23
West	0.65	0.09	0.07	0.04	0.00	0.00	0.84
West Northwest	0.26	0.04	0.01	0.02	0.00	0.00	0.33
Northwest	4.08	0.46	0.28	0.07	0.01	0.01	4.92
North Northwest	2.22	0.24	0.32	0.11	0.01	0.00	2.91
Sum	47.90	15.40	24.00	11.70	0.80	0.30	100

(Source: National Centre for Hydro-Meteorological Network - NCN)

associated with hot, humid conditions and abundant rainfall. March and September are transitional months with variable wind directions, often shifting clockwise. Over a 20-year period (1982-2002), the average wind speed was 3.3 m/s. Calm conditions occurred 3.49% of the time, while wind speeds ranged from 0.5 to 2.1 m/s (33.6%), 2.1 to 3.6 m/s (17.4%), 3.6 to 5.7 m/s (33.4%), 5.7 to 8.8 m/s (11.2%), 8.8 to 11.1 m/s (0.8%), and above 11.1 m/s (0.1%).

From October to February, east and northeast winds dominate, with average speeds reaching 6.5-8.2 m/s. Wind speeds are particularly high from October to January, often exceeding 9.0 m/s. December experiences the highest frequency of these wind directions (99%), while other months see around 67%. Although northeast winds are less frequent than east winds, they are generally stronger.

The southwest monsoon, occurring from April to August, brings average wind speeds of 5.5 m/s, increasing to 7.0 m/s in June. Southerly and southwesterly winds prevail due to the development of the Indian low-pressure system over the Gulf of Tonkin. April is characterized by southeast winds averaging 6.0 m/s, while south and southwest winds dominate from June to August, especially in July (67%). Southwest wind intensity decreases in August. March and September are transitional months with unstable wind directions and speeds. Northeast winds are most frequent in March (17%), while southwest winds peak in September (12%). Average wind speeds during these months are around 5.0 m/s.

Average monthly wind speeds have varied over time. The highest values were recorded in the 1990s (8.2 m/s), followed by 2011-2020 (7.4 m/s), 1980-1989 (7.3 m/s), and 2000-2010 (7.0 m/s). However, all periods experienced average monthly wind speeds exceeding 5 m/s, with peak values occurring in summer or winter (Table 2, Table 3).

Table 2. Monthly average wind speed (m/s) at Bach Long Vi station over a ten-year period

Periods	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
1980-1989	7.28	7.07	6.73	5.73	6.13	6.65	7.3	5.42	5.57	6.98	7.00	7.01
1990-1999	7.12	6.74	6.46	5.95	6.04	7.23	8.19	5.84	5.00	6.73	7.27	7.54
2000-2010	6.57	6.15	5.54	5.75	5.49	6.15	6.43	4.66	5.26	6.15	6.72	6.97
2011-2020	5.67	5.37	4.51	4.84	5.72	6.46	6.03	4.90	4.66	5.78	6.28	7.38

(Source: National Centre for Hydro-Meteorological Network - NCN)

A comparative analysis of average and maximum wind speeds over multiple years in the study area reveals a consistent trend of decreasing wind speeds from the open sea towards the coastline. When comparing the open sea area of Hai Phong to the northwestern coastal islands (Co To), the coast (Hon Dau), the inland region (Phu Lien), and the coast of the Gulf of Tonkin's mouth (Con Co), it is evident that the open sea consistently exhibits the highest average and maximum wind speeds across all months (Table 3). This data highlights the substantial potential for offshore wind power generation in Hai Phong's waters.

Bach Long Vi island, located in the research area's offshore zone, successfully commissioned its first wind power station in 2004 with a capacity of 858 kW. This achievement followed a three-year construction period aided by the expertise of Spanish companies Made (equipment) and Tucme (consultancy) (*Tran Anh Tu, 2014*). Initial testing over three months conclusively demonstrated the island's abundant wind resources, capable of consistently powering the station. A detailed analysis of wind speed data from October 1st to 25th, 2004, revealed a regular station output of 600-800 kW/h, corresponding to wind speeds of 10-16 m/s. Long-term wind monitoring (1980-2010) at an altitude of 10 meters recorded an average annual wind speed of approximately 7 m/s. Calm conditions (≤ 1.0 m/s) occurred 5.56% of the time, while wind speeds exceeding 7.0 m/s constituted 29.41% of the dataset (*Tran Duc Thanh. 2013*).

Table 3. Comparison of average and maximum monthly wind speeds (m/s) in the open sea (Bach Long Vi) and the stations on the west coast of the Gulf of Tonkin in the period of 1980-2020

Station	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Bach Long Vi	19.1	18.9	18.5	17.9	18.3	18.2	21.5	23.4	21.5	21.9	20.3	19.6
Co To	15.3	15.1	14.7	14.9	14.6	18.1	21.0	19.2	18	17	15.9	15.8
Hon Dau	13.5	13.5	13.0	14.6	16.3	16.3	19.7	17.6	17.2	15.2	13.0	12.3
Phu Lien	10.2	11.0	11.5	15.0	15.9	16.6	20.3	18.3	15.8	13.6	11.7	11.3
Con Co	13.1	12.1	11.9	13.0	13.0	12.1	12.2	14.5	14.3	18.3	15.0	14.0

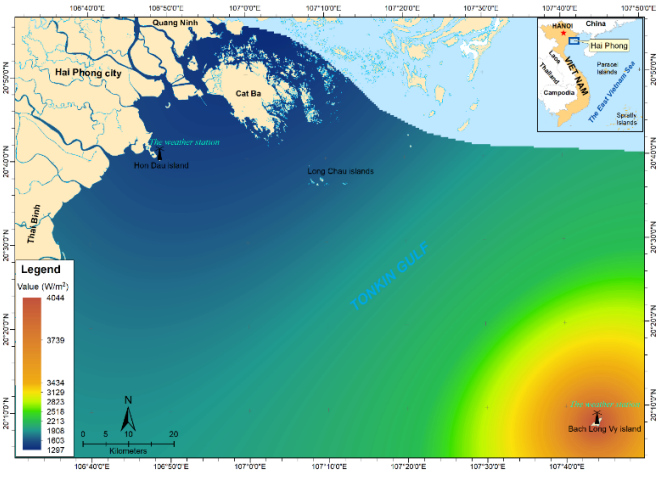
(Source: National Centre for Hydro-Meteorological Network - NCN)

Table 4. The highest average monthly wind energy density, E (W/m^2), during the period 1980-2020 in coastal waters (Hon Dau) and open seas (Bach Long Vi)

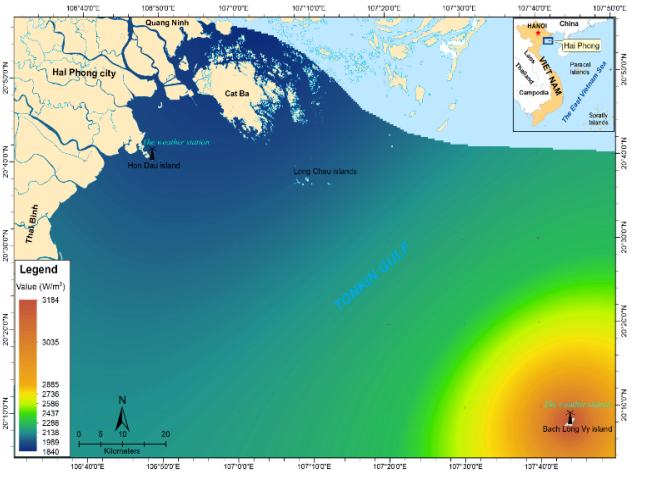
Month/ Station	Bach Long Vi		Hon Dau		Month/Station	Bach Long Vi		Hon Dau	
height	10m	100m	10m	100m	height	10m	100m	10m	100m
1	4378	9103	1483	3084	7	9291	19315	7778	16171
2	4520	9398	1607	3341	8	10635	22108	5057	10514
3	4133	8593	1408	2927	9	8577	17830	4554	9467
4	3578	7439	2042	4245	10	8576	17829	3043	6326
5	4297	9833	2800	5821	11	5764	15662	1400	2911
6	5272	10960	3970	8253	12	5049	10497	1166	2425

3.3. Wind energy density distribution of the study area

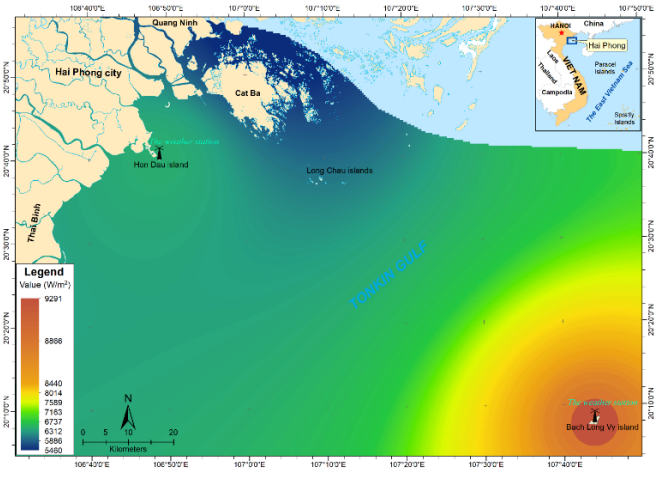
a) Wind energy density at 10m



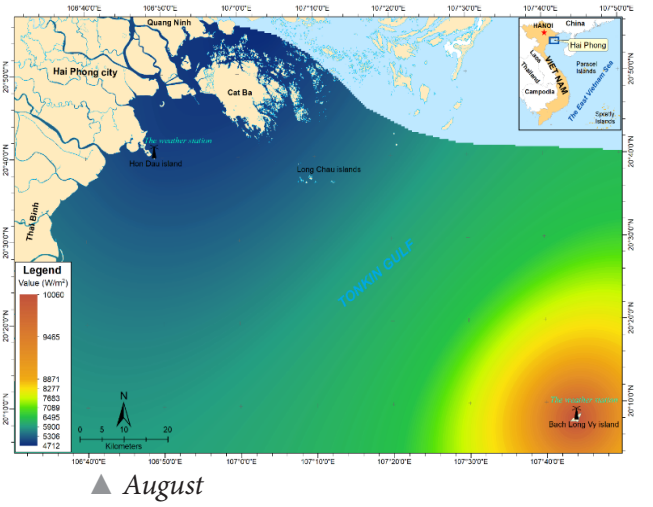
▲ *February*



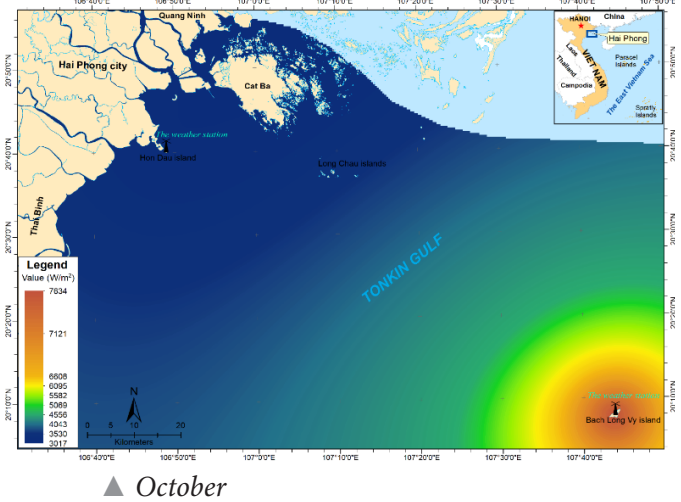
▲ *April*



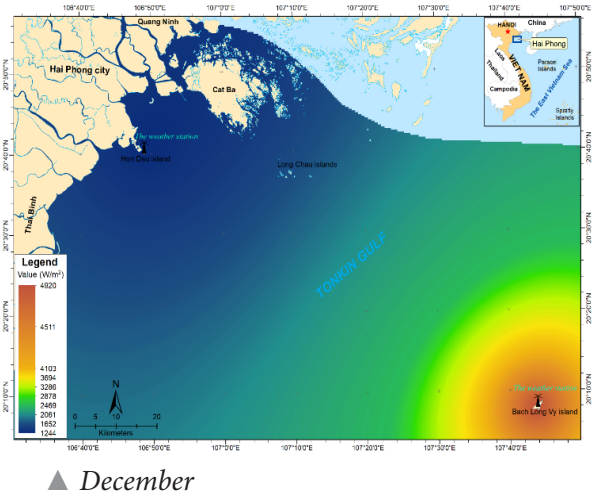
▲ *July*



▲ *August*



▲ *October*



▲ *December*

▲ *Figure 1. Average wind energy density E (W/m²) of the maximum value Hai Phong sea at an altitude of 10m (period 1980-2020)*

Wind energy density in Hai Phong exhibits significant seasonal and spatial variability. Offshore Hai Phong boasts an average monthly wind energy density ranging from 3,578 to 10,635 W/m², with a pronounced monsoon influence. Southwest monsoon months (July to September) consistently exceed 8,000 W/m², doubling the energy density of Northeast monsoon months (below 5,000 W/m²) (Table 4, Figure 1). In contrast, the coastal area experiences a lower average monthly wind energy density between 1,166 and 7,778 W/m². While still influenced by the monsoon cycle, with Southwest monsoon months surpassing 4,000 W/m² and outperforming Northeast monsoon months by a factor of 4-5, the overall energy potential is markedly lower (Table 4). Importantly, the maximum monthly wind energy density offshore is 36% higher than that of the coastal area (Table 4).

b) Wind energy density at 100m

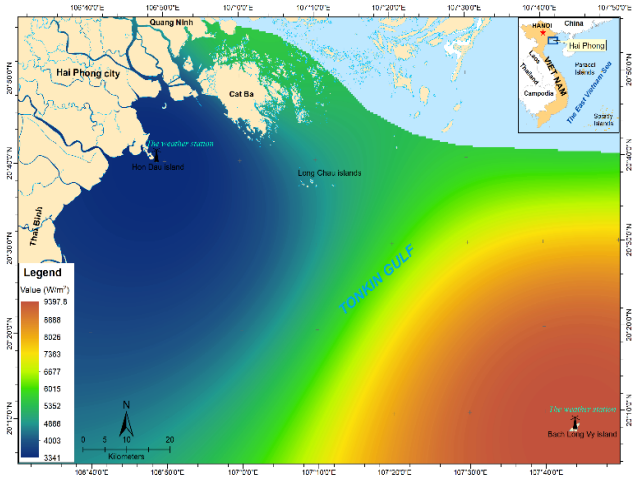
Hai Phong sea at an altitude of 100m (period 1980-2020)

At the 100-meter level, the coastal area of Hai Phong exhibits monthly average wind power density ranging from 2,927 to 22,108 W/m². The open sea consistently surpasses 7,000 W/m² year-round, with values in the southwest monsoon (July-September) averaging 2.04 times those of the northeast monsoon (December-February). The coastal maximum drops to 2,425-16,171 W/m², yet southwest monsoon months still exceed 9,000 W/m², five times the northeast (Table 4, Figure 2). Offshore wind energy density is 2.1 times greater than coastal (Table 4).

Hai Phong boasts one of Vietnam's two most promising offshore wind energy areas (Ministry of Natural Resources and Environment, 2022). Vietnam, overall, leads Southeast Asia in wind energy resources, with a total potential of 513,360 MW (medium to large global density) (Pham Anh Tuan, 2007). Approximately 40% of Vietnam enjoys strong winds (7-9 m/s at 65 meters), ideal for large-scale wind farms (Vu Manh Ha, 2007). This underscores Hai Phong's offshore wind potential as a cornerstone of Vietnam's future renewable energy landscape.

To harness this potential, Hai Phong should:

+ Prioritize wind power development through city resolutions, replacing thermal power gradually. Offer incentives to wind energy investors (tax breaks, legal support, land clearance).



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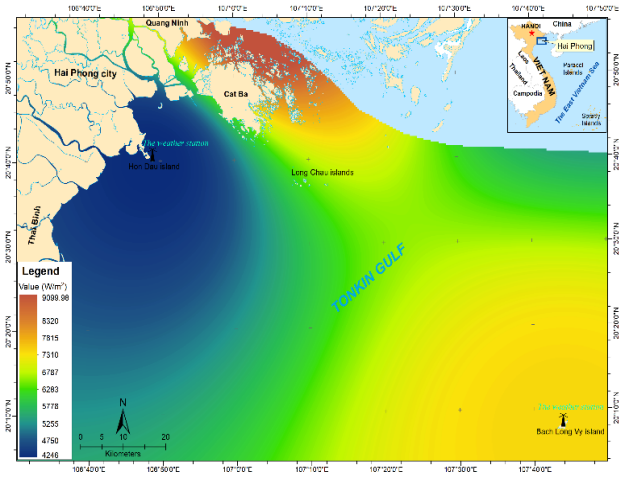
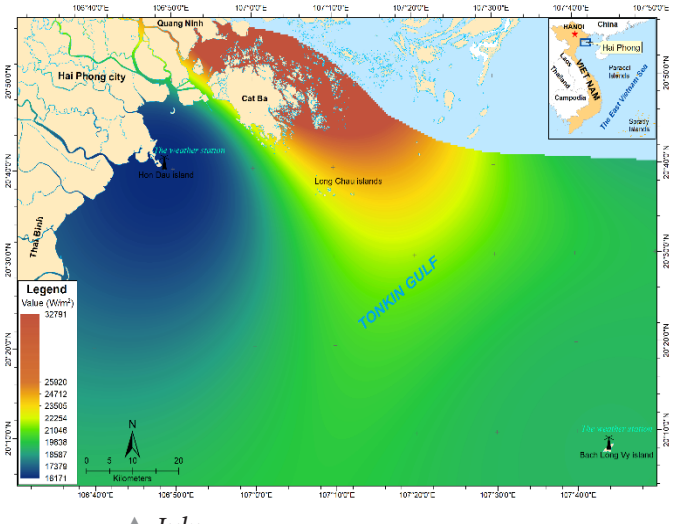
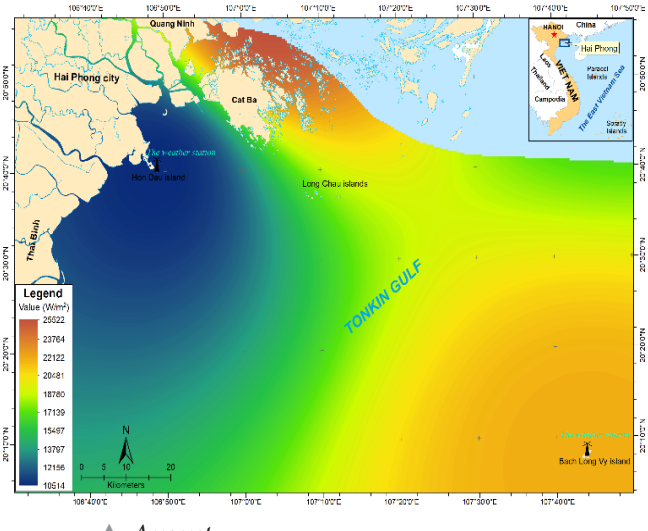


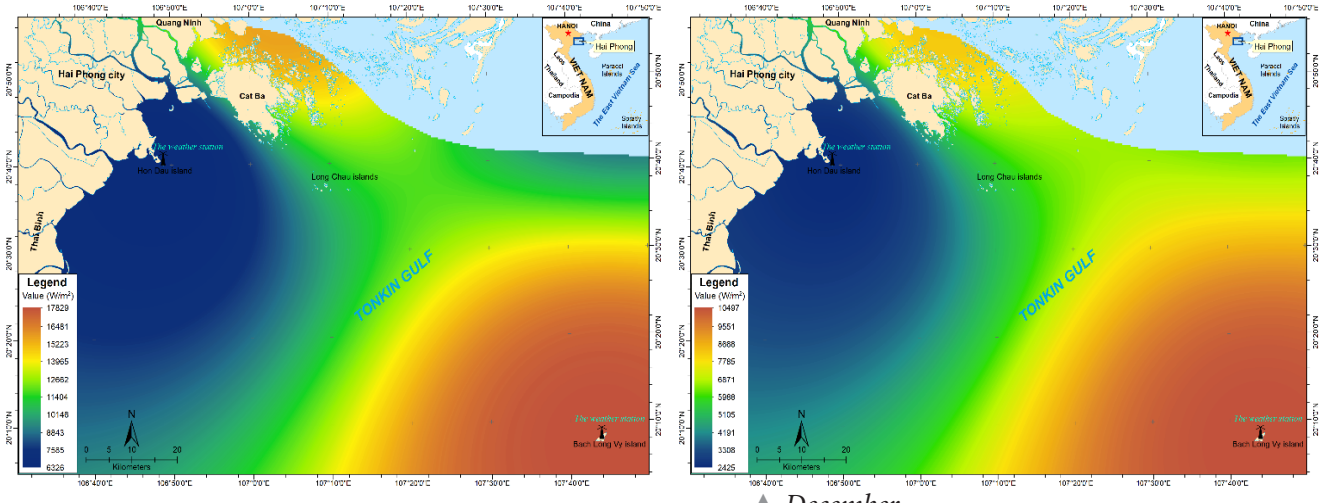
▲ *April*



▲ *July*



▲ *August*



▲ *October* ▲ *December*

▲ *Figure 2. Average wind energy density E (W/m²) of the maximum value Hai Phong sea at an altitude of 100m (period 1980-2020*

+ Establish a renewable energy steering committee led by a vice mayor, with industry, trade, and coastal district representatives.

+ Conduct comprehensive wind resource assessments for coastal and offshore areas, informing detailed land and sea use planning for renewable energy. Pilot small-scale projects to gain practical experience.

+ Enhance the professional capabilities of city officials managing renewable energy through domestic and international training.

+ Foster international collaboration on marine science and technology, specializing in renewable energy. Develop local research and application programs for sustainable coastal and offshore resource management.

4. CONCLUSION

The research findings illuminate Hai Phong's offshore wind energy potential for developing offshore wind power projects. However, the study's scope is limited by its reliance on data from 1980 to 2020, necessitating an update to 2023 for enhanced reference and timeliness. Moreover, this initial assessment of Hai Phong's offshore wind potential on a monthly basis lays the groundwork for more detailed investigations to support specific project development goals.

Marine management agencies, electricity, and offshore wind power companies can utilize this research as a foundation for further, in-depth studies aligned with Vietnam's 2050 net-zero target.

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Summit of the Future 2024: Multilateral Solutions for a Better Tomorrow

The world is not on track to meet the goals we have already set for ourselves. Nor are we effectively rising to new challenges or opportunities. The speed and complexity of developments have outpaced our systems for cooperating and coping. The benefits and opportunities of progress are spread unevenly, with the majority of people left behind. The risks and threats are also unevenly felt, disproportionately impacting the most vulnerable. Extreme poverty and hunger are on the march. Global emissions are at their highest levels in human history, as are levels of human displacement. Threats such as climate, conflict, food security, weapons of mass destruction, pandemics and health crises, and the risks associated with new technologies, are growing. Multilateral governance, designed in simpler, slower times, is not adequate to today's complex, interconnected, rapidly changing world. The Summit is an opportunity to put ourselves on a better path. The UN Summit of the Future is a high-level event, bringing world leaders together to forge a new international consensus on how we deliver a better present and safeguard the future. This once-in-a-generation opportunity serves as a moment to mend eroded trust and demonstrate that international cooperation can effectively tackle current challenges as well as those that have emerged in recent years or may yet be over the horizon. World leaders adopted a Pact for the Future that includes a Global Digital Compact and a Declaration on Future Generations. Leaders set out a clear vision of an international system that can deliver on its promises, is more representative of today's world and draws on the energy and expertise of governments, civil society and other key partners. Viet Nam will actively contribute to the Summit and to our collective efforts to strengthen peace, cooperation and international solidarity with a view to implementing the Sustainable Development Goals.

▲ *General Secretary and President To Lam emphasized that peace and stability are the foundation for building a prosperous future for nations*

1. PACT FOR THE FUTURE

This Pact is the culmination of an inclusive, yearslong process to adapt international cooperation to the realities of today and the challenges of tomorrow. The most wide-ranging international agreement in many years, covering entirely new areas as well as issues on which agreement has not been possible in decades, the Pact aims above all to ensure that international institutions can deliver in the face of a world that has changed dramatically since they were created. The agreement of the Pact is a strong statement of countries' commitment to the United Nations, the international system and international law. World leaders discuss on an ambitious, transformational, urgent, accelerated, action-oriented "Pact of the Future" revolving around five themes with 56 Actions: *1) Sustainable development and financing; 2) International peace and security; 3) Science, Technology, and Innovation (SIT) and digital cooperation; 4) Youth and future generations; and 5) Transforming global governance.* The Pact for the Future open the door to new opportunities and untapped possibilities.

Sustainable Development and Financing

The entire Pact is designed to turbo-charge implementation of the Sustainable Development Goals (SDG). The most detailed agreement ever at the United Nations on the need for reform of the international financial architecture so that it better represents and serves developing countries. Member States recommitted to accelerate the implementation of the 2030 Agenda and of the 2023 SDG Summit Political Declaration through urgent and scaled-up action, policies and investments with the goal to end poverty and hunger and leave no one behind. The Pact also acknowledges the need for Member States to begin to consider how to advance sustainable development beyond 2030. Global leaders agreed on a step-change in financing for the SDGs and closing the SDG financing gap, including through an SDG Stimulus, reaching official development assistance targets, private sector investment, mobilization of domestic resources, inclusive and effective international tax cooperation, and consideration of a global minimum level of taxation on high-net-worth individuals. On climate change, the Pact confirmed the need to keep global temperature rise to 1.5°C above pre-industrial levels, to transition away from fossil fuels in

▲ *Party General Secretary and President To Lam speaks at the General Debate of the 79th Session of the United Nations General Assembly*

energy systems to achieve net-zero emissions in 2050 and promote disaster risk-informed approaches to sustainable development. It also calls for accelerated efforts on the environment, including the promotion of sustainable consumption and production patterns, the conclusion of a legally-binding agreement on plastic pollution, reversing biodiversity loss and protecting ecosystems.

International peace and security

Global leaders vowed to intensify diplomacy to settle conflicts and disputes peacefully, supported by the UN and the UN Secretary-General's good offices. The Pact promotes the need for national whole-of-society sustaining peace efforts through the development and implementation of voluntary national prevention strategies. Strengthened resilience through implementation of the 2030 Agenda, and the importance of ensuring that military spending does not compromise sustainable development investments. Stronger alignment of international financial institutions' funding with countries' efforts to address root causes of instability. The Pact commits to protecting civilians in armed conflict by complying with the laws of war. It also includes a pledge to refrain from the use of explosive weapons in populated areas, and to strengthen accountability for serious crimes and gross violations, such as gender-based violence and starvation as a weapon of war. Leaders also agreed to accelerate the implementation of commitments on Women and Peace and Security and Youth, Peace and Security. The Pact asks for a review of United Nations peace operations to recommend how they can adapt to new and emerging challenges and promotes counter-terrorism efforts that address all drivers and enablers of terrorism and violent extremism conducive to terrorism, including in the digital sphere. The Pact also advanced steps to avoid the weaponization of emerging domains and technologies.

Science, technology and innovation (STI) and digital cooperation

The Pact introduces measures to reduce global disparities in science, technology and innovation, including through scaling-up means of implementation. It addresses barriers to the access, participation and leadership of women and girls in these areas and agrees on the importance of human rights and ethical principles in the development and use of new technologies. Leaders also committed to the increased use of science in policy-making to address complex challenges, and to more funding for SDG-related research and innovation. They decided to strengthen capacities at the UN to leverage STI in the work of the organization, including to support developing countries in achieving the SDGs. The Global Digital Compact, annexed to the Pact, is the first comprehensive global framework for digital cooperation and AI governance. At the heart of the Compact is a commitment to design, use and govern technology for the benefit of all. This includes commitments by world leaders to connect all people, schools and hospitals to the Internet; Anchor digital cooperation in human rights and international law; Make the online space safe for all, especially children, through actions by governments, tech companies and social media; Govern Artificial Intelligence, with a roadmap that includes an International Scientific Panel and a Global Policy Dialogue on AI; Make data more open and accessible, with agreements on open-source data, models, and standards. This is also the first global commitment to data governance, placing it on the UN agenda and requiring countries to take concrete actions by 2030.

▲ *A wide view of the General Assembly Hall during the opening of the Summit of the Future*

Youth and future generations

The first ever Declaration on Future Generations, with concrete steps to take account of future generations in our decision-making, including a possible envoy for future generations. The Pact aims to expand and strengthen youth participation in global decision-making, including in UN intergovernmental bodies and processes. It agrees to the participation of youth from developing countries, facilitated through the UN Youth Fund and development of core principles for meaningful youth engagement. It will strengthen youth participation at the national level, including through the establishment of consultation mechanisms and creating environments that enable young people to fulfill their rights and potential through education, jobs, physical and mental health, resources for youth-led organizations, and flexible funding, including through a global youth investment platform. A strengthening of our work on human rights, gender equality and the empowerment of women.

Transforming global governance

The Pact resolved to make the multilateral system more effective, fit for the future, just and representative, inclusive and networked, and financially stable. Recommitting to the achievement of gender equality and the empowerment of all women and girls, leaders agreed to take steps towards the revitalization of the Commission on the Status of Women. They also underscored their aspiration for a female Secretary-General. On human rights the Pact is clear on the need to ensure the enjoyment by all of all human rights, including through UN human rights mechanisms that are effective and have adequate means to respond to a range of human rights challenges. It also makes a clear appeal to protect human rights defenders. The Pact also agreed steps to deepen partnerships between the UN and other stakeholders, including civil society, the private sector, regional organizations, national parliaments and local and regional authorities. It calls for a UN that uses innovation, data, digital tools, foresight and (behavioural) science effectively. The Pact presents the most detailed agreement ever at the United Nations on the need to reform the international financial architecture, so that it works for everyone and reflects the economic needs and realities of today. Leaders decided on concrete next steps to develop measures of progress on sustainable development beyond GDP, capturing human and planetary wellbeing and sustainability. The Pact also calls for an improved international response to complex global shocks and proposes the consideration of approaches to strengthen the UN system's response, within existing authorities and in consultation with Member States.

2. GLOBAL DIGITAL COMPACT

Annexed to the Pact, the Global Digital Compact is the first comprehensive global framework for digital cooperation. It explicitly includes human rights and concrete commitments to accelerate progress on the 2030 Agenda and puts emphasis on the role of non-state stakeholders. It makes the first global commitment to digital public goods and digital public infrastructure; to open-source data, models and standards; and to data governance. In the Compact, leaders also agreed on ambitious steps to make the digital space safer for all through greater accountability of tech companies and social media platforms and actions to tackle disinformation and online harms. The Compact includes an agreement on a roadmap for global AI governance, through the establishment of an AI Scientific Panel, global policy dialogue on AI and exploration of the establishment of a Global Fund for AI capacity building.

Leaders recognize their shared responsibility to harness the benefits of technology for all. Equally, the misuse and missed use of digital technologies harms all of us and we are committed to anticipate and mitigate risks. The goal is an inclusive, open, safe, and secure digital future for all. Leaders can only achieve this through international cooperation and governance that closes digital divides and advances an equitable and inclusive digital world. This Global Digital Compact sets out the objectives, commitments, and actions undertaken to achieve this goal. It is only by working in collaboration and partnership with all stakeholders, including governments, the private sector, civil society, international organizations and the technical and academic communities, that we can achieve our goal.

To achieve this goal, leaders will pursue the following objectives: *(1) Close the digital divides and accelerate progress across the Sustainable Development Goals; (2) Expand opportunities for inclusion in the digital economy; (3) Foster an inclusive, open, safe, and secure digital space; (4) Advance equitable international data governance; (5) Govern emerging technologies, including Artificial Intelligence, for humanity.* Leaders commit to pursue meaningful and measurable actions to achieve objectives.

Objective 1: Closing the digital divides and accelerating progress across the Sustainable Development Goals: Connectivity, Digital literacy, skills and capacities and Digital public goods and infrastructure.

Objective 2. Expanding inclusion in the digital economy: Access to digital technologies. Leaders commit by 2030 to support international, regional and national e8orts to develop enabling environments for digital transformation, including legal and regulatory frameworks (SDGs 10 & 16); Call on regional and multilateral organizations as well as governments to support national digital readiness assessments and, where requested and as appropriate, provide technical assistance to national authorities (All SDGs); Promote knowledge-sharing and technology transfer initiatives (SDG 17); Encourage South-South and triangular digital cooperation to accelerate knowledge development and expand access to research capacity (SDG 17); Pool knowledge and best practices on digital enterprise to support innovation programmes and local technological solutions in developing countries (SDG 9); Foster innovation and entrepreneurship, including among women and youth entrepreneurs with the goal of increasing the number of digital start-ups and small and medium enterprises in developing countries (SDGs 8 & 9); Mainstream cybersecurity infrastructure and skilling in national digital transformation strategies (SDG 9).

Objective 3. Fostering an inclusive, open, safe and secure digital space: Human rights; Internet governance; Digital trust and safety; Information integrity.

Objective 4. Advancing equitable international data governance: Data privacy and security; Data exchanges and standards; Data for development; Cross-border data flows.

Objective 5. Governing emerging technologies, including Artificial Intelligence, for humanity: Leaders request the President of the General Assembly to appoint at the 79th session of the General Assembly co-facilitators to draft, in consultation with relevant stakeholders, terms of reference and modalities for the establishment and functioning of the International Scientific Panel on AI for the adoption by the General Assembly; identify, in consultation with relevant stakeholders, modalities for the annual global dialogue on AI governance for the adoption by the General Assembly; Request the Secretary-General to establish under his authority a Global Fund for AI and Emerging Technologies for Sustainable Development to catalyze the development of representative and quality standard data sets to inform the public use of AI at scale; support the development of compute capacity that can apply existing AI models to localized data sets; build and deliver skills-based training in collaboration with technology companies and technical and academic communities; promote and align AI-based solutions for the SDGs.

3. DECLARATION ON FUTURE GENERATIONS

Leaders agreed the first ever Declaration on Future Generations, recognizing our obligations and putting in place steps to systematically take future impact into account, consciously avoiding foreseeable harms to and safeguarding the interests of future generations. The Declaration puts forward concrete proposals and processes to help Member States better consider future generations and inspire long-term anticipatory governance at the international level.

Leaders hereby pledge to promote peaceful, inclusive and just societies while taking into account inequalities within and between nations and the special needs of developing countries, as well as those of systemically marginalized communities and groups in vulnerable situations; Implement policies to eliminate gender discrimination in all its forms and promote women's empowerment by providing equitable economic and leadership opportunities for all women and girls, as appropriate, in all spheres of society; Eliminate all forms of persistent historical and structural inequalities, including racism, racial discrimination, xenophobia and related intolerance, and all other forms of discrimination; Honor and promote cultural diversity, foster intercultural dialogue to ensure tolerance, preserve ecosystems and communities, protect territorial rights, languages, knowledge systems and traditions, while safeguarding spiritual and ancestral

beliefs of Indigenous Peoples and ensuring their full, equal and meaningful participation in decision-making processes; Undertake comprehensive and targeted strategies to achieve sustainable development, global resilience and to eradicate poverty, including extreme poverty, in all its forms and dimensions, to meet the needs of the present generations without compromising the ability of future generations to meet their needs; Guarantee climate justice by prioritizing urgent action on climate change, biodiversity loss, pollution, desertification, water scarcity, and other environmental challenges to safeguard vulnerable communities and ensure a safe, healthy, and sustainable environment; Harness the benefits of new and emerging technologies and mitigate the associated risks in a constructive and safe manner through effective and equitable governance at the global and regional levels, including through building capacity and promoting the transfer of technology on mutually agreed terms to eliminate the digital and innovation divide, as outlined in the Pact for the Future and the annexed Global Digital Compact; Strengthen cooperation among states in their response to demographic trends and realities, including on safe, orderly and regular migration between countries of origin, transit and destination, to ensure that the interests of both present and future generations across all regions will be fully safeguarded; Invest in inclusive, equitable and quality education for current generations, as well as opportunities for lifelong learning, allowing for the intergenerational acquisition and transfer of knowledge and skills to advance the prospects of future generations; Guarantee the rights of future generations to the highest standard of health, through universal healthcare, to ensure healthy lives and promote well-being for all throughout the life course.

Leaders will implement, institutionalize and monitor the above commitments in national, regional and global policy-making by Leveraging science, data and strategic foresight to ensure long-term thinking and planning, develop and implement sustainable practices and the institutional reforms necessary to futureproof decision-making while making governance more anticipatory, adaptive and responsive to future risks and challenges; Ensuring that knowledge and data are widely shared and build transparent, inclusive, effective and practical accessibility to information, while promoting critical thinking and life-skills to create generations of citizens that are agents of positive change and transformation. Transforming our systems of national and global accounting by promoting the use of future impact assessments, developing stronger anticipatory risk analysis and elaborating a multidimensional approach to take account of indices beyond GDP; Investing in capacity to better prepare for and respond to future global shocks by avoiding and mitigating risks by using forecasting and foresight, while ensuring that the most vulnerable groups and countries do not bear disproportionate costs and burdens of mitigation, restoration and resilience building; Undertaking a cross-sectoral approach that involves the coordination of government Ministries and agencies, including at the local government levels, in the development, assessment and implementation of policies that safeguard the interests of future generations; Developing partnerships with relevant stakeholders, including civil society, academia, the scientific and technological community and the private sector, as well as intergenerational partnerships, to share best practices and develop innovative, long-term and forward-thinking ideas in order to respect, protect and fulfill the needs, interests and rights of future generations; Equipping the multilateral system, including the United Nations, to support Member States in their efforts to embed future generations and long-term thinking in policy-making processes by fostering and facilitating greater use of foresight, science and data, and raising awareness of and advising on the likely intergenerational or future impacts of policies and programmes; Adopting a more future-oriented organizational culture and ways of working across the United Nations system to facilitate science-based sustainable decision-making by developing diverse capabilities, including foresight and futures literacy, and systematically promoting long-term and intergenerational thinking at all levels; Recognizing the important advisory and advocacy role of the United Nations with respect to future generations.

4. VIETNAM COMMITS TO ACTIVELY AND EFFECTIVELY CONTRIBUTING TO THE COMMON EFFORTS

According to General Secretary of the Communist Party of Viet Nam Central Committee and President of Vietnam To Lam: In the face of rapid development of science and technology, the goal of sustainable development of the world and interests of humans must be placed at the center and remain our highest objective. Scientific and technological achievements must serve social progress, focus on humanity, liberate and develop humanity in a comprehensive manner, constantly improve life, for the benefits and happiness of humanity and for future generations.

Scientific and technological achievements should be to promote cooperation, instead of being tools against nations, going against the aspirations for peace, development, equality and justice of nations. Human intelligence achievements must focus on economic development, building a fair and civilized society, improving life quality and alleviating poverty. Accordingly, we suggest more investments in medical research, education and training, digital transformation, green transition and solutions to serve the masses while minimizing investments in developing and manufacturing

weapons of mass destruction, for peace, stability, sustainable development, and equality among countries and nations around the world.

In this turning point, we need to strengthen solidarity, cooperation and mutual respect, compliance with international law and the United Nations Charter and settle divergences and disputes through peaceful means. Major powers need to act responsibly and share common achievements in scientific and technological research for mutual development. The United Nations and regional organizations, including ASEAN must take the lead in coping with global challenges and harness opportunities from scientific and technological advances.

Viet Nam welcomes the documents adopted at this summit and hopes that these documents would be implemented seriously and effectively. We hope that the United Nations, with its central and coordinating role, and international organizations would continue making more effective and stronger contributions to the goal of preventing dangers to rapid and sustainable development of the world right from today. Viet Nam commits to actively and effectively contributing to the common efforts in building the world of peace and equal development for a prosperous and happy life of humanity.

Attending and speaking at the General Debate of the Seventy-nineth Session of the United Nations General Assembly (September 24, 2024, New York, United States), Party General Secretary and President To Lam said: The world is undergoing transformative changes of historic significance. Although peace, cooperation and development remain the dominant trends, they are facing new and more serious challenges. Strategic competition among major powers is becoming broader, fiercer and more confrontational. Political disputes, conflicts and security environment intensify. Survival and development space narrows. Risks of conflict, new hot spots, arm race, tension, confrontation and direct clashes increase.

These unprecedented challenges to peace, cooperation, sustainable development and human dignity affect this generation and the next. They compel us to unite, act and work together, upholding the role of international institutions, foremost among them the United Nations, regional organizations, including ASEAN, to achieve the ultimate goal of ending war, abolishing all forms of oppression, exploitation, building peace and creating a better world to bring happiness to all humankind. Party General Secretary and President To Lam would like to share Vietnam's vision for a more peaceful, stable, cooperative, prosperous and sustainable future for everyone:

Firstly, as peace and stability are the foundation of a prosperous future, we must promote the observance of international law and the UN Charter by all states, particularly the major powers. Each state must act responsibly, fulfill its commitments, and abide by international law and the UN Charter, including fundamental principles such as the peaceful settlement of disputes, non-use of force, sovereign equality, territorial integrity and respect for the political systems chosen by the people of each nation. States should also contribute to the common work of the international community in line with their capabilities. We must tirelessly strengthen solidarity, sincerity and trust among nations, uphold dialogue, eliminate confrontation and firmly oppose unilateral embargoes and sanctions that contravene international law and the UN Charter.

Secondly, we must ensure equitable development for every state, community, and individual, recognizing the diverse economic, social, and cultural conditions they may have. Every resource must be effectively unleashed, marshaled, and utilized for development according to each country's needs. We must prioritize resources where they are most needed for implementing the SDGs, with particular attention to assisting developing and less-developed countries, especially through preferential loans, transfer of advanced technologies, investment and trade facilitation, and debt relief for poor countries.

Thirdly, we should urgently create smart global governance frameworks with long term vision for science and technology, particularly emerging technologies such as artificial intelligence (AI). This will ensure we make progress and enjoy the benefits of these technologies, while actively preventing and repelling threats to peace, sustainable development and humanity. In this regard, I welcome the documents adopted at the Summit for the Future, especially the Global Digital Compact. This will serve as a crucial basis for advancing global governance and international cooperation in these areas.

Fourthly, we should adopt innovative thinking to build a transformative future across all sectors, focusing on digital transformation, green transition, and global governance transformation. Green transition and digital transformation are essential tools for countries, especially developing ones, to build resilience and self-reliance, enabling a timely and active prevention of and response to shocks, crises and potential disasters. We must also prioritize reforming multilateral mechanisms, especially the UN system and international financial and monetary institutions, to ensure better representation, equity and transparency. Enhancing their capability, effectiveness, and future-readiness is essential for remaining relevant in our changing world.

Fifthly, we must place the human person at the centre in delivering on our visions. People should be the centre, goal and driver of all policies and actions at all levels. Investment should focus on the holistic development of the youth, enriching their knowledge and culture, grounded in shared values and a sense of responsibility and contribution ▪

NHÂM HIỀN

(Source: United Nations)

The National Environmental Protection Master-Plan for the period 2021 - 2030, vision toward 2050

NGUYỄN THƯỢNG HIỀN
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On July 8th, 2024, Deputy Prime Minister Tran Hong Ha signed Decision No. 611/QD-TTg approving the National Environmental Protection Master-Plan for the period 2021 - 2030, vision to 2050 (The Plan). The Plan is built with perspectives consistent with the Party's guidelines, policies, State laws and international commitments on environmental protection that Vietnam participates and signs; meet the requirements of implementing the goals of the Socio-Economic Development Strategy, National Environmental Protection Strategy, National Master Plan, National Marine Spatial Plan, National Land Use Plan, climate change scenarios. The National Environmental Protection Plan is associated with national defense and security tasks throughout the country.

The National Environmental Protection Master-Plan is the environmental protection orientation for national sector plans, regional plans and provincial plans, ensuring the principle of not trade-off between environment and economic development, environmental factors must be taken into account in each socio-economic development activity, in harmony with nature, respecting natural laws, economic development with green economic thinking, circular economy, and sustainable economy, low carbon economy to minimize waste generated, aiming for the goal of net zero emissions by 2050, equitable energy transition, contributing to the successful implementation of the country's socio-economic targets in the current period of 2021 - 2030; ensuring openness and flexibility to be integrated into other related plans, in order to realize the goals of sustainable development, adapt to climate change, and prevent early and remotely environmental problems; promote integrated management methods and a comprehensive approach based on natural ecosystems; strengthening harmonious connection in environmental management and protection activities between socio-economic regions, provinces and centrally run cities; proactively prevent, control, overcome pollution and improve environmental quality, protect areas with environmentally sensitive factors; focus on handling cross-border, inter-regional and inter-provincial environmental issues: combined with preserving natural values and biodiversity, promoting economical, effective and sustainable use of natural resources...

1. OBJECTIVES OF THE PLAN

The Plan identifies the general goal of proactively preventing and controlling pollution and environmental degradation; restore and improve environmental quality; prevent decline and improve the quality of biodiversity in order to ensure the People's right to live in a clean environment on the basis of arranging and orienting reasonable spatial distribution, zoning and environmental quality management; Orientation for establishing protected areas which preserving nature and biodiversity; Forming centralized waste treatment zones at national, regional and provincial levels; Orientation for building an environmental monitoring and warning network at national and provincial levels; Sustainable socio-economic development towards green economy, circular economy, low carbon economy, in harmony with nature and environmentally friendly, proactively responding to climate change. Accordingly, specific goals are set for 4 target groups:

Regarding environmental zoning: Orientation for unified environmental zoning nationwide according to the criteria of environmentally sensitive factors vulnerable to the impacts of pollution, in order to minimize negative impacts on the life and normal development of people and creatures.

Regarding nature conservation and biodiversity: Orientation to preserving natural values, biodiversity, and natural heritage to restore and maintain natural ecosystems, preventing the trend of biodiversity loss on the basis of consolidating, expanding, establishing new and effectively managing nature reserves, biodiversity corridors, high biodiversity areas, important natural landscapes, important wetlands and conservation facilities to store, conserve and develop endemic, endangered, precious and rare genetic resources, plant and animal varieties. By 2030, increase the area of nature reserves; protect and restore important natural ecosystems, improve biodiversity quality; the total area of the protected area system nationwide is expected to reach about 6.7 million hectares. Accordingly, specific targets for nature and biodiversity conservation subjects are determined in the National Biodiversity Conservation Plan for the period 2021-2030, with a vision to 2050.

Regarding the centralized waste treatment area: Orientation to synchronously form a system of centralized waste treatment zones at national, regional and provincial levels with appropriate capacity and treatment technology, meeting the requirements of

receiving and treating the entire amount of domestic solid waste, ordinary industrial solid waste and hazardous waste generated nationwide, minimizing the amount of solid waste directly buried, classify waste at source, promote recycling and reuse of waste. By 2030, the orientation is to form at least 2 national-level centralized waste treatment zones, at least 7 regional-level centralized waste treatment zones, and at least 1 provincial-level centralized waste treatment zone in each province and centrally run city.

Regarding the environmental monitoring and warning network: Orientation to establish a national environmental quality monitoring network in inter-regional, inter-provincial, cross-border areas, focusing on monitoring in areas of important, areas with significance roles for nature conservation and socio-economic development of the country; The national environmental monitoring and warning network must be synchronous and linked with provincial environmental monitoring systems. Orientations for provinces and centrally run cities to establish local environmental quality monitoring networks, focusing on areas at risk of pollution due to socio-economic development activities; areas affected by many waste sources and important landscape, ecological and environmental areas in local management areas, in harmony and closely linked with the National environmental monitoring and warning network to effectively use environmental quality monitoring data sources across the country.

The Plan also defines a vision that by 2050, Vietnam's environment will have good quality, ensuring a healthy living environment for the people; effectively conserve biodiversity and maintain ecological balance; proactively respond to climate change; society develops in harmony with nature, the country develops sustainably in the direction of green transformation based on the development of a circular economy, green economy, and low carbon economy with the aim of bringing net emissions to zero in 2050; ensuring environmental security associated with the goal of rapid and sustainable socio-economic development.

2. SOME TASKS ON ENVIRONMENTAL PROTECTION

Minimize environmental impacts from socio-economic development activities: Implement unified environmental zoning nationwide to deploy appropriate environmental protection activities according to environmental zoning to control, prevent and minimize the impact of environmental pollution on the life and normal development of humans and organisms; Develop a roadmap to upgrade and improve waste treatment technology for production, business and service establishments according to environmental zoning; Develop a roadmap for relocation of production, business and service establishments that do not meet the environmental protection requirements of environmental zoning and environmentally safe distance from residential areas; Monitor, proactively prevent and respond to incidents of pollution of the air environment, sea water environment, inter-national, inter-regional and inter-provincial river basins.

Management of domestic solid waste, industrial solid waste, and hazardous waste: Investigate, evaluate and identify suitable areas to establish centralized waste treatment zones at national and regional levels, provincial level. Invest in the construction and completion of infrastructure of centralized waste treatment zones at national, regional and provincial levels; Invest in collection equipment, build domestic solid waste transfer stations in urban areas, expand the domestic solid waste collection service network in rural areas; Encourage rural households and individuals to take advantage of the most of food waste to make organic fertilizer and animal feed; Organize the classification of household solid waste at source, implement measures to minimize waste generation, increase reuse and recycling of waste to meet environmental protection regulations and technical requirements; reduce plastic waste and ocean plastic waste; Develop and implement measures to prevent the import of old and outdated technology which is generating a lot of waste and consuming a lot of raw materials, materials and energy; Implement regulations on responsibility for recycling and handling products, packaging, and waste of producing and importing organizations and individuals (EPR)...

Manage, improve and enhance environmental quality: Develop and implement a plan to manage surface water environmental quality for rivers and lakes. Proactively control and warn of environmental pollution of surface water in inter-national river basins; Prevent, control, overcome pollution, improve water environment quality in river basins. Focus on handling serious environmental pollution in some river basins; Preventing and controlling pollution and protecting the underground water environment in underground water prospecting and exploitation activities. Control the impact of socio-economic development activities on the groundwater environment; Prevent and control incidents that pollute the marine and ocean environment; Build a coordination mechanism between relevant countries to handle marine environmental issues...

Conservation of nature and biodiversity: Establish new, consolidate, expand and effectively manage natural heritage systems, nature reserves, biodiversity corridors, important natural landscapes, important wetlands and facilities, conservation department. Develop mechanisms and policies

to promote socialization in the establishment, management and development of nature reserves and voluntary biodiversity conservation areas; Investigate, evaluate and identify areas of high biodiversity, important natural landscapes, and important wetlands; Provide guidance on implementing effective biodiversity conservation measures in these areas; Develop regulations and guidelines for environmental protection of natural heritage, biodiversity compensation, and investment policies for natural heritage and nature reserves; Assess and evaluate biodiversity value; Continue to effectively deploy the payment mechanism for natural ecosystem services; Expand payments for ecosystem services for mangrove forests, wetlands, rocky mountains, caves, geoparks...

Promoting sustainable growth models: Transforming growth models based on increased productivity, scientific and technological progress, innovation, and digital transformation; effectively use resources, aiming to achieve the dual goal of economic growth, while reducing pollution, environmental degradation and reducing net emissions to "zero" by 2050; Developing industry in an environmentally friendly direction; Greening industrial production and promoting the development of green industries, high-tech industries, and ecological industrial parks; Developing ecological agriculture, high-tech agriculture, and organic agriculture; increase reuse of agricultural by-products; Limit and control the use of inorganic fertilizers, plant protection chemicals and antibiotics in farming, animal husbandry and aquaculture; Implement sustainable urbanization, urban development associated with technical infrastructure development for environmental protection; Focus on developing green cities, ecological cities, smart cities, adapting to climate change...

3. SOLUTIONS FOR ORGANIZING AND SUPERVISING THE IMPLEMENTATION OF THE PLAN

Strengthen propaganda and raise public awareness: Disseminate and raise awareness of all levels and sectors on strengthening resource management and environmental protection. Gradually change the awareness and thinking of all levels and sectors about the role of environmental protection in socio-economic development; Disseminate and propagate the contents of the National Environmental Protection Plan to socio-political organizations, residential communities, enterprises, production, business and service establishments. Promoting the sense of compliance with the law, performing well the environmental social responsibility of businesses, the responsibility of recycling products, packaging, and waste treatment of manufacturing and importing organizations and individuals. Raise awareness and understanding of circular economy, green economy, low carbon economy; Encourage businesses to implement voluntary environmental standards and commitments...

Improve mechanisms, policies and legal systems on environmental protection: Review, amend and supplement administrative sanctions in the direction of increasing fines. Develop and promulgate regulations and technical regulations on wastewater and exhaust gases in accordance with the protection requirements of environmental zoning. Review, develop and promulgate regulations on environmental protection for areas with environmentally sensitive factors, such as natural heritage areas, nature reserves, biodiversity corridors, areas of high biodiversity, important natural landscapes, important wetlands, historical and cultural relics ranked according to regulations, surface water sources used for domestic water supply. Develop technical and economic norms for pollution treatment, renovation and environmental restoration of landfills; Develop technical guidelines for renovating polluting waste landfills...

▲ *Conservation of nature and biodiversity is one of the important goals of the National Environmental Protection Plan for the period 2021-2030, with a vision to 2050*

Improve organizational structure and promote reform of administrative procedures in environmental protection: Continue to strengthen the organizational apparatus of the system of environmental management agencies from central to local levels to ensure consistency, professionalism, effective and efficient operation. Promote decentralization and increase the responsibility of local governments for environmental protection; At the same time, strengthen the capacity of provincial, district and commune level governments; Strengthen links and coordination between socio-economic regions and localities in environmental protection. Promote reform and simplify environmental administrative procedures in the direction of improving the effectiveness and efficiency of state management, while minimizing legal risks and compliance costs for people and businesses...

Strengthen the implementation of policies and laws on environmental protection: Strengthen inspection and supervision of production and business establishments with high risk of causing environmental pollution; Apply the mechanism of unexpected inspection when there are signs of violations. Promote effective coordination between state environmental management agencies, inspection agencies and people's police units with functions and tasks to prevent and combat environmental crimes. Strengthen the provision, publicity, and transparency of information in environmental management to the community, while improving the accountability of environmental management officials at all levels. Strengthen the supervision of residential communities, the Vietnam Fatherland Front, organizations, individuals and media agencies on environmental protection; Developing and applying digital platforms, social networks, hotlines... to promote environmental monitoring ...

Increase financial investment: Review, amend and improve mechanisms and policies to mobilize investment from non-budget sources for environmental protection, and regulations on bidding for public environmental services. Deploy public-private partnerships (PPP) in the collection, transportation, and treatment of domestic solid waste and domestic waste water. Mobilizing investment from domestic and international socialization, properly arranging state budget, improving efficiency in using resources for environmental protection; Prioritize strengthening management capacity and solving key and urgent environmental issues. Arrange the state budget to increase gradually in each period, in accordance with the requirements and tasks of environmental protection and budget capacity; Review and research to restructure budget spending tasks for environmental protection in a focused and key direction at the same time improving efficiency of budget use...

Application of science and technology, innovation, digital transformation; Building technical infrastructure, monitoring network and environmental database: Encourage the application of clean technology, economical and efficient use of raw materials, fuel and energy. Promote innovation and digital transformation; improving, converting technology, applying best available techniques (BAT), high technology in industries and fields to protect the environment, conserve nature and biodiversity. Applying

▲ *Building a monitoring network to ensure consistency across the country, meeting the need for environmental information and data for environmental management*

scientific and technological achievements, the fourth industrial revolution, digital transformation, information technology, remote sensing technology and modern technology in management, monitoring, supervision and surveillance environmental newspaper; Promote the provision of online public services for environmental administrative procedures. Promote the application of solid waste treatment technologies, prioritizing advanced, modern and environmentally friendly technologies, energy recovery, reuse, recycling and treatment of solid waste and hazardous waste in a synchronous and effective manner, without causing environmental pollution, reducing the amount of solid waste treated by direct landfill.

International cooperation on environmental protection: Actively participate in negotiations and shape international commitments on environmental issues, climate change, biodiversity, and plastic waste; Organize the implementation of international treaties and international commitments in the field of environment of which Vietnam is a member; Promote the implementation of cooperation agreements, technical assistance, capacity building, technology transfer and international projects on environmental protection. Strengthen and advocate for cooperation with bilateral and multilateral partners, international financial institutions, international organizations... to support resources (financial, technical, technological, capacity) to implement COP26, sustainable development goals and green transition.

With the above goals, tasks, and solutions, the National Environmental Protection Plan for the period 2021-2030, with a vision toward 2050, includes the main contents to contribute to the implementation of the National Strategy on Environmental Protection to 2030, vision to 2050 and the Law on Environmental Protection in 2020. At the same time, the Plan also includes content on orientation of spatial distribution, zoning, environmental quality management, and conservation of nature and biodiversity, waste management, environmental monitoring and warning in defined territories to protect the environment, serving the country's sustainable development goals for a specified period as prescribed in the Law on Environmental Protection 2020 ■

In the context of plastic pollution becoming increasingly serious and becoming one of the global environmental crises, in 2022, United Nations member countries agreed to negotiate to develop a binding legal instrument to end plastic pollution. The fourth conference of the Intergovernmental Negotiating Committee to develop an international legally binding instrument (the Agreement) on plastic pollution (INC-4 Conference) took place from April 21st to 30th, 2024 in Ottawa, Canada, following the previous Conferences. INC-1 in 2022 and INC-2 and INC-3 in 2023, where a number of important outcomes were achieved towards concluding negotiations and possibly adopting a global agreement on plastic pollution by the end of 2024 to respond to the above crisis.

SOME IMPORTANT NEGOTIATION CONTENTS AND RESULTS

The INC-4 Conference marked the first time countries officially negotiated on the basis of revised draft No.0 of the Agreement with the following contents: managing plastic products along the entire life cycle of plastic; financial mechanisms and capacity building, technology transfer; national plan, implementation and compliance, progress report, evaluation, periodic progress monitoring, international cooperation, information exchange, awareness raising, stakeholder participation... The discussion focuses on the following issues:

Regarding primary polymer plastics: This is a controversial issue and shows a large division in the views of countries. Some petroleum oil producing countries such as Russia, China, India, Saudi Arabia, Kuwati, Malaysia, Kazastan... (about 20 countries) proposed not to stipulate this content in the Agreement. While in the meantime, developed countries proposed to include mandatory regulations on primary polymer plastics in the Agreement and called for measures to control the production and consumption of sustainable plastics throughout the life cycle of plastics. Vietnam also supports not including regulations on primary plastic management in the document and suggests compliance must be carried out according to each country's capacity.

Chemicals and polymers of concern: Developed countries propose globally binding provisions (as opposed to nationally determined measures) to control or regulate the use of chemicals, group of chemicals and polymers, through the list set out in the annexes and implemented through domestic measures and reflected in national plans. A group of countries proposed to include two lists in an annex, which would differentiate between chemicals in plastics that should be banned or removed and those that should be avoided and minimized, and propose criteria for identifying chemicals of concern.

Regarding the issue of microplastics: This is also an issue on which countries have many different views. Many countries such as India, countries of European Unions, United Arab Emirates, South Korea, and Thailand believe that this content has been mentioned in other sections such as plastic emissions, removal and suggest not regulating it. This content

Negotiation results at the Fourth Conference on global agreement on plastic pollution

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is in the Agreement. A group of countries including Kenya and the Philippines proposed asking the parties to "take effective measures to promote research on the scale and scope of leakage of micro-plastics and nanoplastics throughout the entire life cycle of plastics and their impacts on all ecosystems, biodiversity, food chains, and human health", and proposes measures to promote transparency and reduce emissions of intentionally added microplastics and unintentionally released microplastics; establish regional centers to monitor and report on microplastic leakage and dispersion, and establish a dedicated fund to provide resources to promote research on this issue.

▲ *Overview of the INC-4 Conference held in Ottawa, Canada*

Extended producer responsibility (EPR): The INC-4 Conference discussed 3 options: (1) there is no regulation on this issue in the Agreement's documents; (2) encourage application according to each country's conditions; (3) Member States should ensure all producers are part of the EPR scheme. Basically, countries support the introduction of EPR to reduce plastic pollution, in which developed countries (USA, Norway...) propose to establish a binding EPR mechanism with a common set of rules for uniform application. Countries such as Russia, China, India, Thailand, Korea, Malaysia or other countries that are developing or have not applied the EPR mechanism... suggest to establish an EPR mechanism to implement producer responsibility for its products, but it needs to be implemented flexibly, based on the circumstances and capacity of each country; some countries support voluntary EPR programs or explicitly remove the EPR provisions.

The INC-4 Conference drafted the EPR into 02 options: (1) no regulations on this issue; (2) each member is required or encouraged to establish an EPR implementation program/system. Currently, member countries have added necessary and specific contents and groups of issues on reducing, reusing, recycling and treating plastic waste, preventing and combating plastic waste pollution, and the process of plastic waste. Fair transition, traceability, accountability, enhanced regional and global cooperation in implementing EPR programs for further discussion and completion at the next INC-5 Conference.

Emission and disposal of plastic during the life cycle of plastic: In draft No.0, the content of plastic emission and disposal according to the life cycle offers 05 options, including: (1) member countries need to implement the following measures: to prevent and control plastic emissions, prevent the emission and disposal of plastic products along the life cycle; (2) Member States shall prevent and eliminate the release and disposal of plastic polymers, plastics, including microplastics and plastic products throughout their life cycle into the environment from sources identified in the Annex E; (3) Member States should take the necessary measures to regulate the emission and disposal of plastics, including microplastics, throughout their environmental life cycle as determined by national plans and based on circumstances and capabilities of the country; (4) Member States must take measures to prevent and control the release and disposal of plastic and microplastic waste into the environment from sources identified in Annex E; (5) Member States must manage and eliminate the loss and disposal of plastic products and product waste, including microplastic waste into the environment.

At the INC-4 Conference, basically the majority of countries, including the European Union, the United Kingdom, Samoa, Sri Lanka,... achieved high consensus on waste management content in the waste management plan in a strict direction from source to treatment; Unify the implementation of integrated waste management according to existing conventions and treaties (Basel Convention, Rotterdam). Developing countries emphasize the importance of financial and technological support based on the principle of common but differentiated responsibilities. They specifically recommend prioritizing nationally determined voluntary measures outlined in the national plan; recommend controlling cross-border transport of plastic waste, noting the challenge posed by importing waste from other countries. Developed countries recommend measures across the plastic life cycle and value chain, developing a waste hierarchy.

At the end of the negotiation session, the content of emissions and disposal in the plastic life cycle was reduced into two proposed options for further discussion at the next meeting including: (1) Member States, depending on their national plans and based on their national circumstances and capacities, need to take measures to regulate, prevent, minimize, and eventually eliminate plastic emissions and plastic waste, including microplastics, into the environment throughout the plastic life cycle; (2) Member countries, according to national plans and based on circumstances and national capacity, should encourage or should take measures to regulate, prevent, reduce, and eventually eliminate plastic emissions and waste. Both of these options are still being discussed to add necessary content and groups of issues and be discussed in the next INC5 sessions.

Plastic waste management: In Draft No. 0, the content of plastic management has 04 options including: (1) member countries will implement effective measures to ensure plastic waste is safely managed and environmentally friendly in different stages of the life cycle. The measures taken to implement this provision shall be reflected in national plans to achieve nationally determined targets and minimum requirements based on harmonized indicators as set out in Part II, Annex F; (2) Member States shall implement safeguard measures for the environmentally sound management of plastic waste. Measures taken to implement this provision are encouraged to be reflected in national plans, aiming at achieving nationally determined targets and minimum requirements that have been developed basing on harmonized indicators as set out in Part II, Annex F; (3) Each Party should take effective measures to meet existing best practices for the safe and environmentally friendly collection, recycling and disposal of the minimum level, taking into account the relevant guidance, available waste management infrastructure and national priorities; (4) Each Party, in accordance with its national plan and based on national circumstances, capabilities and relevant national regulations, shall implement safe and environmentally sound waste management measures with the environment. Measures taken to implement this provision shall be reflected in the national plan.

At the INC-4 Conference, basically, most countries had high consensus on the content of waste management in the plan: strict waste management from source to treatment; Unify the implementation of integrated waste management according to existing conventions and treaties (Basel Convention, Rotterdam). For the group of developing countries, it is emphasized the importance of improving infrastructure, including financial and technological support on the basis of common but differentiated responsibilities; In particular, it is recommended that priority should be given to nationally determined voluntary measures outlined in the national plan. These countries also recommended controls on cross-border transport of plastic waste, noting the challenge posed by importing waste from other countries. Developed countries are calling for solutions throughout the plastic life cycle and value chain, developing a waste hierarchy.

Fishing gear management: In draft No. 0, the content of fishing gear management is a content in the plastic waste management section (section b, part II.9) with 3 options including: (1) no content regulations on this issue; (2) Member countries, according to their national plans and based on national circumstances and capabilities, must take or encourage the implementation of appropriate measures in terms of design, marking, tracing, and trace to prevent, reduce and eliminate lost, forgotten or discarded fishing gear at sea. The measures taken to implement this provision shall be reflected in the national plan; (3) Member States, depending on their circumstances and national capacities, should cooperate to take appropriate, effective measures for the disposal of fishing gear.

At the negotiation session, this content is still being discussed and there are still many conflicts because the exact content of fishing gear and scope of management has not been determined. Some countries state that fishing gear is not waste and is just lost tool. Many developed countries recommend strict management from the beginning of the watershed using a life cycle approach, labeling and tracing fishing gear. Developing countries such as Indonesia and Malaysia believe that life cycle management of fishing gear is very challenging and requires capacity building and guidance and support to be able to implement it. Some countries propose to move the content of fishing gear from the waste management section to the emissions section.

At the end of the negotiation session, the content of fishing gear management was separated into a separate section in the issues of obligations with 2 options continued to be proposed for discussion at the next session, including: (1) no regulation making fishing gear management a main content of core obligations; (2) Member States shall, according to their national plans and national circumstances and capabilities, take or encourage the implementation of appropriate measures for design, marking, tracing, and trace to prevent, reduce and eliminate lost, forgotten or discarded fishing gear at sea. Currently, necessary content and groups of issues have been added to this plan for further discussion and completion at the next INC-5 Conference.

Financing: Many developing countries in South America and small island states support the establishment of a new, specialized financing mechanism (e.g. Plastic Pollution Fund) to support developing countries. Meanwhile, developed countries such as the United States, Canada, Japan, European Union, Switzerland, United Kingdom...) want to take advantage of current financial mechanisms such as ADB, World Bank, Global Environment Facility... ensures effectiveness and can be put into operation immediately to solve the currently relatively urgent problem of plastic pollution globally; Establishing a new fund does not guarantee additional budget resources. Although Vietnam, Indonesia and a number of other Asian countries support a new fund, they also believe that they should still take advantage of current financial mechanisms (including the GEF that is operating effectively), utilize existing administrative apparatus and financial resources to maximize resources, pending the establishment of a new mechanism.

Finance section also addresses the establishment of global plastic pollution charging methods, which would require polymer manufacturers to take responsibility for the pollution costs of all the plastic they produce. This fee can be used to fund environmentally friendly waste management and cleaning initiatives. The European Union supports the pollution fee plan. Many developing countries proposed not to stipulate this type of fee in the Agreement because many countries have regulated EPR and collecting plastic pollution fees would cause double payment, which may create investment barriers for businesses.

Capacity building, technical support and technology transfer: developing countries propose to have separate chapters on this content, ensuring developed countries support capacity building, technology and transfer technology in solving plastic waste and in research to have specific, feasible solutions suitable to real conditions. Meanwhile, developed countries only want shortened content. Some countries proposed adding specific mechanisms and policies for capacity building, technical support and sustainable and effective technology transfer, with an emphasis on promoting innovation in the entire process of development, transfer, dissemination and especially access to new, environmentally friendly techniques and technologies. Some countries suggested emphasizing capacity building, technical assistance and technology transfer; clarify the need for coordination and cooperation with multilateral environmental agreements and other related initiatives to ensure effectiveness.

VIETNAM'S PARTICIPATION AND SOME KEY ISSUES

Vietnam has actively participated in discussion sessions according to Contact Groups and Sub-groups with a proactive and responsible spirit in the process of developing the draft Agreement in the spirit of closely following the Vietnamese viewpoints, guidelines, policies, laws, and international environmental treaties to which Vietnam is a member, in accordance with the conditions and level of socio-economic development of the country, strengthen mobilization and attraction of financial and technological resources to implement the Agreement.

During the discussion, the Delegation focused on the approved contents in the Negotiation Project related to supporting the life cycle approach of plastics on the basis of cooperation and sharing of benefits and obligations between Member States, placing national interests together with the goals of environmental protection and minimizing and ending plastic pollution, emphasize the importance of considering mandatory obligations to take into account the conditions and circumstances of each country, support the principles and viewpoints of countries with equivalent conditions in the region, propose technological and financial support and prioritize the implementation of mitigation towards ending plastic pollution according to the roadmap for developing countries; coordinate with the Philippines to include the content of responsibility for protecting the marine environment under the United Nations Convention on the Law of the Sea (UNCLOS 1982) in the Preamble of the draft Agreement.

To prepare for participating in negotiations at the INC-5 Conference and related events, in the coming time, Vietnam needs to implement a number of contents:

The current negotiation process has entered into the substance of the Agreement, therefore, the Ministry of Natural Resources and Environment, Ministries and branches participating in the Negotiation Working Committee need to carefully prepare negotiation plans, including: viewpoints, high options, options and acceptable limits to discuss at the upcoming negotiation sessions, while continuing to protect the options stated at the INC-4 Conference.

Relevant ministries and branches need to allocate enough resources to carry out assigned tasks; Responsible for negotiation contents in areas under management authority; Directly participate in negotiation sessions and technical meetings within the framework of the Agreement negotiations.

Send experts and members of the negotiating team to attend the meeting of 02 groups of technical experts to discuss, monitor and even participate in informal negotiations at this meeting.

Regarding procedures for concluding negotiations, the INC-5 Conference is the final negotiation conference for member countries to negotiate and develop the Agreement, therefore, the procedures are according to the provisions of the 2016 Law on International Treaties, the lead agency, the Ministry of Natural Resources and Environment, needs to coordinate with ministries and branches to develop a plan to end the negotiations and submit it to the Prime Minister according to regulations before the INC-5 Conference and the member ministries of the Negotiation Working Group need to provide relevant content to prepare for the conclusion of the negotiations.

Regarding issues of concern, it is necessary to take policy impact assessments as soon as possible based on trend forecasts, especially for new contents such as: 40x40 target, plastic pollution fee.

Mobilizing the participation of relevant parties, at the INC-4 Conference, a number of negotiating delegations, in addition to the participation of Government agencies, also had the participation of experts and consultants representing Relevant associations in the plastic industry, research institutes, independent legal consultants for the negotiating team (such as Malaysia, Chile, China, Philippines...). Vietnam can also consider adding representatives from these aforementioned insitutes/organisations to advise on related contents for the negotiating team.

Continue to organize consultations with relevant parties through technical workshops on the contents to be discussed at expert group meetings in Bangkok, Thailand, from August 24th – 28th, 2024; It is necessary to propose the main contents of the Agreement on the basis of the draft Comprehensive Agreement announced by the Intergovernmental Negotiation Committee in July 2024.

Step by step communicate the negotiation process and the content of the draft Global Agreement to people and businesses to gradually raise awareness of the serious impact caused by plastic pollution and change behavior from production to consumption and responsible disposal of plastic products, avoiding environmental pollution.

Strengthen international cooperation to assess the current situation of plastic pollution, promote plastic circulation models, and manage and treat plastic waste ■

Dong Nai river basin is the third largest river basin in the country, after the Mekong and Red - Thai Binh river systems, with water resources accounting for about 5.5% of the country's total water resources. Dong Nai river basin has a natural area of 36,530 km^2, within the administrative boundaries of 10 provinces and cities: Dong Nai, Binh Duong, Binh Phuoc, Tay Ninh, Ba Ria - Vung Tau, Dak Nong, Lam Dong, Long An, Binh Thuan provinces and Ho Chi Minh City. Dong Nai river basin is considered having great values, the most prominent of which is the value of water resources, the main source of supply for economic development activities, people's livelihood and regulating the climate of the whole region. This is one of 13 river basins in Viet Nam that must develop a general master plan for the river basin.

1. CHALLENGES FOR WATER RESOURCES IN THE DONG NAI RIVER BASIN

Water resources in the Dong Nai river basin are exploited and used to meet the purposes of domestic water use, agricultural and industrial production, electricity generation, thereby annually contributing about 35.2% of the country's GDP. Thanks to the abundant water resources, the river basin has additional values such as: forest resources, mineral resources, fisheries, hydroelectricity, eco-tourism... There are currently values that have been and are being exploited effectively, contributing to local socio-economic development. However, in recent years, water resources in the Dong Nai river basin are facing many challenges due to pressure on water exploitation and use, sharp decline in water amount in the dry season, water pollution, salinity intrusion and impacts of climate change, specifically:

(i) Water resources in the planned area are unevenly distributed in space and time. The total amount of water in the planned area is about 56.73 billion m^3 (including surface water about 46.13 billion m^3, underground water about 10.6 billion m^3). Of which, the total amount of surface water in the flood season accounts for about 78% and in the dry season accounts for about 22% of the total annual flow. The average amount of water per capita in the dry season is about 797 m^3/person, but access to water sources in many areas is still difficult, especially in high mountainous areas, remote areas and areas affected by saltwater intrusion, leading to local water shortages in some areas during the dry season.

(ii) There is no general master plan for the Dong Nai river basin, while the general master plan for river basins is one of the foundations for formulating and implementing sectoral master plans for exploiting and using water resources. On the other hand, a number of sectoral and local master plans for exploiting and using water resources have been and are being

Master plan for the Dong Nai river basin in the 2021-2030 period, with a vision to 2050

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implemented such as: irrigation master plan, rural water supply master plan, urban water supply master plan... However, these master plans are still single-sectoral, mainly focusing on the goal of exploiting and using water resources without considering the overall allocation of water resources among sectors in different conditions of water sources, without mentioning the issue of integrated management of water resources on the basis of protecting water resources, protecting the ecological environment, preventing and controlling harmful effects caused by water.

(iii) Strong socio-economic development, rapid urbanization and expanded industrial production activities of localities in the planned area have increased the demand for water use. In addition, activities of discharging wastewater into water sources, especially types of wastewater that are not treated in accordance with technical regulations have been impacting and putting increasing pressure on the quantity and quality of water sources of rivers, streams, canals, as well as aquifers in the planned area, especially in Dong Nai, Binh Duong, Ba Ria - Vung Tau provinces and Ho Chi Minh City. On the other hand, the exploitation and use of water without general master plan for water resources, without regulation on functions of water sources, without regulation on minimum flow... have caused water resources to become increasingly seriously degraded, causing risk of insecurity for water sources in such areas.

(iv) Dong Nai river basin is one of river basins strongly affected by climate change, in which water resources will be affected the most and soonest due to unusual developments in rainfall and sea level rise. This fluctuation causes extreme hydrological phenomena such as saltwater intrusion, floods, and droughts that change flow regimes in both the rainy season and dry season. Climate change also affects the balance of water resources, making the uneven distribution of water resources between the dry season and rainy season increasingly serious. As a result, saltwater intrusion, floods and droughts appear with increasing frequency and severity, and this phenomenon has appeared more clearly in recent years, seriously affecting water resources, typical example is the historic drought phenomenon in the dry season of 2016, its consequence is that the flow of most rivers and streams in the planned area has seriously decreased, many places have reached record low levels, leading to drought, saltwater intrusion, water shortage, including domestic water in many areas.

(v) Wasteful and ineffective exploitation and use of water resources is still happening. The rate of water loss in urban and rural water supply is still high (about over 20%), the actual water exploitation capacity is much lower than the designed capacity, especially water exploitation capacity in agriculture is only at 70 to 80% of the designed construction capacity...

From above challenges, in order to manage, improve efficiency in using, restoring, minimizing degradation, pollution and depletion of water sources and adapt to climate change for national water resources in general, Dong Nai river basin in particular, on 8 January 2024, the Prime Minister issued Decision No. 22/QĐ-TTg approving the General master plan for the Dong Nai river basin in the 2021-2030 period, with a vision to 2050. The master plan specifically stipulates goals, solutions, functions of water sources and management, regulation and distribution of water sources, contributing to ensuring security for water sources for the exploitation, use purposes and socio-economic development goals in planned area; develops solutions and stipulates specific responsibilities for each relevant Ministry and local authority to organize the implementation of the master plan to ensure effectiveness.

2. ENSURE SECURITY FOR WATER SOURCES ON THE RIVER BASIN AND THE ENTIRE PLANNED AREA

The integrated master plan for the Dong Nai river basin in the 2021-2030 period, with a vision to 2050 has a planning scope including the area of Dong Nai river basin within the administrative boundaries of Ho Chi Minh City and Dong Nai, Binh Duong, Binh Phuoc, Tay Ninh, Ba Ria - Vung Tau, Dak Nong, Lam Dong provinces (excluding a part of the area of Long An province belonging to the General master plan for the Mekong river basin) and a part of the area of Ninh Thuan and Binh Thuan provinces which is the area receiving water from Dong Nai river basin, divided into 6 planned sub-areas including: Dong Nai river upstream; Dong Nai river downstream; Sai Gon river - Vam Co river upstream; Be river; La Nga river and coastal surroundings.

The Master plan was issued based on the viewpoints that water resources are managed in an integrated manner according to river basins, consistent in quantity and quality, between surface water and underground water, between upstream and downstream, inter-

regions and between localities in the same basin, ensuring compliance with master plans of the provinces and provisions of international treaties and bilateral cooperation in which Viet Nam participates. At the same time, the Master plan for the river basin is developed on the basis of taking water resources as the core factor, identifying climate change and sea level rise as inevitable trends that must be lived with and proactively adapted to...; storing, regulating, and distributing water sources flexibly, respecting natural laws and in accordance with the capacity of water sources. Use water economically, effectively for multiple purposes, improve water use values, ensure security for water sources and adapt to climate change; ensure reasonable exploitation and use, and harmonious sharing of water sources among sectors and localities in the basin and some localities with difficulties in water sources in the South-Central coastal region (Ninh Thuan and Binh Thuan). Protect water resources on the basis of protecting functions of water sources to meet water quality requirements for purposes of use, protect aquatic resources and prevent, control and remedy consequences and harmful effects caused by water with the motto "Proactive prevention is key to minimizing losses, stabilizing social security, and maintaining national defence and security".

The overall goal of the Master plan is to ensure security for water sources on the river basin and the entire planned area; store, regulate and distribute water resources in a fair and reasonable manner; exploit and use water sources economically and effectively in association with the protection and sustainable development of water resources to meet water needs for people's livelihood, socio-economic development; ensure national defence and security, environmental protection, conservation of ecosystem, vegetation cover and biodiversity; protect water resources, prevent degradation, depletion, pollution of water sources and harmful effects caused by water; have a roadmap to restore degraded, depleted, and polluted water sources, meeting the requirements of integrated management of water resources according to river basins and adapting to climate change; gradually implement the national digital transformation goal on the basis of building and operating a water resources information and data system, ensuring connection with the natural resources and environment information system, sectors that exploit and use water.

The Master plan sets the goal of striving to 2030 as to achieve a number of basic targets such as: 100% of inter-provincial water sources having their wastewater receiving capacity and load-bearing capacity are announced; 80% of works exploiting and using water are monitored for operation and system connection according to regulations; 70% of lakes, ponds, canals having regulating functions and having high values of biodiversity, history, culture, and beliefs not filled are announced, managed and protected; complete the establishment and announcement of protection corridors for water sources, ensure flow circulation, prevent bank and riverbank erosion, and minimize harmful effects caused by water; 100% of industrial parks and export processing zones have centralized wastewater treatment systems that wastewater is treated to meet technical standards according to regulations before being discharged into water sources; 40% to 45% of wastewater in urban areas of type II and higher and 25% to 30% of wastewater in urban areas of type V and higher are collected and treated to meet technical standards according to regulations before being discharged into water sources.

Vision to 2050, maintain and develop water resources, regulate and distribute water sources to ensure security for water sources, adapt to climate change in accordance with international treaties and bilateral, multilateral cooperation related to water resources that Viet Nam has participated in; restore areas with excessive groundwater level decline, degraded, depleted, and seriously polluted rivers, canals; effectively prevent and control landslides of river banks, canals, and ditches, control river bottom elevation, sand and gravel exploitation on river beds; redeploy riverside residents with other measures to gradually enhance the value of riverside landscape; supplement and improve a number of targets of the Master plan, implement integrated management of water resources in accordance with the country's development stage, on par with developed countries in the region; ensure security for water sources, improve water use values in accordance with the world's general development trends.

Main contents of the Master plan

Functions of water sources: Water sources in the planned area have one or more basic functions such as water supply for living, business, and services; water supply for agricultural and aquacultural production; water supply for industrial production; water supply for hydropower and tourism; water transportation; creation of landscape and environment; protection and conservation of aquatic ecosystems and biodiversity; storage, flood drainage and water drainage. Functions of water sources are determined on the basis of distribution characteristics of water sources, current status, goals of water use and socio-economic development master plans and plans. Functions of water sources are determined for each period (to 2030 and vision to 2050); periodically review and adjust functions of water sources to suit the actual situation of each water source and the need to use water sources for socio-economic development.

Management, regulation and distribution of water sources contribute to ensuring security for water sources for exploitation, use purposes and socio-economic development goals in the planned area: Distribution of surface and underground water sources that can be exploited and used under normal conditions in the planned area from 36,088 million m^3 (corresponding to frequency of 85%) to about 46,134 million m^3 (corresponding to frequency of 50%) contributes to ensuring security for water sources, meeting the need for water exploitation and use by 2030 of about 12,169 million m^3 within the planned area...

Under normal conditions, People's Committees of provinces and centrally-run cities shall proactively regulate and distribute water resources to ensure compliance with inter-reservoir operating procedures issued by competent authorities, in accordance with the detailed plan for regulating, distributing, exploiting, using water for areas using water with high economic efficiency (for the Dong Nai river downstream sub-region) and coastal sub-region (Ninh Thuan and Binh Thuan), detailed plan for regulating, distributing, exploiting, using water and preventing, controlling and remedying harmful effects caused by water (for the Sai Gon river sub-region - Vam Co river upstream), appropriate with legal regulations on water resources.

Every year, the MONRE presides and coordinates with line ministries, ministerial-level agencies and Provincial People's Committees to develop and announce scenarios for water sources (for the whole year and updated at the beginning of the dry season) based on the current status and forecasting trends in rainfall, trends in surface water and underground water sources, and the amount of water stored in reservoirs during different periods of the year. Line ministries, ministerial-level agencies and Provincial People's Committees proactively direct and guide the organization for implementation of appropriate water exploitation and use, ensuring priority for water for daily life and other activities using water economically, effectively, harmonizing benefits between planned sub-areas...

Management of exploitation and use of surface water sources to ensure minimum flow on rivers: The exploitation and use of water sources on rivers, streams and canals must ensure the minimum flow value announced by the MONRE specified in Appendix VI attached to this Decision. In case of implementing socio-economic development activities that require adjusting the minimum flow value, based on actual conditions and characteristics of water sources, the Provincial People's Committee shall submit to the competent authority for consideration and decision in accordance with the provisions of legislations on water resources.

In addition, the Master plan also specifically stipulates contents such as: Backup water sources for domestic use in areas at risk of water pollution; dams, reservoirs, works for water regulation and storage, development of water sources; protection of water resources; prevention and control of landslides in rivers and lakes; prevention and control of floods, land subsidence and saline intrusion of underground water; monitoring of water resources, exploitation and use of water...

3. SOLUTIONS TO IMPLEMENT THE MASTER PLAN

Firstly, continue to implement legal and policy solutions proposed according to the Master plan for water resources in the 2021-2030 period, with a vision to 2050, research and supplement special policies (if any) for this planned area.

Secondly, regulate, distribute, develop and protect water resources, use water economically and effectively, reuse water to contribute to ensuring security for water sources. Accordingly, implement specific con-

▲ *General master plan for the Dong Nai river basin to ensure security for water sources and improve water use values*

tents: Build and operate information systems, digital models, and decision supporting tool systems; develop and announce scenarios for water sources; prioritize detailed planning for regulation, distribution, exploitation, use and protection of water resources in areas where water shortages often occur; complete the meteorological, hydrological and water resources monitoring system on Dong Nai river basin; provide trainings and improve the quality of human resources to ensure synchronous and effective management and operation of the system; control water exploitation and use activities on Dong Nai river basin through connecting and transmitting information and data to the water exploitation and use monitoring system according to regulations...

Thirdly, prevent, control and remedy consequences and harmful effects caused by water: Research and implement solutions to handle landslides on the main stream of Dong Nai river in Binh Phuoc, Binh Duong, Lam Dong, Dong Nai, Ba Ria - Vung Tau provinces and Ho Chi Minh City. Research on measures for works to prevent and control landslides in urban areas and concentrated residential areas, including: Dong Xoai City (Binh Phuoc Province); Bac Tan Uyen District and Tan Uyen City (Binh Duong Province); District 12, Binh Thanh District, Can Gio District, Cu Chi District (Ho Chi Minh City)...; develop a map to zone land surface subsidence, build and put into operation a monitoring system to monitor subsidence developments in some areas at risk of land surface subsidence, high levels of subsidence, assess and determine causes of land surface subsidence as a basis for ministries, sectors and local authorities to implement appropriate response solutions as in the area of Ho Chi Minh City; develop a flood map for the entire basin based on the application of modern technology and techniques...

Fourthly, strengthen science, technology and international cooperation: Apply advanced, modern, smart science, techniques and technology in monitoring, forecasting, warning, supervising and using circulating water, saving and reusing water, managing and protecting water sources, developing water sources, connecting water sources; strengthen international cooperation in exchanging, providing information, researching and transferring science on water resources, technology for using circulating water, saving and reusing water; apply science and technology, organize the building and operation of specialized hydro-meteorological monitoring networks, synchronously invest in technical infrastructure solutions to ensure meeting inter-reservoir operating requirements to regulate, operate reservoirs in real time, effectively exploit water resources ■

The Land Law officially takes effect on August 1st, 2024. Its implementation is brought forward by five months compared to the original plan to quickly realize new policies and initiatives, create breakthroughs in land administration. This breakthrough aims to the comprehensive reform of many regulations, from compensation and support to resettlement and land valuation; from maximizing the potential of agricultural land to leveraging the advantages of various types of land use; from streamlining administrative reforms to harmonizing the interests of different land users…

1. ENSURING THE RIGHTS OF LAND-EXPROPRIATED INDIVIDUALS

Institutionalizing the Party's policy in Resolution 18, the Land Law 2024 has inherited regulations proven to be appropriate in practice while also amending and supplementing many new provisions to better protect the legitimate rights of people, especially in cases of land acquisition. This contributes to reducing and more effectively addressing land-related complaints, such as diversifying compensation forms and adding various support measures for those affected by land acquisition.

Specifically, the law stipulates the principle of compensation by diversifying forms of land compensation. Households and individuals whose land is acquired can be compensated with land of the same purpose as the acquired land, or with money, other land, or housing, in accordance with the needs of the affected landowners and the land fund of each locality.

In addition, the law specifies the principle of "having housing, ensuring income, and living conditions equal to or better than the previous residence" through regulations on the criteria for resettlement areas regarding technical infrastructure, social infrastructure, and the location of resettlement implementation… The resettlement area can be designated for one or more projects. When the State acquires land and the remaining area of the land parcel after acquisition is smaller than the minimum area, if the land user agrees to the acquisition, the competent People's Committee will decide on the land acquisition and carry out compensation, support, and management of this land area according to legal regulations.

At the same time, the law specifies and expands the composition of the Compensation, Support, and Resettlement Council to include representatives from the People's Council, the Vietnam Fatherland Front at the same level, and representatives of land users whose land is being acquired. This aims to ensure objectivity, transparency, and the participation of relevant parties in the compensation, support, and resettlement processes.

Additionally, attention is given to social policy beneficiaries and individuals directly involved in agricultural production. The steps for compensation, support, resettlement, and land acquisition ensure the

The Land Law 2024 drives socio - economic development in the new era

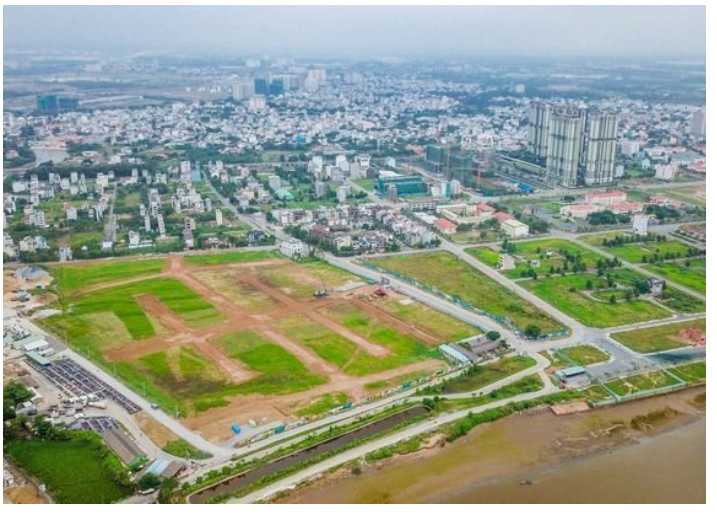
HOÀNG NHẤT THỐNG
Ministry of Natural Resources and Environment

participation of people at various stages, adhering to the principle that those whose land is expropriated receive compensation and resettlement before the land is taken… This ensures that affected individuals have housing and a standard of living equal to or better than before. The law also considers property owners who are not simultaneously land users, ensuring they are informed when the State acquires land.

To provide specific guidance on these regulations, on July 15th, 2024, the Government issued Decree No.88/2024/ND-CP stipulating compensation, support, and resettlement when the State acquires land.

Accordingly, Decree No. 88 stipulates compensation with land for a different purpose than the type of land acquired or with housing when the State acquires land, as specified in Clause 1 of Article 96, Clause 1 of Article 98, and Clause 1 of Article 99 of the Land Law as follows: The land price used for compensation with land of a different purpose for households, individuals, and overseas Vietnamese currently using residential land and owning housing attached to land use rights in Vietnam is determined according to the land price table at the time of approving the compensation, support, and resettlement plan. In cases of compensation through land leasing with a one-time payment for the entire lease period, the land price used for calculating the lease is the specific land price decided by the competent People's Committee at the time of approving the compensation, support, and resettlement plan.

The land price used for calculating land use fees and land rent when compensating with land for a different purpose than the type of land acquired for economic organizations whose residential land is being acquired is the specific land price determined by the competent People's Committee at the time of approving the compensation, support, and resettlement plan.



▲ *The Land Law includes many new administration policies*

The decree also stipulates that individuals whose land is acquired and are compensated with land for a different purpose than the type of land acquired or with housing, where there is a difference in value between the compensation for land and the land use fees or rent to be paid when receiving other land or housing, will be handled as follows: If the compensation for land is greater than the land use fees or rent to be paid when receiving land for a different purpose or the price of housing, the land user will receive the difference; If the compensation for land is less than the land use fees or rent to be paid when receiving land for a different purpose or the price of housing, the land user must pay the difference.

The provincial People's Committee, based on the land fund, housing fund, and actual situation in the locality, will stipulate the conversion rate and conditions for compensation with land for a different purpose than the type of land acquired or with housing to compensate individuals whose land is being acquired.

Regarding resettlement, Clause 8 of Article 111 of the Land Law stipulates that individuals whose residential land is acquired and must relocate, and who are compensated with residential land or resettlement housing, but whose compensation for residential land is insufficient compared to the value of a minimum resettlement package, will receive sufficient financial support from the State to secure a minimum resettlement package.

This decree also guides that in cases where households, individuals, and overseas Vietnamese eligible for resettlement support wish to arrange their own housing, in addition to receiving monetary compensation for the land, they will also receive financial support to arrange their own housing.

The provincial People's Committee will stipulate the support level based on the scale of the acquired residential land, the number of household members and specific conditions in the locality.

2. RENEWING LAND PRICES - EXPLOITING ECONOMIC BENEFITS FROM LAND UNDER MARKET MECHANISMS

One of the significant innovations of the Land Law 2024 is related to financial content and land pricing. This is crucial as it directly impacts the interests of the State, land users, and determines the exploitation of economic benefits from land under a market mechanism. Therefore, the Land Law 2024 has amended and supplemented many provisions regarding land pricing that were limited and inadequate in the Land Law 2013, aiming to effectively exploit land resources for sustainable development.

To enhance the financial policy on land and establish a mechanism for determining land prices based on market principles, along with monitoring and oversight mechanisms from the Central Government and the People's Council in creating the land price table, the Land Law 2024 has abolished the regulations regarding the land price framework set by the Government. It specifies principles, bases, and methods for land valuation; requires that the land price table be constructed annually, with the first version published and applied from January 1st, 2026, and adjusted, amended, and supplemented starting January 1st of the following year. The creation of the land price table will be based on value zones and standard plots for areas with digital cadastral maps and land price databases.

In addition, the Law specifies the timing for determining land prices, the time for calculating land use fees and land rent for each case of land allocation, land leasing, permitting changes in land use purpose, extending land use, and changing land use forms that adjust decisions on land allocation or leasing, which alter the area, purpose, or duration of land use. It also clearly states that the competent People's Committee must issue specific land price decisions within 180 days from the date of land price determination for cases where the State allocates land, leases land, permits changes in land use purpose, extends land use, adjusts land use duration, changes land use forms, or adjusts land allocation or leasing decisions, and detailed planning. For cases where the land price from the land price table is applied to calculate land use fees or land rent, the competent People's Committee must specify the land price in the decisions regarding land allocation, land leasing, permitting changes in land use purpose, extending land use, adjusting land use duration, and changing land use forms.

Additionally, the law adds provisions stating that the annual land rent will be applied stably for a period of five years from the time the State decides to lease the land or permits a change in land use purpose associated with transitioning to a form of annual land lease. The land rent for the subsequent period will be calculated based on the land price table of the year in which the next land rent is determined. If the land rent increases compared to the previous period, the payable land rent will be adjusted but not exceed the ratio set by the Government for each phase. This adjustment ratio set by the Government for each phase cannot exceed the total consumer price index (CPI) of the entire country over the previous five-year period.

Notably, the law decentralizes the authority to determine specific land prices to the Chairperson of the District People's Committee. This authority includes deciding on specific land prices for cases of land allocation, land leasing, permitting changes in land use purpose, recognizing land use rights, extending land use, adjusting land use duration, determining the starting price for auctioning land use rights for allocation or leasing, and adjusting detailed construction planning, as well as recovering land under the jurisdiction of the District People's Committee.

The law also specifies methods for land valuation, including the comparative method, income method, surplus method, and land price adjustment coefficient method. It entrusts the Government with the authority to establish additional land valuation methods beyond these four, subject to the approval of the National Assembly's Standing Committee. Furthermore, the law outlines the cases and conditions for applying these land valuation methods. In instances where the application of these methods results in a specific land price lower than the price in the land price table, the price in the land price table will be used.

To provide specific guidance on certain provisions of the law, the Government has issued Decree No. 71/2024/ND-CP stipulating land prices, which takes effect from the date the Land Law No. 31/2024/QH15 comes into force.

Accordingly, Decree 71/2024/ND-CP outlines the procedures and content for determining land prices using the four methods: comparative, income, surplus, and land price adjustment coefficient methods. The decree also specifies the application of land valuation methods for the cases mentioned in point c, clause 2, Article 257 of the Land Law.

According to the Decree, from August 1st, 2024, many regulations regarding land prices will come into effect, including factors influencing land prices. Specifically, instead of specifying factors affecting land prices according to each land valuation method, Article 8 of Decree 71/2024/ND-CP outlines the factors affecting land prices for each type of land, such as for non-agricultural land: location and site of the land plot; traffic conditions including road width, road structure, and proximity to one or more roads; drainage and electricity supply conditions; area, dimensions, and shape of the land plot and site; land use duration; environmental status and security conditions…

For agricultural land, the factors include: crop and livestock yield; location and characteristics of the land parcel and site; land use duration, except in cases where agricultural land is allocated to households or individuals within the limits of transfer rights, in which case there is no basis for considering the land use duration; and other factors.

3. APPLICATION OF DIGITAL TRANSFORMATION TO REFORM ADMINISTRATIVE PROCEDURES

To institutionalize the Party's directive perspective in Resolution No. 18 on "promoting administrative reform, digital transformation, and enhancing state management capacity in land management," and to improve the effectiveness and efficiency of land law, the Land Law has established a foundation for implementing online public land services. This ensures the accuracy and consistency of information among agencies and units. The Land Law dedicates one chapter to administrative land procedures (Chapter XIV), which includes 7 articles (amending and supplementing 4 articles compared to the Land Law 2013). It clearly stipulates the announcement and transparency of administrative land procedures; the responsibilities for carrying out these procedures; the process for changing land use purposes; the procedures for land allocation and leasing; and assigns the Government to specify the administrative procedures related to land.

The law also stipulates that administrative procedures related to land can be carried out in person, via postal systems, or electronically, all of which hold equal legal validity. The agency responsible for resolving land-related administrative procedures must adhere to the authority and timelines established by law. This regulation clarifies the methods for submitting applications to ensure flexibility, aligning with practical conditions and technology applications. It includes options for direct submission, postal submission, or electronic submission, aimed at facilitating convenience for people and businesses.

Along with that, implementing administrative procedures in the electronic environment brings many practical benefits to citizens and businesses; it will facilitate businesses and citizens in searching for information and public services in various sectors and localities; monitor the entire process of handling administrative procedures; carry out administrative procedures anytime, anywhere; pay fees and charges for administrative procedures and public services online; streamline the process and time for handling administrative procedures; enhance transparency in the handling of administrative procedures; expand communication channels with people; and strengthen support activities for people...

The above regulations will serve as an important basis for ensuring transparency and simplifying administrative procedures, creating a foundation for modernizing the provision of public services in the land sector for people and businesses, thereby contributing to the overall socio-economic development of the country.

In addition, Articles 203 and 204 have removed the provisions regarding the authority to allocate land and lease land from the Civil Aviation Authority, the High-Tech Park Management Board, and the Economic Zone Management Board, transferring these responsibilities directly to the State for land allocation, leasing, and issuing land use certificates to organizations and individuals using land in airports, civil airports, high-tech parks, and economic zones. This aims to ensure the right of access to land for organizations and individuals, simplify administrative procedures, and reduce intermediary steps in land management and use.

4. READY TO IMPLEMENT THE LAW

In the report on the preparations for the implementation of the Land Law 2024 at the conference to disseminate and implement the laws and resolutions passed during the 7th session of the 15th National Assembly. The Government has issued several decrees, including: Decree No. 42/2024/ND-CP regulating coastal encroachment; Decree No. 71/2024/ND-CP stipulating land prices; Decree No.88/2024/ND-CP stipulating compensation, support, and resettlement when the State recovers land; and Decree No.101/2024/ND-CP stipulating basic land investigations, registration, issuance of land use rights certificates, ownership of assets attached to land, and the land information system. Regarding the decree detailing the implementation of certain articles of the Land Law, Deputy Prime Minister Tran Hong Ha has signed it for issuance.

For the documents under the authority of the Minister of Natural Resources and Environment, the Ministry has issued several Circulars, including: Circular No.08/2024/TT-BTNMT stipulating statistics, land inventory, and the preparation of land use status maps; Circular No.09/2024/TT-BTNMT regulating cadastral records, land use rights certificates, and ownership of assets attached to land; Circular No.10/2024/TT-BTNMT stipulating the content, structure, and types of information for the national land database, as well as technical requirements for the application software of the national land information system; and Circular No.11/2024/TT-BTNMT stipulating the techniques for land investigation, assessment; the techniques for protecting, improving, and restoring land.

Additionally, the Ministry of Natural Resources and Environment has issued Circular No.12/2024/TT-BTNMT on July

29th, 2024, which details the training, refresher courses, and knowledge updates for individuals practicing land valuation consulting, as well as the framework for training and professional development programs related to land pricing. Thus, the documents under the responsibility of the Ministry regarding the development of detailed regulations and guidelines for the implementation of the Land Law have been essentially completed.

For documents under the primary responsibility of the Ministry of Finance (including: decrees stipulating land use fees and land lease fees, and decrees stipulating the Land Development Fund), the Ministry of Agriculture and Rural Development (decree detailing rice-growing land), the Ministry of Labor, Invalids and Social Affairs (decision of the Prime Minister on mechanisms and policies for job creation and vocational training for individuals with land recovered), and the Ministry of Home Affairs (circular stipulating the establishment and management of administrative boundary records), the summary indicates that these ministries are urgently finalizing their documents to ensure they take effect simultaneously with the enforcement date of the Land Law.

For documents under the authority of the People's Council and the People's Committee: based on the data collected from 42 out of 63 provinces and centrally-controlled cities regarding the implementation of the Land Law nationwide, localities are currently accelerating the progress of developing guiding documents for the implementation of the Land Law as per their assigned authority to ensure timely, consistent, and unified enforcement of the Land Law. The total number of documents and detailed regulations expected to be developed is 544, including 63 documents or detailed content under the authority of the provincial People's Councils, and 481 documents or detailed content under the authority of the provincial People's Committees.

Thus, it can be said that the documents under the authority of ministries, sectors, and localities have largely been detailed by these entities when implementing the steps to bring the Land Law 2024 into effect, ensuring progress, quality, and effectiveness from August 1st, 2024 ▪

On 13th August 2024, the Prime Minister issued Lists of sectors and establishments emitting greenhouse gases (GHGs) subject to GHG inventory (updated) in Decision No. 13/2024/QĐ-TTg. Accordingly, there are 2,166 establishments emitting GHGs subject to GHG inventory, an increase of 254 establishments compared to Lists issued by the Prime Minister in 2022, accounting for about 30% of total national GHG emissions.

Implementing the Law on Environmental Protection 2020, the Government's Decree No. 06/2022/NĐ-CP dated 07th January 2022 on GHG emission reduction and ozone layer protection, the Ministry of Natural Resources and Environment is responsible for presiding over and coordinating with relevant agencies and local authorities to develop Lists of sectors and establishments emitting GHGs subject to GHG inventory, submit to the Prime Minister for promulgation and update every 2 years.

Implementing above regulations, the Ministry of Natural Resources and Environment has submitted to the Prime Minister to issue the Lists of sectors and establishments emitting GHGs subject to GHG inventory for promulgation in Decision No. 01/2022/QĐ-TTg. Accordingly, sectors emitting GHGs subject to GHG inventory include: energy, transportation, construction, industrial processes, agriculture, forestry and land use, waste. Establishments emitting GHGs subject to GHG inventory include 1,912 establishments, belonging to following sectors: industry and trade, transportation, construction, natural resources and environment.

Updating lists of sectors and establishments emitting GHGs subject to GHG inventory aims to improve the effectiveness and efficiency of state management in reducing GHG emissions; is the basis for strengthening the implementation of GHG inventory, reducing GHG emissions and determining GHG emission reduction goals of establishments in the 2026-2030 period, contributing to the effective implementation of the Party's guidelines and State's policies on responding to climate change, implementing green transformation, developing low-carbon economy, implementing Nationally Determined Contribution (NDC) and aiming to realize the goal of achieving "net-zero" emissions by 2050. The promulgation and implementation of Decision No.13/2024/QĐ-TTg of the Prime Minister also contributes to implementing the provisions of the Paris Agreement on climate change, aiming to control at least 85% of major emission sources depending on national conditions and capacity.

Based on the review of People's Committees of provinces and centrally-run cities and documents of relevant ministries, the Ministry of Natural Resources and Environment has submitted Lists of sectors and establishments emitting GHGs subject to GHG inventory (updated) to the Prime Minister for promulgation. These Lists promulgated by the Prime Minister include 06 sectors and 2,166 establishments emitting GHGs subject to GHG inventory.

06 sectors subject to GHG inventory:

(1) Energy: Energy production industry; Energy consumption in industry, commerce, services and civil use; Coal mining; Oil and natural gas exploitation.

Lists of sectors and establishments emitting greenhouse gases subject to greenhouse gas inventory

(2) Transportation: Energy consumption in transportation.

(3) Construction: Energy consumption in the construction sector; Industrial processes in the production of building materials.

(4) Industrial processes: Chemical production; Metallurgy; Electronic industry; Use of alternative products for ozone-depleting substances; Production and use of other industrial products.

(5) Agriculture, forestry and land use: Livestock; Forestry and land use change; Crop production; Energy consumption in agriculture, forestry and fisheries; Other sources of emissions in agriculture.

(6) Waste: Solid waste landfill; Solid waste treatment using biological methods; Incineration and open burning of waste; Wastewater treatment and discharge.

2,166 establishments emitting GHGs subject to GHG inventory:

The List of establishments emitting GHGs subject to GHG inventory in 2024 include 2,166 establishments, an increase of 254 establishments compared to the List issued in 2022. Accordingly, 297 establishments have been eliminated because they have stopped operating or reduced operating scale and capacity, 551 new establishments have been updated.

The Industry and Trade sector has 1,805 establishments that are power plants and industrial establishments with a total annual energy consumption of 1,000 TOE (tons of oil equivalent) or more; accordingly, 199 establishments have been eliminated and 342 new establishments have been updated.

The Transportation sector has 75 establishments that are freight transportation companies with a total annual energy consumption of 1,000 TOE or more; accordingly, 26 establishments have been eliminated and 31 new establishments have been updated.

The Construction sector has 229 establishments including cement manufacturing enterprises and commercial buildings with a total annual energy consumption of 1,000 TOE or more; accordingly, 37 establishments have been eliminated and 162 new establishments have been updated.

The Natural Resources and Environment sector has 57 solid waste treatment establishments with an annual operating capacity of 65,000 tons or more; accordingly, 35 establishments have been eliminated and 16 new establishments have been updated.

Establishment semitting GHGs subject to GHG inventory will have to carry out GHG inventory at the grassroot level according to the guidance of the ministry managing the relevant sector (Ministry of Industry and Trade, Ministry of Transport, Ministry of Construction, Ministry of Natural Resources and Environment), be responsible for submitting the establishment's GHG inventory report according to the Government's Decree on GHG emission reduction and ozone layer protection.

▲ *There are 2,166 establishments emitting GHGs subject to GHG inventory, an increase of 254 establishments compared to Lists issued by the Prime Minister in 2022*

The Decision stipulates implementation responsibilities for People's Committees of provinces and centrally-run cities and ministries managing relevant sectors. Accordingly, People's Committees of provinces and centrally-run cities are responsible for directing relevant specialized agencies to urge establishments emitting GHGs subject to GHG inventory on the List in the area to carry out GHG inventory according to regulations; updating and adjusting the List of establishments emitting GHGs subject to GHG inventory in the area and sending it to the Ministry of Natural Resources and Environment and ministries managing relevant sectors according to regulations.

The Ministry of Natural Resources and Environment presides over and coordinates with Ministries: Industry and Trade, Transport, Construction, Agriculture and Rural Development, and People's Committees of provinces and centrally-run cities to review, update Lists of sectors and establishments emitting GHGs subject to GHG inventory and submit to the Prime Minister for consideration and decision.

Decision No. 13/2024/QĐ-TTg takes effect from 1st October 2024. Decision No. 01/2022/QĐ-TTg of the Prime Minister dated 18th January 2022 promulgating Lists of sectors and establishments emitting GHGs subject to GHG inventory will no longer be effective from the effective date of this Decision.

Establishments emitting GHGs on Lists specified in Decision No. 01/2022/QĐ-TTg but not on Lists specified in this Decision are not obliged to carry out and submit GHG inventory reports at the grassroot level in 2025 ▪

HÀN TRẦN VIỆT

Agreement on the conservation and sustainable use of biodiversity in waters beyond national jurisdiction (BBNJ) and opportunities for Vietnam

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Vietnam's signing of The Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (BBNJ) marks a strategic commitment to protecting the marine environment and natural resources. This analysis aims to evaluate the significance of Vietnam's participation in the BBNJ Agreement, particularly for a developing country, including access to advanced technology and knowledge, fair and equitable sharing of benefits (both monetary and non-monetary) from marine genetic resources in ABNJ, and enhanced cooperation in marine biodiversity protection. Additionally, this signing reaffirms Vietnam's active contribution to global sustainable development goals, ensuring long-term benefits for both the nation and the world.

1. INTRODUCTION

Nearly two-thirds of the world's oceans lie in areas beyond national jurisdiction (ABNJ). This is where 95% of earth's species are concentrated. 2/3 of fish stocks in waters beyond national jurisdiction are overexploited. Many marine gene resources, which have high economic value in providing food sources, and raw materials for the production of pharmaceuticals and cosmetics, are being freely exploited. Marine biodiversity in areas beyond national jurisdiction now faces many risks leading to decline, even to the disappearance of many marine species due to climate change, sea level rise, ocean acidity, deep-sea exploitation, environmental pollution, plastic waste, and other human activities to degrade marine resources and environment[1].

This article will begin by highlighting the historic achievement of the adoption of The Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (BBNJ). This milestone marks a significant step in global marine biodiversity protection and sustainable resource management. Following this, the paper will analyze and present perspectives on the BBNJ Agreement, focusing on its implications and the opportunities it offers for Vietnam. This includes examining how Vietnam, as a developing country, can leverage the agreement to enhance its access to advanced technology and knowledge, achieve fair and equitable sharing of benefits from marine genetic resources, and strengthen international cooperation in marine biodiversity protection.

2. ADOPTION OF THE BBNJ TREATY – AN HISTORIC ACHIEVEMENT

The BBNJ Agreement would be the third implementing agreement of the United Nations Convention on the Law of the Sea (UNCLOS). The current implementing agreements, the 1994 Agreement relating to the implementation of Part XI[2] and the 1995 Agreement relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks[3].

The global community agreed that there needed to be a more coherent approach to the conservation and sustainable use of marine biodiversity beyond national jurisdiction (BBNJ) and launched negotiations for a treaty that aims to meet that objective[4].

UNCLOS has clearly defined the maritime zones under the sovereignty, sovereign rights and jurisdiction of coastal states as internal waters, territorial waters of 12 nautical miles, exclusive economic zones of 200 nautical miles and continental shelves. However, UNCLOS contains no provision specifically addressing the access, use, ownership and benefit sharing of marine biodiversity resources in ABNJ.

The 1992 Convention on Biological Diversity (CBD) and the 2010 Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits arising from their utilization, also known as the Nagoya Protocol on Access and Benefit Sharing (ABS) introduce a number of concepts of "Biodiversity", "Biological Resources", "Gene Resources" and "Genetic Materials". However, these provisions mainly regulate the management and conservation of biodiversity in areas under national jurisdiction. The 2018 Vietnam Biodiversity Law does not adequately cover forms of marine gene resources and is limited to waters under

national jurisdiction. The 2013 Vietnam Law on Science and Technology does not define marine technology and marine technology transfer.

The BBNJ Agreement has been adopted and opened for ratification on June 19th, 2023. The agreement will enter into force 120 days after having at least 60 ratifications of UN member states. The BBNJ Agreement is a supplement to UNCLOS, within the framework of UNCLOS and does not replace the basic principles of UNCLOS. BBNJ is built on the principles of the common heritage of humankind and freedoms of the seas.

The BBNJ Agreement aims (article 2) to ensure the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction, for the present and in the long term, through effective implementation of the relevant provisions of the Convention and further international cooperation and coordination. The Agreement emphasizes the principle of taking into account the needs and priorities of developing countries, creating great advantages for Vietnam and developing countries in building and enforcing a fair and equitable maritime legal order.

3. BBNJ TREATY AND OPPORTUNITIES FOR VIETNAM

The implementation of The Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (BBNJ) will offer several significant advantages to Vietnam, a developing country[5].

Firstly, it will provide a clear legal framework to support Vietnam's efforts in the conservation and sustainable use of marine biodiversity, ensuring fair and equitable sharing of benefits - both monetary and non-monetary - from marine genetic resources in areas beyond national jurisdiction (ABNJ). This framework will also aid in the effective utilization of regional management tools, including Marine Protected Areas, while respecting the sovereignty and interests of states. For instance, the initiative for a Marine Protection Zone or Peace Park could potentially be applied in the Spratly Islands area, subject to agreements with relevant states and regional organizations.

Secondly, Vietnam will benefit from assistance in capacity building and technology transfer from developed countries. This will facilitate access to advanced marine technologies crucial for managing marine genetic resources and bolster Vietnam's capabilities in marine science and conservation.

Thirdly, the agreement ensures that Vietnam's interests are safeguarded not just within the East Sea but also across international waters and the seabed beyond national jurisdiction. It will also provide opportunities to uphold the effectiveness of the United Nations Convention on the Law of the Sea (UNCLOS) and ensure consistency with other related documents.

Additionally, it will contribute to the development of legal and scientific expertise in Vietnam, aligning with global advancements and renovation requirements. Finally, the agreement will promote extensive international cooperation to address maritime issues, enhancing Vietnam's role in global marine governance and sustainability efforts. Moreover, it will help Vietnam engage in crucial dialogues and partnerships for global marine conservation initiatives, further integrating the country into the international community's efforts to protect and sustainably manage ocean resources.

4. CONCLUSION

This article provides a comprehensive analysis of Vietnam's signing of The Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (BBNJ). It highlights the historic achievement of the treaty's adoption and examines the benefits Vietnam stands to gain, such as access to advanced technology and support from developed countries. The article details how the agreement will safeguard Vietnam's interests not only in the East Sea but also across international waters, while enhancing legal and scientific capacity. It also underscores the opportunity to uphold the effectiveness of the United Nations Convention on the Law of the Sea (UNCLOS) and strengthen international cooperation. By doing so, it affirms Vietnam's proactive role in global marine conservation efforts and sustainable development ▪

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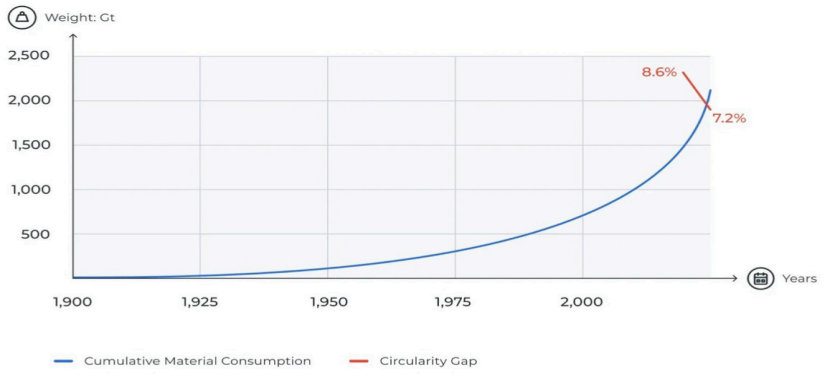
Circularity Gap Report 2024 – A cicular economy to live with in the safe limits of the planet

The 2024 edition of the Circularity Gap Report (CGR), published by Circle Economy in collaboration with Deloitte, finds that global circularity rate has decreased from 9.1% in 2018 to 7.2% in 2023. That means the share of secondary materials consumed worldwide is in decline. The report recommends policy, finance, and labor reforms that can reshape global systems to promote circularity.



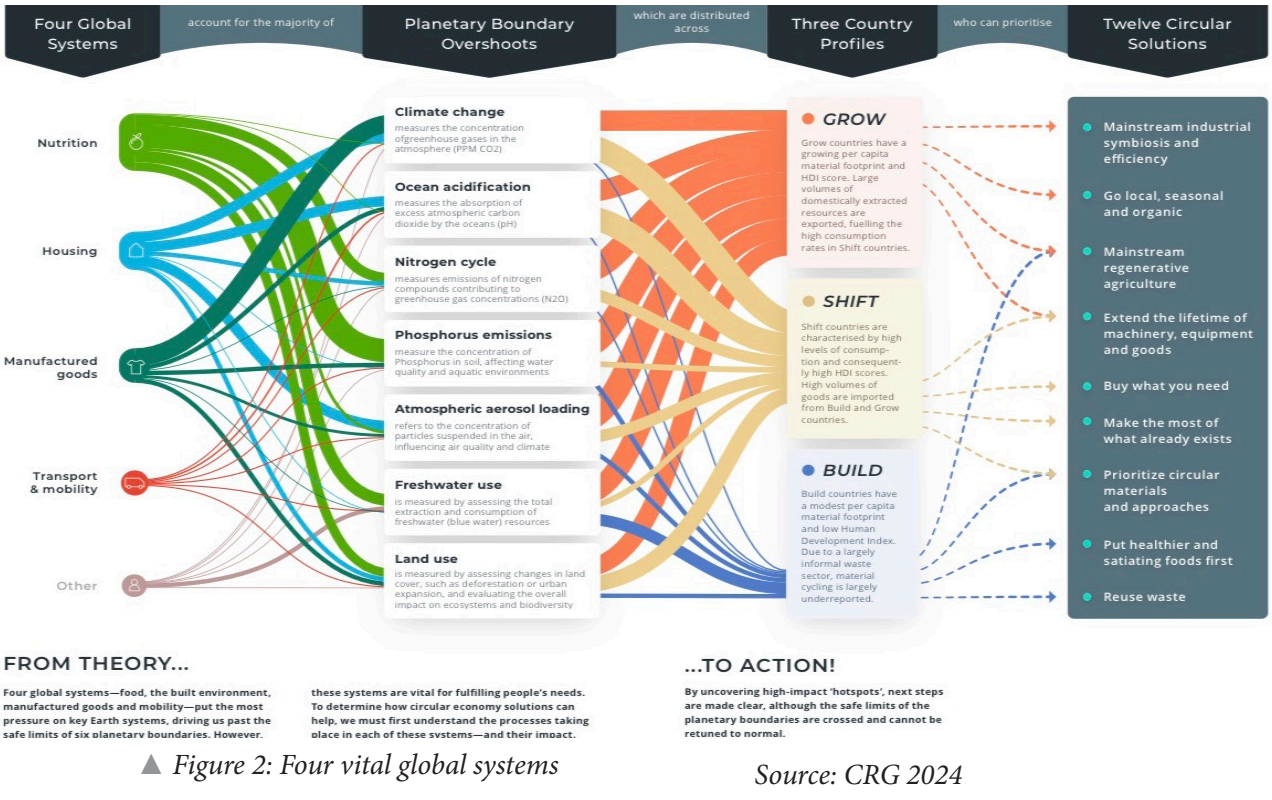
▲ *Figure 1: The global circularity rate*

Source: CRG 2024

IMPORTANT VALUE CHAINS TO TRANSITION TO A CIRCULAR ECONOMY

The previous Circularity Gap Reports have defined the 'what' - this report lays out the 'how' to put these solutions into action. To pinpoint key leverage points for each country profile. Build, Grow and Shift countries all have a role to play in the transition but these roles will look different. This report uncovers the most important value chains to transition to a circular economy across these three country profiles. This report explores the underlying political, financial and social conditions these solutions need to succeed. The Circularity Gap Report 2023 findings show that this is possible: we can deliver on societal needs such as housing, nutrition, mobility and manufactured goods with 30% less of the materials we use now, reversing the overshoot of five planetary boundaries.

The report reveals that in the last five years, the world consumed 500 billion tonnes of materials – almost as much as was consumed during the entire 20th century. And while the volume of



▲ *Figure 2: Four vital global systems*

Source: CRG 2024

discussions, debates, and articles about circular economy has almost tripled over the same period, consumption continues to grow.

To accelerate progress towards a circular economy, the report calls for addressing the root causes of linear impacts. It recommends changing the "rules of the game" in favor of circular practices and proposes a strategy to unlock capital, roll out policies that are bold but contextually appropriate, and close the sustainable and circular skills gap. The report recommends different solutions based on country income. For high-income countries (HICs), the report urges a "shift" to radically reduce material consumption while upholding well-being. Middle-income countries (MICs), it argues, should "grow" to stabilize their material consumption, while low-income countries (LICs) should "build" to increase their material consumption to meet their populations' needs.

The report shows how policies and legal frameworks can incentivize sustainable and circular practices. To unlock finance in HICs, the report recommends rethinking accounting standards and practices and increasing the price of unsustainable products through taxation. In MICs, it suggests governments shift subsidies away from polluting practices in agriculture and manufacturing towards clean, regenerative activities. Regenerative farming and smart urban planning are among the recommendations the report puts forward for LICs.

To enable a just transition, the report calls for, bridging labor and skills gaps by including green disciplines and skills in education curricula and short-term courses. Circle Economy launched the Circularity Gap Report series in 2018. The series aims to provide decision makers with structured evidence about circular strategies and their economic, environmental, and social impacts, to enable them to adequately consider the quality of life and well-being of people and the planet.

CURRENT STATUS OF TRANSITIONING TO A CIRCULAR ECONOMY

According to the report, the development level of countries is divided into 3 categories: Developed countries, developing countries, and least developed countries.

Developed countries are those with high incomes and excessive consumption, which is the main cause of overloading and ecosystem disruption. These countries have a high average Human Development Index (HDI) and far exceed the Earth's carrying capacity. Although these countries have stricter domestic environmental regulations and advanced waste management systems, they cause significant environmental degradation in the rest of the world. The demand from developed countries leads to exploitation and pollution in other countries, as wealthy industrial production countries in places with fewer environmental regulations. Developed countries are characterized by rapidly aging workforces. This is causing damage to key industries such as construction and manufacturing, which are lacking young talent.

On average, the material consumption per capita in developed countries is 22.6 tons, 4.6 times higher than in least developed countries and 1.6 times higher than in developing countries. They also account for 43% of global greenhouse gas emissions. The mission of these countries will be to reduce material consumption levels and ultimately minimize the current negative impacts that are causing global harm.

Developing countries such as China, Indonesia, Brazil, Mexico, Vietnam, Myanmar, and Egypt need to continue improving the quality of life for their people. The average per capita material consumption in these countries is 17 tons per year. While these countries contribute 41% of global emissions, nearly equal to developed countries despite having double the global population share compared to developed countries.

The increasing growth and income have led to a nutritional transition in developing countries: dietary patterns are shifting towards animal protein-rich foods like meat, dairy, and processed foods. While many of these countries are and may remain important production and industrial centers for the rest of the world and their own consumption, this requires changes to create a sustainable environment that supports and ensures the safety of workers.

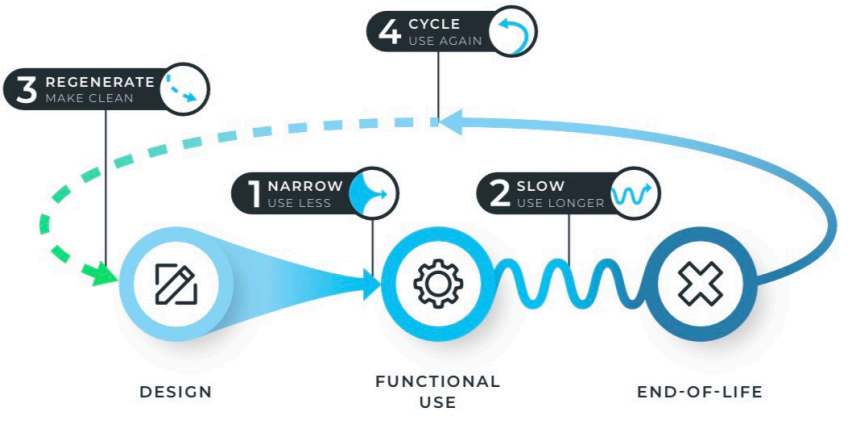


Figure two depicts the four flows of the circular economy: a comprehensive framework for managing resource flows in a circular economy by using less (Narrow), using for longer (Slow), using again (Cycle), and using clean, regenerative materials and energy (Regenerate).[28]

▲ *Figure 3: The four flows of the circular economy*
Source: CRG 2024

Least developed countries have rapidly expanding economies, abundant populations, and diverse natural resources. They have significant potential to drive the transition towards a circular economy. Therefore, low-income countries must balance essential needs to improve living standards and reduce poverty while also addressing urgent environmental issues. These countries require more resources and face competition for investment in critical sectors such as healthcare, education, and infrastructure.

Least developed countries have not invested in new technologies and practices that enable sustainable human development, especially in resource-intensive sectors such as food, energy, and construction. For example, least developed countries like Bangladesh, Ethiopia, Nigeria, Pakistan, the Philippines, and some small island nations account for 18.5% of global material consumption, despite being home to nearly half (46%) of the global population. Their average per capita material consumption is only 5 tons per year, lower than the estimated sustainable level is 8 tons per person per year. Similarly, they also contribute a relatively small portion to global greenhouse gas emissions: only 17%.

Since these countries often struggle to meet basic needs for healthcare and education, their primary goal is to improve living standards. This requires enhancing material use to provide infrastructure, goods, and essential services to improve welfare. It also necessitates boosting morale for workers in countries with prevalent informal economies, especially common in sectors such as agriculture, forestry, and waste management.

DIFFERENT COUNTRIES HAVE DIFFERENT PRIORITIES

The report gives three key systems for the circular solutions cover: food, the built environment and manufactured goods. For each country profile: lower-income (Build), middle-income (Grow) and higher-income (Shift). The report highlights the most relevant systems. And, for the first time, report place people at the centre of this story, exploring the jobs and skills powering the circular transition.

Shift countries

On average, residents of high-income Shift countries enjoy affluent, comfortable lifestyles and perform well on social indicators. However, they consume far more than their fair share of materials. These countries must focus on reducing material extraction and use to lighten their environmental burden. Two key systems that can lead this transformation are:

Built environment

Reward market players for investing in circular solutions and business: Implement regulations that prioritise renovation, retrofitting and adaptive reuse; develop certifications and warranties for secondary materials; roll out standards and criteria for circularity; roll out circular land ownership models, such as Community Land Trusts. Make circular building projects an attractive investment option. Close the labour and skills gap with a mix of education and policy.

Manufacturing

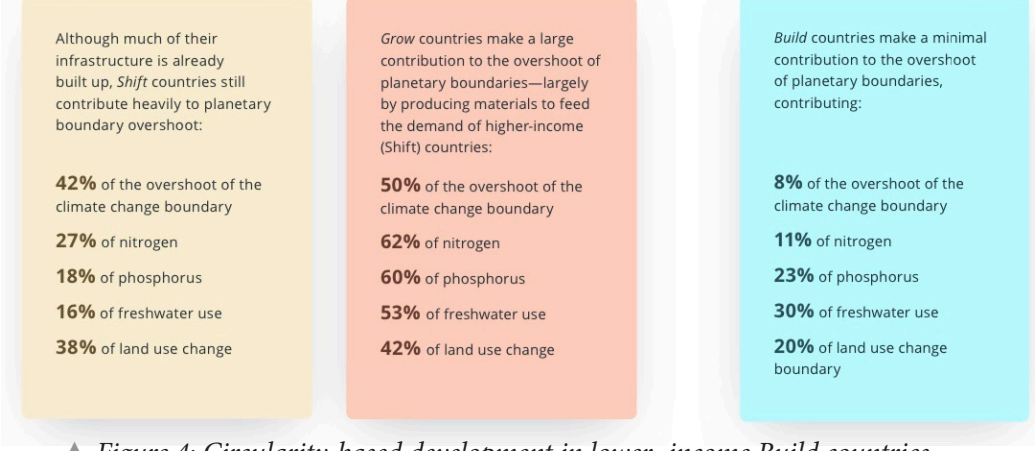
Encourage products to be designed for circularity: durable and easy to reuse, repair and recycle: Strengthen universal Right to Repair legislation and Extended Producer Responsibility; set standards for material efficiency and product durability. Use pricing and convenience to nudge people toward sufficiency lifestyles. Foster a cultural shift through education and legislation.

Grow countries

Many middle-income countries are and will likely remain key manufacturing and industrial hubs. This necessitates a shift to make their growth sustainable as well as supportive and safe for workers. Two key systems that can lead this transformation are:

Food system

Roll out policies to encourage nutritious choices and cut food waste: Roll out market-based incentives that make healthy and sustainable foods the most attractive option; mandate food waste reporting and reduction targets; raise awareness about food products' environmental and social impact; reform economic incentives



▲ *Figure 4: Circularity-based development in lower- income Build countries, promote circular industrial processes in Grow countries and shift consumption patterns in higher- income Shift nations.*

Source: CRG 2024

and regulations to prioritise regenerative farming and holistic land management; direct subsidies away from industrial agriculture and towards sustainable farming; establish fact-based regulatory frameworks by introducing efficient approval processes, certifications, labels and accessible intellectual property. Empower and protect farmers engaged in regenerative agriculture.

Manufacturing

Remove barriers to scaling circular manufacturing with clear and mandatory targets and aligned incentives: Introduce policy measures that impose and enforce public bans and limits on pollution; Tax material- and carbon-intensive production and subsidise energy- and material-efficient practices; Integrate eco-industrial parks and hubs into national policy frameworks. Direct capital investments and promote technology transfers to scale up green tech; Ensure investments integrate social requirements. Develop a plan for sustainable skills development for the jobs of tomorrow; Set up systems for mapping skills needed across the entire value chain; encourage exchanges between vocational education institutions and industry; promote social dialogue and partnership in planning, designing and implementing national and sectoral policies.

Build countries

Lower-income Build countries generally struggle to meet basic needs for healthcare and education. For these countries, the primary objective is to use materials to improve living standards. Two key systems that can lead this transformation are:

Food system

Unlock investment in climate mitigation and adaptation: Implement debt relief and fair access to capital markets via Green Bonds and Climate Funds; implement efficient, stable and transparent regulatory and business frameworks; secure land rights and tenure policies to protect smallholder farmers; set concrete policy targets for soil, water and biodiversity. Enable farmers to invest in innovations to increase agricultural output and quality.

Built environment

Cultivate enabling policy conditions for a circular built environment value chain; allow local governments to plan and adapt for circularity with financial and technical resources; facilitate labour-intensive circular building solutions with skills development and informal economy processes.

SOLUTIONS FOR TRANSITIONING TO A CIRCULAR ECONOMY

The circular economy is an upgraded system that can help address the complex and intertwined challenges that humanity is facing if approached correctly. However, to move from theory to action, we must look at the big picture rather than individual perspectives. Identifying circular solutions with strong impacts across all sectors in all countries and demonstrating how legal, regulatory, and financial incentives can be changed to bring about real change and benefit people.

In developed countries

Group of solutions for establishing a circular build environment:

Firstly, reward market participants for investing in circular solutions and business models: Implement strict regulations prioritizing renovation, retrofitting, and adaptive reuse whenever possible, while requiring recycling and reuse of high-value construction and demolition waste; establish effective certifications and warranties for secondary materials to confirm their safety and quality, while helping contractors comply with construction regulations much easier when using these materials; implement standards and criteria for circularity in procurement guidelines, zoning, and spatial planning; deploy innovative land ownership models, such as community land trusts, to ensure long-term affordable housing for the community.

Secondly, make circular building projects an attractive investment choice: Encourage financial incentive for circular construction by reducing property taxes for buildings meeting circular criteria, providing tax credits for using circular materials, or reducing insurance premiums for circular buildings or infrastructure; establish common language among stakeholders in financial and building sectors to enhance transparency and enable better cooperation; review accounting standards and practices to better capture the value of built assets.

Thirdly, narrow the labor and skills gap through education and policy integration: Address labor shortages in the industry by adjusting policies and increasing job attractiveness; support the development of necessary circular skills in the labor market by incorporating the circular economy into educational programs and vocational training; review and (re)formulate skill development policies, especially for the validation and recognition of skills and qualifications for migrant and more informal workers.

Group of solutions for advancing circular manufacturing

Firstly, encourage products designed for circularity: durable, easy to reuse, repair, and recycle: Strengthen laws on the right to repair and extended producer responsibility, require manufacturers to provide spare parts, tools, and repair manuals to customers and their repair shops; set standards for material efficiency and product durability, especially for electronics and appliances.

Secondly, use pricing and convenience to nudge people toward sufficiency lifestyles; apply progressive taxes and heavier inheritance and property taxes to limit excessive wealth and income inequality, while reducing overconsumption of luxury goods; provide consumers with financial incentives such as rewards vouchers, or reduced or zero taxes on repair services and refurbished goods; Governments may also consider taxing material extraction rather than labour.

Thirdly, foster a cultural shift where sustainability is the norm and sufficiency mindsets prevail: Invest in and use just transition funds to invest in skills development, education and training; roll out job guarantees and explore reducing the standard work week to gradually break the "work and spend" cycle and foster a less materialistic, more relational and participatory society.

In developing countries

Group of solutions for establishing a circular food system

Firstly, roll out an integrated policy mix to encourage nutritious choices and cut food waste: Roll out effective market-based incentives tailored to consumers that make healthy and sustainable foods the preferred option; create an effective regulatory environment, including advertising sales bans on certain high-impact food products that threaten human and planetary health; use information-based incentives, such as food labeling with environmental and social impact information on food products.

Secondly, use policies to ensure that financial institutions invest in regenerative agriculture and circular food: Policymakers can ensure that the financial regulatory environment supports long-term transformation by introducing transparency requirements; restructure economic incentives and regulations to prioritise regenerative farming models and holistic land management practices: Ensure a true price for sustainable food that fully reflects the social and environmental impacts so that products of regenerative and sustainable farming are competitive and attractive.

Thirdly, empower and protect farmers engaged in regenerative agricultural practices: Create just transition funds to de-risk and enable changes in farming practices, supplying farmers with the tools and knowledge they need to convert their farms.

Group of solutions for advancing circular manufacturing

Firstly, remove barriers to scaling circular manufacturing with clear and mandatory targets and aligned incentives; create economic incentives through mechanisms such as properly taxing production and trade activities using multiple resources and carbon, while implementing subsidies to encourage energy-efficient production and properly pricing shared resources.

Secondly, ensure policy alignment to support industrial transitions: Take an ambitious, mission-oriented approach to industrial policy that directs investments towards maximising public-value creation and people's wellbeing within ecological limits; scale eco-industrial parks via public-private partnerships with centralised management to effectively plan and coordinate services, including the maintenance of a data system that can optimise resource-use and pollution control systems.

Thirdly, direct significant capital investments and promote technology transfers to increase access to and help scale up innovative green and clean technology that delivers cost savings, drives down material demand and reduces pollution; develop a forward-looking plan on sustainable skills development for the jobs of future: Invest in skills development programmes with particular focus on workers vulnerable to the transition; set up systems for identifying and anticipating skills needs and mapping skills needs across the entire value chain;

In least developed countries

Group of solutions for establishing a circular food system

Firstly, enact policies to mobilize investment in climate mitigation and adaptation: Implement debt relief and fair access to capital markets to national governments in least developed countries, such as reliable nature-for-debt swaps and via Green Bonds and Climate Funds; set concrete policy targets for soil, water and biodiversity to establish long-term strategic goals and send clear signals to market players about where to invest in the future.

Secondly, strengthen resilience in small- and medium-scale agriculture with improved market access: Promote farming cooperatives by supporting and financing aggregator models where a central entity, such as a cooperative or social enterprise, consolidates smallholder farmers' produce and provides services such as access to finance and technical assistance.

Thirdly, enable farmers to invest in innovations to increase agricultural output and quality: Provide credit to farmers and landowners engaging in regenerative agriculture to restore and stewardship of ecosystems; implement a less risky transition process for small-scale farmers; ensure "future-proof" skill-sets with training and skills pathways and recognise indigenous, regenerative practices.

Group of solutions for establishing a circular build environment

Firstly, cultivate a conducive policy environment for a circular built environment value chain.

Secondly, allow local governments to plan and adapt for circularity with financial and technical resources.

Thirdly, facilitate labour-intensive circular building solutions with skills development and informal economy processes.

The transition to a circular economy is becoming an essential trend in life to protect the environment, address climate change for sustainable development for the health of people, the natural environment, and the planet. However, the implementation in different groups of countries still faces many limitations due to various challenges. Therefore, many solutions have been proposed to encourage and guide the development of a circular economy tailored to the specific circumstances, economic conditions, social factors, and environmental aspects of each group countries ▪

NHÂM HIỀN

(Source: Circularity Gap Report 2024)

Policy and legal framework on renewable energy of the Federal Republic of Germany and implications for Vietnam

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At COP26, Vietnam committed to developing and implementing strong greenhouse gas (GHG) emission reduction measures using its own resources, along with the cooperation and support of the international community in both finance and technology transfer, including implementing mechanisms under the Paris Agreement to achieve net-zero emissions by 2050. To achieve this goal, Vietnam has identified one of effective solutions that needs to be implemented is to develop renewable energy (RE), gradually reduce traditional fossil energy, aiming to reduce CO_2 emissions. Over the past time, Vietnam has gradually improved the system of mechanisms and policies for RE development. However, the policy and legal framework only includes directional regulations and principles, and is still scattered in many different legal documents, without a legal corridor strong enough to exploit the potential of Vietnam's RE development, promoting effective implementation in practice. In the above context, studying and improving the policy and legal framework on RE in Vietnam based on international experience is necessary in the current period, contributing to developing an appropriate legal system on RE, ensuring national energy security. This article introduces and analyses the legal framework for RE development of the Federal Republic of Germany, thereby proposing some suggestive solutions for Vietnam.

LEGISLATIONS ON RE OF THE FEDERAL REPUBLIC OF GERMANY

The Federal Republic of Germany is known as one of successful countries in developing RE in the world today. RE is considered by the German Government to be the core of the country's energy transition process. The RE proportion in Germany's total electricity output in 2021 is 41.1%, of which onshore wind power accounts for 15.7%; solar power accounts for 8.8%; biomass power accounts for 6.8%; offshore wind power accounts for 4.3%; and hydropower accounts for 3.4%. In recent years, wind energy has become the main source of growth in RE production in Germany. In 2021, onshore and offshore wind energy contributed 48.8% of Germany's electricity output [7]. Policies and legislations on RE in Germany are mainly governed by the Energy Industry Act (EnWG) [10] and the Renewable Energy Sources Act (EEG) [9] regulated by the Federal Government.

According to the Energy Industry Act (EnWG), developing RE in the Federal Republic of Germany has three purposes: (1) Ensure the safe, cheap, consumer-friendly, and most effective supply of electricity, gas, and hydrogen, environmentally compatible and GHG neutral for the public; (2) Regulations on electricity and gas supply networks must serve the goal of ensuring competition, effective and reliable operation in the long term; (3) Transform and implement the European Community Law in the field of grid-connected energy supply.

Directly regulating RE and introducing policies to promote RE development is the Renewable Energy Sources Act (EEG). This Act has three main purposes: (1) Especially for the benefit of climate and environmental protection, transition to a sustainable and GHG neutral electricity supply entirely based on RE; (2) To achieve the above goal, the proportion of electricity generated from RE in total electricity consumption on the territory of the Federal Republic of Germany, including its exclusive economic zone (Federal territory), will be increased to at least 80% by 2030; (3) The expansion of RE necessary to achieve the goal of 80% of total electricity consumption across the entire territory must be stable, cost-effective, environmentally friendly and compatible with the power grid (Article 1 of the EEG).

Policies to encourage, provide incentives for investment in RE development

The Federal Government plays an active role in developing RE projects in Germany and seeks to encourage the production of electricity from RE sources. Specifically, EEG is the main tool to promote investment in and sale of electricity from renewable sources. In particular, the EEG stipulates a payment system for electricity generated from RE, specified in Articles 19 to 27 of the EEG, which clearly stipulates the forms of subsidies (Right to payment, market premium) and regulations guiding payments to electricity suppliers.

RE storage

Due to the characteristic of RE being unstable because of its dependence on the weather, there are times during the day when RE provides excess electricity or there are times when there is not enough electricity to meet the market demand. Therefore, electricity storage activities are of great interest to the German Government. The operation of an energy storage establishment is governed by energy regulations, most notably the Energy Industry Act (EnWG). Construction

of a battery storage establishment requires a building permit, depending on the storage technology used, such as battery storage, energy-to-gas storage, compressed gas storage, and pump storage that licensing conditions are different. For example, energy-to-gas storage establishments or hydrogen plants require a permit under the Act on the Prevention of Harmful Effects on the Environment Caused by Air Pollution, Noise, Vibration and Similar Phenomena. Compressed gas storage establishments may require a permit under the Federal Mining Act (BbergG) and pumped storage establishments typically require a plan approval process under the Federal Water Act (WHG) that includes an environmental impact assessment.

Another way to store electricity from RE is to convert it into gas (power-to-gas), especially hydrogen, is flexible in its use in terms of time and location. The specific legal framework for the production, transportation and storage of "green hydrogen" comes into effect in 2021. The first amended Energy Industry Act regulates the construction of hydrogen infrastructure, including pipelines and storage establishments as well as non-discriminatory access to such establishments.

The analysis of the legal framework on RE development of the Federal Republic of Germany shows that RE is a key issue of concern to the German Government, demonstrated in the promulgation of a separate act on RE, in addition to the act on energy in general. The promulgation of a separate act on RE has created a unified body of views, policies, and legal norms governing investment, exploitation, and use of RE towards the goal of developing RE in the coming time. These regulations include a system of regulations on contractor selection, preferential policies to encourage investment and use of RE, electricity selling prices, electricity storage... Some lessons can be drawn from experience of Germany in the process of promulgating legislations on RE as follows:

Firstly, promulgating a separate act on RE, in addition to acts on energy or electricity in general, and having a separate policy mechanism to encourage and promote the development of this type of energy is really necessary. Because RE is an environmentally friendly energy source, it depends significantly on weather conditions and requires a large financial resource to invest... therefore, a separate policy mechanism is needed to regulate production, investment and business activities and use of this special type of energy.

Secondly, clearly defining the purpose of the act on RE will be the guideline and orientation for all provisions in this act.

Thirdly, the Government's direct price support policy on electricity purchase prices (FIT price) is only meaningful in the early stage to accelerate the transition to RE. However, in the long term, developing electricity price policy according to market mechanisms, aiming to promote investment in RE development, creating incentives for investors and energy producers to produce and use energy economically and effectively is necessary in the future.

Fourthly, developing a mechanism to encourage and motivate investors to have a plan to store electricity in case of excess RE and supply it back to the grid in case of shortage of RE, gradually reducing dependence on traditional energy sources are important and core contents, contributing to stabilizing RE in the Federal Republic of Germany, contributing to achieving the country's goal of gradually replacing traditional energy in the Renewable Energy Sources Act (EEG).

POLICY IMPLICATIONS FOR VIETNAM

Prioritizing the RE development is the consistent viewpoint of the Party and Government. The Power Development Plan VIII has set a goal of achieving the RE proportion for electricity generation from 30.9 - 39.2% by 2030 and increasing to 67.5 - 71.5% by 2050... Targets in the Power Development Plan VIII meet the green growth targets set in the Resolution No. 55-NQ/TW of the Politburo on the orientation of Vietnam's National Energy Development Strategy to 2030 with a vision to 2045; meet Vietnam's commitments at COP26 and international agreements to achieve the net-zero goal by 2050 as well as the National Strategy on Climate Change to 2050 in Decision No. 896/QĐ-TTg; and are in accordance with the Political Declaration on establishing the Just Energy Transition Partnership (JETP) with Vietnam by international partners.

To realize the clean energy/RE development strategy, in recent times the Party and the Government have paid attention to developing and gradually improving the system of mechanisms and policies for RE development. Vietnam's legal system on RE development is regulated in many different documents such as: Law on Economical and Efficient Use of Energy 2010, Electricity Law 2004 and 2012, Law on Investment 2020, Law on Environmental Protection 2020... In addition to above legal documents, there are also implementation instructions from the Government such as: Decree No. 137/2013/NĐ-CP detailing the implementation of a number of articles of the Electricity Law and the Law on amending and supplementing a number of articles of the Electricity Law, Decree No. 08/2018/NĐ-CP amending a number of Decrees concerning business investment conditions under the state management of the Ministry of Industry and Trade. The Prime Minister also issued many Decisions to orient and develop RE, including: Decision No. 37/2011/QĐ-TTg on mechanism supporting the development of wind power projects in Vietnam, Decision No. 39/ 2018/QĐ-TTg on amending and supplementing a number of articles of Decision No. 37/2011/QĐ-TTg on the mechanism supporting the development of wind power projects in Vietnam, Decision No. 2068/QĐ-TTg approving Vietnam's Renewable Energy Development Strategy

to 2030, with a vision to 2050, Decision No. 428/QĐ-TTg approving adjustments to the National Power Development Plan for the 2011-2020 period, taking into account 2030 and other policy mechanisms to encourage RE...

As the Ministry in charge and management of energy, the Ministry of Industry and Trade has also issued many documents to promote RE development such as: Circular No. 32/2014/TT-BCT of the Minister of Industry and Trade on procedures for establishment and application of avoidable cost tariff schedule and promulgation of model power purchase agreement to small hydropower plants, Circular No. 32/2015/TT-BCT of the Minister of Industry and Trade on project development and model power purchase agreement to power projects using solid wastes, Circular No. 44/2015/TT-BCT of the Minister of Industry and Trade on project development, avoidable cost tariff schedule and model power purchase agreement to biomass power projects, Circular No. 54/2018/TT-BCT of the Minister of Industry and Trade abolishing Article 7 of Circular No. 44/2015/TT-BCT on project development, avoidable cost tariff schedule and model power purchase agreement to biomass power projects, Circular No. 02/2019/TT-BCT of the Minister of Industry and Trade on the implementation of wind power project development and model power purchase agreement to wind power projects, Circular No. 18/2020/TT-BCT of the Minister of Industry and Trade on project development and model power purchase agreement to solar power projects...

In addition, the mechanism to encourage RE development is expressed in many legal documents such as: Electricity Law, Law on Economical and Efficient Use of Energy, Law on Environmental Protection, Law on Investment, specifically:

Clause 4, Article 4; Point c, Clause 1, Article 13; Clause 1, Article 29; Article 60, Clause 4 of the Electricity Law stipulate that the electricity development policy is to promote the exploitation and use of new energy and RE sources to generate electricity; have preferential policies for investment projects to develop power plants using new energy and RE sources. The State supports and encourages electricity saving through policies for investment projects to develop power plants using new energy and RE sources, enjoying investment incentives, electricity prices and taxes according to the guidance of the Ministry of Finance. Regarding electricity price policy, create favourable conditions for economic sectors to invest in electricity development with reasonable profits, saving energy resources, using new forms of energy and RE that do not pollute the environment in electricity activities, contributing to promoting socio-economic development, especially in rural, mountainous and island areas. Encourage organizations and individuals to invest in building power grids or power generating stations using on-site energy, new energy, and RE to provide electricity to rural, mountainous, border, and island areas [3].

The Law on Economical and Efficient Use of Energy 2010 stipulates that develop RE in accordance with Vietnam's potential and conditions to contribute to ensuring energy security and environmental protection (Clause 3, Article 5); promote economical and efficient use of energy, prioritize the reasonable development of clean energy technology, and increase the proportion of RE use (Clause 1c, Article 6); encourage the production and use of local energy sources such as water, wind, sunlight, biogas, agricultural by-products and other RE sources (Clause 2, Article 24); the State encourages households to implement the following measures to use energy economically and effectively: use insulation materials and household appliances that are energy-saving products; increase the use of vehicles and equipment using RE (Clause 2, Article 27) [4].

Clause 3, Article 5 of the Law on Environmental Protection 2020 stipulates the exploitation, reasonable and economical use of natural resources; development of clean energy and RE; development of technical infrastructure to protect the environment. In addition, Clause 2, Article 64 clearly states that the planning of urban areas and concentrated residential areas must aim to develop ecological urban areas, save energy, and use RE. Activities to respond to climate change; develop and use clean energy and RE; minimize GHG emissions that deplete the ozone layer; producing, importing and using machinery, equipment, and vehicles using RE are among environmental protection activities encouraged by the State. The Government promulgates preferential policies to support and encourage the development of public transport, vehicles using RE, having low fuel consumption, low emissions or no emissions; roadmap for converting and eliminating vehicles that use fossil fuels and vehicles that pollute the environment (Clause 7, Article 65). Investment and business activities related to environmental protection that receive incentives and supports include: Enterprises that produce and provide technology, equipment, products and services to serve environmental protection requirements, including waste treatment technology combined with energy recovery; energy saving technology; centralized domestic wastewater treatment services; ambient environment monitoring services; public transport services using electric energy and renewable fuels; clean energy, RE production (Clause 2b, Article 141). Encourage organizations and individuals to participate in providing environmental services in the following fields: Consulting, transferring environmentally friendly production technology, environmental technology; Energy saving technology, clean energy, RE production; Consulting, training, providing information about the environment, clean energy, RE, energy saving (Clause 3 (d) and (đ) Article 144) [1].

Clause 1b, Article 16 of the Law on Investment 2020 also stipulates, that production of new materials, new energy, clean energy and RE; production of products with added value of 30% or more, energy-saving products in sectors and occupations enjoy investment incentives [2].

In addition to above legal documents, the mechanism to encourage RE development is also recognized in many documents issued by the Prime Minister to support the development of wind power projects, biomass power projects, power generation projects using solid wastes, and encourage the development of solar power.

Thus, Vietnam has had a system of legal documents regulating investment, production and use of RE. These regulations are recognized in legal documents as well as decisions of the Prime Minister, circulars of the Ministry of Industry and Trade and other relevant ministries and agencies. However, because legal regulations on RE are still scattered in many different legal documents (Electricity Law, Law on Investment, Law on Environmental Protection, Law on Economical and Efficient Use of Energy), they have not created a unified policy system in regulating related activities to develop RE. Therefore, it is necessary to study and develop a suitable document system to ensure consistency in investment, exploitation and effective use of RE. Some following suggestions will help Vietnam study and improve legislations on RE in the coming time.

Firstly, lessons learned from analysing the legal framework on RE development of the Federal Republic of Germany show that, in order to ensure uniformity and improve the management effectiveness and efficiency of the current legal framework, a specific legal document should be developed to manage investment, exploitation, management and use of RE. Based on the inheritance of current legal documents on mechanisms and policies for RE development currently recognized in legal documents, decisions of the Prime Minister and guiding decrees and circulars of relevant ministries, sectors as analysed above, it is necessary to supplement and rearrange the contents to include in the draft Law on Renewable Energy regarding: (1) Objectives, strategies, principles, and planning for RE development; (2) Policies to encourage, incentivize, and support investment, exploitation, and use of RE; (3) Pricing policies for RE sources; (4) Regulations on investor selection and investment procedures for RE power projects; (5) Model power purchase agreement and risk sharing mechanism for relevant parties; (6) Regulations on power grid development and electricity connection; (7) Regulations on RE storage; (8) Regulations on information technology application in RE development; (9) Regulations on responsibilities of state management agencies in RE development.

Secondly, it is necessary to study and develop financial policies to increase the mobilization of investment capital for RE development from private and self-accumulated financial sources of enterprises in the power sector through solutions such as increasing attraction of foreign direct investment capital for development of RE projects; increase attraction of capital sources from abroad (including concessional official development aid, non-concessional official development aid, foreign commercial loans); mobilize capital through domestic and foreign bond issuance to invest in RE power projects; improve the efficiency and performance of enterprises in the power sector, ensure accumulation, and ensure the ratio of equity capital for development investment according to the requirements of domestic and international financial institutions.

Thirdly, supplement and improve the system of legal regulations on smart power development, including smart grid and information technology application in the electric energy sector, energy efficiency in the economy; invest in energy storage systems in accordance with the market development situation... ▪

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UN Secretary-General issues call to action on extreme heat

Crippling heat is everywhere. Billions of people around the world are wilting under increasingly severe heatwaves driven largely by a fossil-fuel charged, human-induced climate crisis. More than 70% of the global workforce – 2.4 billion people are now at high risk of extreme heat. The most vulnerable communities are hit hardest. In response to the rapid rise in the scale, intensity, frequency and duration of extreme heat, UN Secretary-General António Guterres called for an urgent and concerted effort to enhance international cooperation to address extreme heat in four critical areas: Caring for the vulnerable; Protecting workers; Boosting resilience of economies and societies using data and science; Limiting temperature rise to 1.5°C by phasing out fossil fuels and scaling up investment in renewable energy.

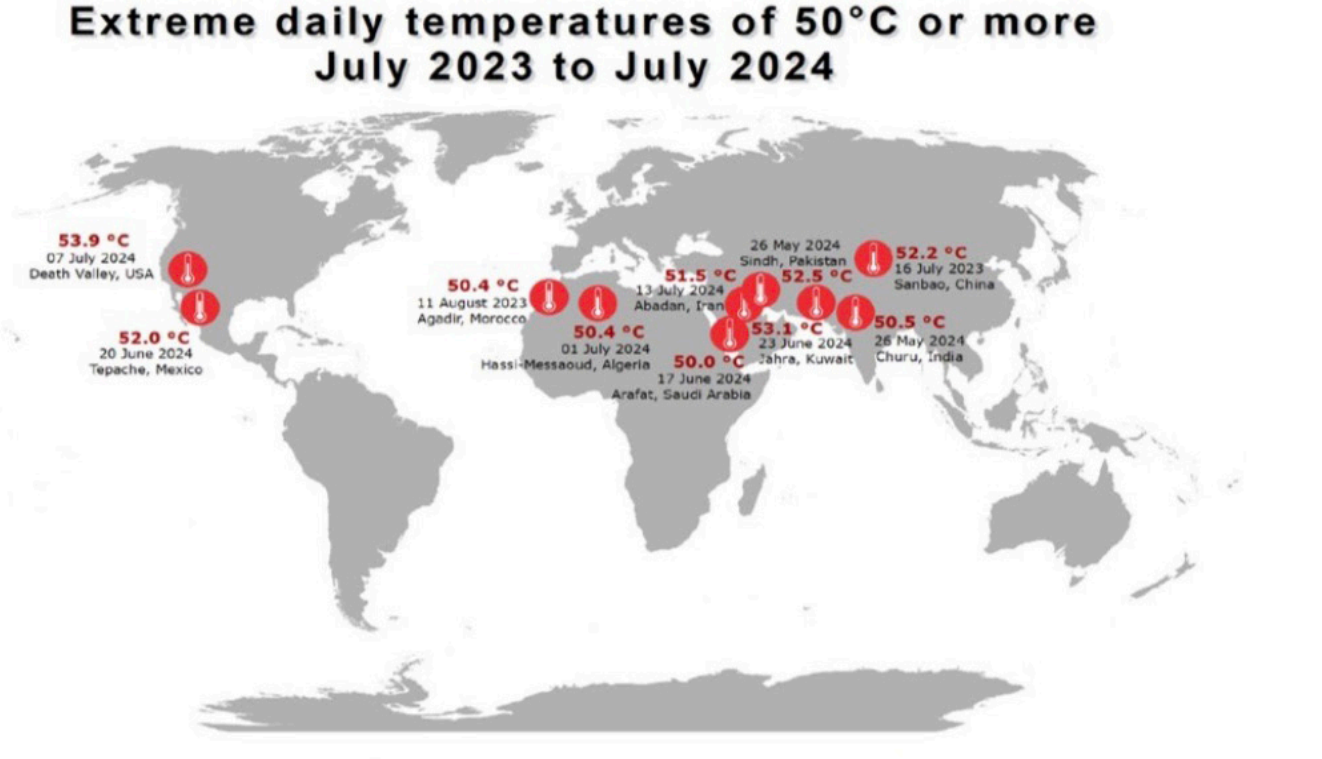
THE WORLD MUST RISE TO THE CHALLENGE OF RISING TEMPERATURES

The World Meteorological Organization is one of ten specialized United Nations entities rallying behind UN Secretary-General António Guterres' Call to Action on Extreme Heat, which is posing an increasing threat to our socio-economic and environmental well-being. The new initiative was launched in a week which saw the three warmest days recorded on Earth in recent history, according to one of the datasets that the WMO uses to monitor the climate.

Earth is becoming hotter and more dangerous for everyone, everywhere. Billions of people are facing an extreme heat epidemic - wilting under increasingly deadly heatwaves, with temperatures topping 50 degrees Celsius around the world. That's 122 degrees Fahrenheit and halfway to boiling.

The World Meteorological Organization, the Intergovernmental Panel on Climate Change, and others have documented a rapid rise in the scale, intensity, frequency and duration of extreme-heat events. Extreme heat is increasingly tearing through economies, widening inequalities, undermining the Sustainable Development Goals and killing people. It is estimated to kill almost half a million people a year, that's about 30 times more than tropical cyclones.

It brings together the expertise and perspectives of ten specialized UN entities, including extensive and detailed input from experts at WMO and in the WMO-WHO Joint Office on Climate and Health. It is a first-of-its-kind joint report underscoring the diverse multi-sectoral impacts of extreme heat on human health, lives, and livelihoods. National and local governments and businesses who are the most impacted around the world also supported the launch of the Call to Action.



Note: Based on reported daily maximum near surface air temperature by NMHSs. List is not exhaustive and includes provisional data.

Source: World Meteorological Organization, 2024

"Our Earth is running an unprecedently high fever," said WMO Secretary-General Celeste Saulo. "In addition to this week's three new global daily temperature records, we have seen monthly temperature records for 13 successive months. Widespread, intense and extended heatwaves have hit communities on every continent. At least ten countries have recorded temperatures of more than 50°C in more than one location this year. Many dozens of locations have seen daytime maximum temperatures of more than 40°C and dangerously high minimum overnight temperatures.

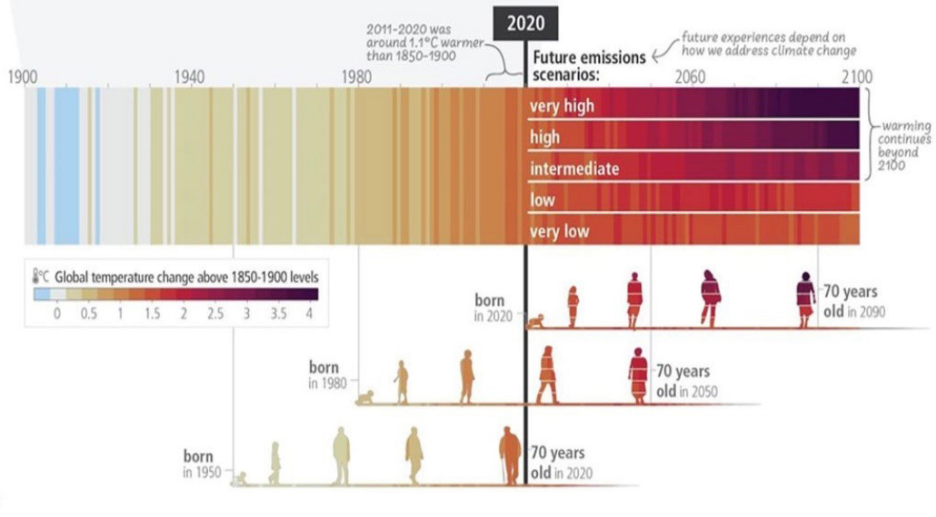
"The WMO community is working hard with many partners to strengthen heat-health action plans and early warnings to treat the symptoms of this fever. But, in addition, we need to tackle the root cause and urgently reduce greenhouse gas levels, which remain at record observed levels," said Celeste Saulo.

The Call to Action stresses the need to establish and bolster heat early warning systems in line with the Early Warnings for all initiative, ensuring at-risk populations receive timely alerts that include information on protective actions to undertake and sources of assistance. Strengthening capacities of National Meteorological and Hydrological Services (NMHSs) would be critical.

There is good news, it says, heat illness and deaths are preventable and many impacts can be minimized with targeted economic and social policies and concrete actions, including public awareness campaigns. It cites recent estimates produced by the WHO and WMO that the global scale-up of heat health-warning systems for 57 countries alone has the potential to save an estimated 98,314 lives per year.

The need is urgent. Modelled estimates show that between 2000 and 2019, approximately 489,000 heat-related deaths occurred each year, with 45 per cent of these in Asia and 36 per cent in Europe. Worldwide, the official diagnosis and reporting of heat-related illness, injuries and deaths are recognized to be under-reported. The lack of uniform reporting standards makes the aggregation and comparison of nationally reported impact statistics challenging, it says.

The extent to which current and future generations will experience a hotter and different world depends on choices now and in the near term



Source: IPCC, 2023: Summary for Policymakers. Figure SPM.1. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001.

Source: United Nations Secretary-General's Call to Action on Extreme Heat 2024

MULTI-SECTORAL HEALTH ACTION

Heat directly impacts people and amplifies the risks of wildfire, droughts, and water shortages and food insecurity. Therefore, the acute, long-term, and compounding risks of extreme heat must be managed across society by multiple sectors.

The WMO and UNDRR Center of Excellence for Disaster and Climate Resilience together with the Global Heat Health Information Network have been working with more than a dozen UN agencies and the International Federation of the Red Cross and Red Crescent Societies to find common approaches to integrated planning, better resource allocation, and improved collaboration to address the systemic drivers of extreme heat risk.

WMO is committed to collaboration with partners in the Early Warnings for All Initiative and the Global Heat Health Information Network to provide a solid framework for more integrated and impactful heat action.

Heat risk management solutions are many. The WMO State of Climate Services for Health 2023 features case studies from around the world showcasing how integrated climate and health action makes a very real difference in people's daily life. This includes early warning systems for extreme heat at city and national level, community-based heat risk awareness campaigns, and nature - based solutions for local cooling.

The Intergovernmental Panel on Climate Change (IPCC) indicates that Heat Action Plans and Heat Health Warning Systems are some of the most effective adaptation options for extreme heat. Sensible occupational safety and health measures that protect indoor and outdoor workers could save US$361 billion a year, according to the International Labor Organization.

Source: ILO. 2024. Heat at work: Implications for safety and health. Geneva: ILO.

EXTREME HEAT IN 2024

According to the report, extreme heat, like other facets of the climate crisis, does not affect everyone equally. It is the most vulnerable and exposed communities in society who are hit hardest. Urban poor and displaced persons are particularly defenseless in the face of extreme heat.

New data from the International Labour Organization (ILO) warns that over 70 per cent of the global workforce – 2.4 billion people – are now at high risk of extreme heat, resulting in 22.85 million injuries and 18,970 deaths annually among workers.

This year heatwaves have hit countries across the globe this year. This led to: A spike in hospitalizations and deaths in the Sahel in Africa; Record temperatures across the United States reportedly placing 120 million people under heat advisory warnings; Scorching conditions that killed 1,300 pilgrims during Haj; Extended heatwaves in Europe; The closure of schools across Asia and Africa – impacting more than 80 million children.

Extreme heat is having devastating impacts on the global economy. One important channel is through diminished worker productivity. Heat exposure-related loss in labour capacity resulted in average potential income losses equivalent to US$863 billion in 2022. Implementing occupational, safety and health (OSH) measures to prevent occupational injuries related to excessive heat could save over US$361 billion globally.

While extreme heat is impacting virtually everyone, everywhere, the costs and burdens are not shared equally. Higher temperatures mean more poverty and greater inequality. According to the Food and Agriculture Organization (FAO), in an average year, poor rural households lose 5 per cent of their total income due to heat stress relative to better-off households.

Repeated seasonal heatwaves can place significant stress on healthcare service delivery and systems. Demand for ambulatory services and healthcare can dramatically increase during extreme heat conditions. It is hard to learn in extreme heat. Many parts of Asia and North Africa experienced school closures in 2024 due to extreme heat, leaving millions of children out of school, widening learning gaps.

More cooling uses more electricity, and around 60% of the world's electricity is currently generated by burning fossil fuels, the very energy source driving climate change in the first place. Greater usage of air conditioners is straining power systems around the world. Cooling accounts for almost 20 per cent of global electricity consumption.

Extreme heat: Impacts

489,000
heat-related deaths occurred 2000–2019 each year, more than from tropical cyclones

12%
About 12 per cent of all food produced is lost due to a lack of cooling

Triple
The installed capacity of cooling equipment globally will almost triple by 2050

80 million
Working hours equivalent to 80 million full-time jobs could be lost due to heat stress by 2030

9.1%
An annual 1°C increase in temperature leads to a 9.1 per cent increase in poverty

80 million students
More than 80 million students are impacted by worldwide school closures due to heat in 2024

Extreme heat: Solutions

98,314
Scaling up heat health warning systems in 57 countries alone can save about 98,314 lives per year

$361 billion
Occupational safety and health measures can save $361 billion a year in medical and other costs

$1 trillion
Reducing cooling energy demand can cut electricity bills for end users by $1 trillion in 2050

Source: United Nations Secretary-General's Call to Action on Extreme Heat 2024

The risk of extreme heat is in part driven and exacerbated by the very practices that prevail in the development of the built environment. Extreme heat poses risks to the built environment, including the transport, energy, water and communication sectors. Global agriculture and food systems are being severely impacted by extreme heat. Extreme heatwaves can trigger a rapid onset of drought and wildfires, which can also be detrimental to agricultural production. The lack of access to sustainable cold chains results in the loss of 526 million tons of food production, or 12 per cent of the total, and contributes to a significant reduction in smallholder farmers' income.

Extreme heat is significantly impacting the global environment. Heatwaves, without concomitant increases in precipitation, can lead to water shortages and increased stress for plants, particularly in arid regions. This has the effect of reducing plant growth, the basis of energy production and the food chain, with an overall drying out of the landscape.

CALL TO ACTION ON EXTREME HEAT

The world needs a strategy to deal with heat that serves to mobilize Governments, policy makers and all stakeholders to act to: prevent and reduce heat risk; increase resilience to heat; manage extreme heat crises; and mitigate its worst impacts. The United Nations will continue to mobilize global heat, health ecosystem and policy experts and bring together the existing expertise and ongoing work of the UN and scientific and technical communities on extreme heat. The crisis we see unfolding globally requires an urgent response. Deadly heat is becoming commonplace. Now is the time to strengthen global action on extreme heat that:

Firstly, recommends concrete measures that can be taken now by Governments and communities to ease the suffering of people everywhere, while building resilient economies and protecting lives and livelihoods.

Secondly, supports Governments and communities everywhere by collecting good practices in policy and governance, risk reduction and management, and including the latest data and science on extreme heat. This is information that can help Governments, and their partners, build resilience to heat risk and save lives.

Thirdly, identifies key areas of national and international cooperation to help address extreme heat risk. The world needs a strategy to deal with heat that serves to mobilize Governments, policy makers and all stakeholders to act, prevent and reduce heat risk; to increase resilience to heat; to manage extreme heat crises; and to mitigate its worst impacts.

Besides, the report call on all countries and communities to protect the most vulnerable people from the impacts of extreme heat, reduce extreme heat risk and build their resilience; enhance social protection schemes to integrate specific measures that help address the risks of extreme heat; establish and bolster heat early warning systems in line with the Early Warnings for All initiative, ensuring at-risk populations receive timely alerts that include information on protective actions to undertake and sources of assistance; increase equitable access to and scale up low carbon cooling; strengthen health systems and operationalize heat-health action plans to prepare healthcare professionals to diagnose and treat heat-related conditions and provide quality care during acute heat emergencies; develop and implement targeted public education campaigns, including in school curriculums, that raise awareness about extreme heat risks and actionable steps that can be taken at all levels, including self-protection; develop and expand international, regional and national financing mechanisms to support early response to heatwaves, with a focus on ensuring that resources reach the local level; invest in preparedness for early, locally-led humanitarian responses to severe heatwaves; improve standardized surveillance and reporting of heat-related morbidity, mortality, and injuries.

The report call on all countries to protect all workers in all sectors through appropriate occupational safety and health measures based on a rights-based approach; call on all countries and communities to build sustainable multi-sectoral and multi-scalar partnerships that ensure development and implementation of comprehensive extreme heat action plans, strategies and solutions to build heat resilience; call on all countries to accelerate the pace of the just transition away from fossil fuels and scale up investment in renewable energy. Limiting global warming to below 1.5°C will significantly reduce the risks, adverse impacts and related human suffering from climate change, including extreme heat. By early 2025, under the Paris Agreement, every country must submit a new Nationally Determined Contribution (NDC) that is 1.5°C-aligned and economy-wide, providing absolute emissions reduction targets for 2030 and 2035, covering all greenhouse gases and all sectors. Take urgent measures to cut super pollutants or short-lived climate pollutants, emanating especially from the cooling sector. Prevent dumping of new inefficient equipment that uses obsolete refrigerants. Finance is critical to raise ambition on mitigation and enhance adaptation measures. needed, and generates momentum for reform of the international financial architecture ▪

XUÂN THẮNG

(Source: United Nations Secretary-General's Call to Action on Extreme Heat 2024)

Protect seagrass through payments for ecosystem services

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1. IMPORTANCE AND THREATS TO SEAGRASS BEDS

Seagrasses are flowering plants or angiosperms that grow in intertidal and shallow intertidal zones in tropical to temperate oceans globally. They form "grasslands" that vary in size and density depending on species and geographical location. Seagrasses provide important ecosystem services to those who depend on them for food and income, and to all people around the world. Healthy seagrass beds support fisheries by is a nursery and safe haven for juvenile fish and shellfish, and also provides a food source for this group of organisms. By acting as a coastal buffer against waves, they protect shorelines from erosion and help maintain other coastal ecosystems such as mangroves. They also provide further benefits for climate regulation by sequestering large amounts of carbon in sediments, preventing its release into the atmosphere as carbon dioxide.

However, seagrass beds are at risk of damage or loss due to many direct and indirect pressures caused by human activities. Seagrass meadows can be eliminated to make way for infrastructure such as marinas. Vessel operations, including anchoring and some fishing methods such as purse seines and dredging, can damage or destroy seagrass beds. Due to pollution and sedimentation or due to land use practices including deforestation and upstream fertilizer runoff, the health of seagrass beds can be affected, in many ways, situations that can cause seagrass to die and disappear. Overall, these threats have resulted in the loss of 29% of global seagrass cover [1].

Therefore, community-based conservation offers an opportunity to fill this gap in protecting seagrass beds. Community groups conserve and manage natural resources through a comprehensive and structured approach, appropriate to the needs and resources of the community. The primary beneficiaries and community-based seagrass conservation project managers will be those communities that live adjacent to seagrass beds and depend on seagrass beds for food or livelihood. Through a community-based approach, communities are empowered to manage the natural resources they depend on, delivering positive outcomes for both ecosystems and people.

2. PROTECT SEAGRASS BEDS THROUGH PAYMENTS FOR ECOSYSTEM SERVICES

One mechanism that facilitates and finances community-based conservation is Payments for Ecosystem Services (PES). PES is an economic tool used for beneficiaries of ecosystem services to pay participants to maintain, protect and develop the functions of that ecosystem. In other words, PES is an environmental protection mechanism, through which individuals and organizations pay communities to carry out conservation activities or enhance the provision of ecosystem services. Those who pay for PES are motivated by direct or indirect benefits. For example, coastal mangrove forests have the effect of blocking waves, resisting the impact of natural disasters, maintaining the region's aquatic resources... Therefore, those who benefit through direct exploitation of the values that mangrove forests create must be responsible for paying a commensurate amount to those directly involved in maintaining and protecting the functions of mangrove forests. Or food and beverage manufacturers may benefit from improved water quality for their products and will therefore have to pay for environmental protection to improve water quality instead of paying for high - cost water treatment facilities. Other "beneficiaries" of payment for ecosystem services may be indirect. A common example is the purchase of carbon credits, in which individuals or organizations whose activities (such as flying by plane) emit carbon pay for activities such as planting or preserving trees that sequester that carbon. This allows individuals and organizations to reduce their environmental footprint.

In fact, payment for ecosystem services has been widely recognized as a successful policy tool for natural resource management in more than 60 countries. These programs have been applied to various ecosystem services internationally, including: biodiversity conservation, river basin services, carbon sequestration and landscape beauty. The total annual payout of PES programs worldwide is over 36 billion USD. Through PES, natural resource managers can receive environmental protection funds paid by individuals or organizations. PES deals are typically managed by third parties and are based on measurable outcomes such as biodiversity conservation or carbon sequestration. To date, no PES project has focused exclusively on seagrass conservation. However, the Mikoko Pamoja Blue Carbon Project, Kenya is a typical model of community groups using PES to support coastal conservation projects and demonstrates initial successes in mangrove and seagrass beds protection.

The Mikoko Pamoja blue carbon project has been running since 2013 on the southern coast of Kenya and is run by the Mikoko Pamoja Community Organization (MPCO) to restore mangroves and seagrass beds through the sale of carbon credits. The Mikoko Pamoja blue carbon project exploits the natural carbon capture ability of these ecosystems and uses it to sequester emissions instead of releasing them into the atmosphere to restore habitats, while also generating profits finance for sustaining communities. In addition, the Project will create positive economic and environmental impacts on coastal communities, while minimizing the impact of climate change.

▲ *Kenyan coastal communities work to restore mangroves*

The Mikoko Pamoja blue carbon project applied an integrated coastal ecosystem approach. Here, people have planted 117 hectares of mangrove forests with an average of 2,500 credits sold each year (one credit is equivalent to 1 ton of CO_2). On average, carbon sales generate about $24,000 per year, 35% of which covers project costs, while 65% is reinvested in the community. The project operates as a carbon credit-funded mangrove conservation project for 6 years, then integrates seagrass as an added benefit. The Project design allows monitoring of seagrass beds in an effective yet simple and inexpensive way. Through the Mikoko Pamoja Project, the community gains skills, experience and services, as well as exposure on international platforms. Collaborating organizations have the opportunity to conduct research and support community in innovative climate mitigation activities.

The Project's successful network building is a result of clear roles and responsibilities, shared trust developed over many years, and shared benefits from participating in the partnership. Mikoko Pamoja's success is mainly due to community participation, support from scientific institutes, government support and international networks. The Mikoko Pamoja project is managed by the community restored 117 hectares of mangrove ecosystem in Gazi Bay, Kenya. This project is called "The world's first blue carbon project and has brought the community awards as well as a higher standard of living.

3. PAYMENT MECHANISM FOR MARINE AND WETLAND ECOSYSTEM SERVICES IN VIETNAM

Article 138 of the Law on Environmental Protection clearly stipulates payment for natural ecosystem services. Accordingly, payment for natural ecosystem services is when organizations and individuals using natural ecosystem services pay organizations and individuals providing environmental and landscape values created by natural ecosystems to protect, maintain and develop natural ecosystems. Natural ecosystem services covered include: Forest environmental services of forest ecosystems according to the provisions of forestry law; wetland ecosystem services serve the purposes of tourism, entertainment, and aquaculture; Marine ecosystem services serve the purposes of tourism, entertainment, and aquaculture; ecosystem services of rocky mountains, caves and geoparks for tourism and entertainment business purposes; natural ecosystem services serve the purpose of absorbing and storing carbon.

Regarding the principle of payment for natural ecosystem services, organizations and individuals using one or several natural ecosystem services must pay for natural ecosystem services; payment for natural ecosystem services is made in the form of direct payment or indirect payment through Trust fund; payment for natural ecosystem services is included in the cost of products and services of the users of natural ecosystem services, and must ensure compensation for costs of activities to protect, maintain and develop natural ecosystems; organizations and individuals providing natural ecosystem services must use the money collected from payments for natural ecosystem services to protect, maintain and develop natural ecosystems.

Organizations and individuals must pay for natural ecosystem services when engaging in the following activities: Exploiting and using the water and sea surface of the ecosystem for aquaculture and underwater entertainment services; Exploit and use the landscape of the ecosystem for tourism and entertainment services; Production and business

▲ *Seagrass conservation plays an important role in maintaining coastal ecosystems*

that emit greenhouse gases must use the ecosystem's carbon absorption and storage services to mitigate greenhouse gas emissions.

In Vietnam, payments for forest environmental services have been successfully implemented for more than a decade, contributing to increasing financial resources for forest protection and development. Lessons learned from payments for forest environmental services are the basis for replicating similar mechanisms for other ecosystems, including marine and wetland environments. Vietnam has implemented initiatives for marine and wetland ecosystems, however, there is currently no comprehensive form of payment for the services of these ecosystems. Some practical applications of payment for ecosystem services in Vietnam include: collecting service fees for visiting protected marine and wetland areas, co-management models of aquatic resources, or developing environmentally friendly aquaculture methods in some coastal areas with the support of international organizations and related industries... Many of these initiatives cannot be maintained for long term due to unclear legal basis.

The success of PES programs depends on many different factors. Watershed services, forest environmental services, biodiversity conservation, carbon sequestration and landscape beauty are the main objectives of PES programs globally. The best results are achieved when services are clearly defined, beneficiaries are well organized, and land and resource management communities have clear ownership rights and a strong legal framework.

Therefore, to implement PES programs for coastal areas in the near future in Vietnam, it is necessary to: Develop criteria and methods to evaluate national marine and wetland ecosystem services; support assessment and evaluation of ecosystem services at the grassroots level; mapping the current status of marine and wetland ecosystem services in Vietnam; Develop guidelines for provincial and grassroots level payment mechanism schemes; Pilot payment activities and complete policies and regulations on payments for natural ecosystem services, focusing on marine and wetland ecosystems.

4. CONCLUSION

Conservation is critical way to maintaining healthy coastal ecosystems, including maintaining productive fisheries. As a "Blue Carbon" habitat, seagrass beds are an important carbon store and maintaining healthy seagrass beds will help to increase carbon sequestration and prevent the release of carbon dioxide into the atmosphere.

As many local communities rely on seagrass beds for their livelihoods and as a food source, they are well suited to community-based conservation management, allowing local people to benefit from sustainable management. This conservation can be based on the PES model, enable results-based financial benefits to local communities for sustainable management of seagrass beds, which may be based on carbon sequestration or other ecosystem services including enhanced fisheries or coastal protection. PES provides a useful framework for seagrass conservation and benefits to communities ▪

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3. Promoting international cooperation and information exchange for tackling environmental pollution caused by pesticide packaging.

Promoting international cooperation and information exchange for tackling environmental pollution caused by pesticide packaging

Collection and disposal of empty pesticide containers does not only create an environmental impact but also contribute to protecting the health of farmers and communities in agricultural areas, preserving water quality, reducing soil and air pollution, and moving towards agricultural production that meets higher safety standards. On the occasion of the "2024 International Container Management Symposium" co-organized by the Plant Protection Department (MARD), CropLife International, EuroCham, and CropLife Vietnam in Ho Chi Minh City, the Environment Magazine interviewed Dr. Andrew Ward – Stewardship, Director of CropLife International and Dr. Tan Siang Hee – Executive Director of CropLife Asia on solutions to tackling pollution caused by empty containers in different countries around the world, including Vietnam.

✓ ***Could you please update us with the current context of container management in the world, including plastic waste in agriculture? Is there any international experience that can be applied to Vietnam?***

Dr. Andrew Ward – Stewardship, Director of CropLife International: In 2023, the global container management collection rate (average) was 66%. We do not know of any other industry which has a higher collection rate. However, we are not satisfied with this and are looking to establish new Container Management Systems and increase the effectiveness of already existing systems. The sharing of experience is vitally important and therefore, the global community of Container Management Systems, representing 69 countries are urged to share data and experiences so as to help each other grow. Such information was previously shared with China in a similar event organized in 2022, which has afterwards become an incredible container management success story. Therefore, there is a huge amount of global experience which can be called upon and be applied to Vietnam in the future.

✓ ***At CMS 2024, in addition to Container management, the Extended Producer Responsibility (EPR) and Innovations in Container Management are discussed to figure out opportunities and how they influence the container management in the future. As a co-host of the symposium, could you please elaborate on these topics discussed at the event?***

Dr. Andrew Ward – Stewardship Director of CropLife International: Extended Producer Responsibility (EPR) and Innovations in container management will affect container management, potentially helping to increase the scale and effectively of Container Management Systems. Globally, EPR provides a legal context for industries to support packaging collection. CropLife advocates for a particular consideration for empty pesticide packaging management which does have a level of risk and so is different to the management of other plastics. EPR fees from across the crop protection industry can be allocated to establish Container Management Systems which we have seen grow in many countries to also manage other types of agricultural plastics. Innovations in container management are numerous and can include innovations in how we communicate with farmers and their families, sorting machinery, crushing or shredding machinery and then innovations in mechanical or chemical recycling.

▲ *Dr. Andrew Ward – Stewardship Director of CropLife International*

✓ ***Vietnam is among the top rice exporters in the world with a vast area of agricultural production. Each year, the agricultural industry generates hundreds of tons of pesticide containers, along with post-use chemical residues. What do you think about the current situation of pesticide management in Vietnam?***

Dr. Tan Siang Hee – Executive Director of CropLife Asia: Vietnam's position as one of the top rice exporters globally places a spotlight on the country's agricultural practices, including pesticide management. The issue of pesticide containers and chemical residues management is an important one that requires sustained attention and work – not just in Vietnam, but around the region and world.

In recent years, there have been positive developments in Vietnam's approach to pesticide management. CropLife Asia, in collaboration with the Vietnam Government's Plant Protection Department (PPD), signed an Memorandum of Understanding (MoU) to establish a national Sustainable Pesticides Management Framework (SPMF). This framework underscores the commitment of both parties to enhance pesticide management practices, particularly through the promotion of responsible pesticide use, improved farmer education, and establishment of empty container collection systems.

We are actively engaged in promoting solutions such as the Empty Container Management (ECM) program, which focuses on the safe disposal and incineration of post-use containers. While progress has been made, continued efforts in strengthening regulatory frameworks, increasing public-private partnerships, and boosting on-the-ground training for farmers are crucial in addressing the environmental impact of pesticides and ensuring the long-term sustainability of Vietnam's agricultural sector.

✓ ***At present, the collection of empty containers must comply with regulations subject to the environmental protection law; Decree and Circular giving guidance on its implementation, and specifically Article 3 in Joint Circular No.05/2016/TTLT-BNNPTNT-BTNMT. From CropLife's perspective, how do you think these regulations have addressed the issue of container management? What limitations need to be overcome in years to come?***

Dr. Tan Siang Hee – Executive Director of CropLife Asia: The regulatory framework in Vietnam, including the Environmental Protection Law and the guidance provided through Decrees and Circulars such as Joint Circular No.05/2016/TTLT-BNNPTNT-BTNMT, reflects the government's strong intent to manage the disposal of pesticide containers responsibly. These regulations are a significant step forward in addressing the environmental impact of pesticide use, particularly by setting clear requirements for the collection and disposal of empty containers.

From CropLife's perspective, while these regulations have laid an essential foundation, their effectiveness hinges on consistent enforcement, on-the-ground implementation, and widespread farmer engagement. The framework needs to be supplemented with more robust infrastructure to support collection points and disposal systems, especially in rural and hard-to-reach areas where many of Vietnam's agricultural activities take place.

Looking ahead, some limitations that need to be surmounted include increasing farmer education and awareness on proper container disposal, enhancing the accessibility of collection points, and developing incentive mechanisms to encourage broader participation. Public-private partnerships, such as the collaboration between CropLife Vietnam and the government, can play a crucial role in filling these gaps by driving innovative solutions and expanding outreach to farmers. These efforts will be critical to make sustainable progress in container management over the coming years.

✓ ***What are your expectations for the outcome of CMS 2024? Do you have any recommendations for government units to address pollution caused by empty containers in the world as well as in Vietnam?***

Dr. Tan Siang Hee – Executive Director of CropLife Asia: CMS 2024 creates an important platform for fostering collaboration and driving meaningful discussions on the global challenges related to pesticide container management. My expectations for CMS 2024 are focused on advancing the dialogue around innovative, scalable solutions for sustainable container management and fostering stronger partnerships between the public and private sectors. I anticipate that the event will highlight best practices from around the world and inspire new commitments to reducing pollution caused by empty containers.

▲ *Dr. Tan Siang Hee – Executive Director of CropLife Asia*

In terms of recommendations for government units, both in Vietnam and globally, I believe a multi-faceted approach is essential to effectively address the pollution caused by empty pesticide containers, specifically:

Firstly, strengthening regulatory frameworks: Governments should look at enhancing existing regulations and ensuring that they are aligned with international best practices in container management. This includes adopting clear guidelines on collection and safe disposal.

Secondly, expanding infrastructure for collection and disposal: Establishing more accessible collection points, especially in rural areas, and creating efficient incineration facilities will help prevent improper disposal and reduce environmental pollution.

Thirdly, public-private partnerships: Governments should actively engage with the private sector, including organizations like CropLife, to leverage expertise, resources, and technology. Collaborations can drive the development of innovative, eco-friendly solutions and ensure effective implementation.

Fourthly, education and awareness campaigns: Governments should continue investing in farmer education programs that emphasize the importance of proper container disposal. This includes promoting stewardship programs like the Empty Container Management (ECM) initiative, which has been successful in several regions.

Fifthly, incentivizing participation: Introducing incentive mechanisms to encourage farmers and other stakeholders to actively participate in container collection and disposal programs can significantly enhance their effectiveness.

The focus must be on sustainability. Ensuring that Vietnam and other countries continue to develop their agricultural industries goes hand-in-hand with prioritizing environmental protection and responsible pesticide management at the same time.

Thanks for joining us in this interview.

PHẠM ĐÌNH

Viet Nam net-zero commitment - Opportunities, challenges and solutions

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Net-zero is an environmental goal that aims to reduce emissions of greenhouse gases (GHGs) such as CO_2, CH_4, N_2O in balance with the earth's ability to absorb or remove emissions, to the point where total net gas emissions are reduced to "zero", contributing to minimizing the impact of climate change according to the Paris Agreement, with the hope of keeping global temperature increase below 2°C and efforts to limit warming to below 1.5°C above pre-industrial levels. To achieve this goal, it is required to reduce emissions from sources such as transportation, industrial production, and electricity; enhance carbon absorption through new afforestation, forest conservation, carbon capture and storage technology. Therefore, the Government and businesses as well as every Vietnamese citizen need to join hands to take useful actions to reduce emissions, and actively support solutions to enhance the ability to absorb carbon, creating a low-emission and more sustainable economy.

1. THE NEED TO REDUCE CARBON EMISSIONS TOWARDS THE NET-ZERO GOAL

Climate change and global warming have become one of the biggest threats to humanity in the 21st century, this is caused by human activities, in which the root cause is the burning of fossil fuels such as coal, oil and natural gas, leading to CO_2 emissions and increasing GHG concentration in the atmosphere. CO_2 concentration in the atmosphere in pre-industrial times (1750) was 280 ppm (IPCC, 2014) and reached a record level of 407.4 ppm in 2018 (IEA, 2019b). IPCC (2018) shows that the global average temperature in the 2006-2015 decade was 0.87°C higher than the average for the 1850-1900 period. Climate models predict that, if strong measures are not taken to reduce fossil fuel use, CO_2 concentration in the atmosphere will reach 700 - 900 ppm by 2100, thereby leading to an increase in global average temperature from 3 - 5°C by 2100 (IPCC, 2014).

On the other hand, in the 1990s, scientists from the Intergovernmental Panel on Climate Change (IPCC) warned that the global average surface temperature would increase by 0.3 - 0.6°C within 100 years from now, however, the IPCC Sixth Assessment Report (AR6) published in 2021 shows that GHG emissions from human activities have caused the earth to warm by 1.1°C since the 1850-1900 period and each decade of the past 40 years has been successively hotter than the previous decades since 1950. Compared to 1901, the average sea level rose 20cm in 2018; the average sea level rise is about 3.7mm per year (from 2006 to 2018). However, the IPCC Special Report also points out that, if the world reaches net-zero by 2040, the chance of limiting warming to 1.5°C will be significantly higher. The earlier and lower the emissions peak, the faster net-zero will be reached, making the Earth less dependent on carbon removal in the second half of the century.

Faced with the above reality, the 26th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26) taking place in Glasgow - Scotland, UK (November 2021) is considered the last chance for all countries in the world to fulfill their commitments to limiting global warming under the Paris Agreement. There are 6 main issues of special concern at COP26, including: (i) propose solutions to achieve the goal of carbon neutrality by the middle of the 21st century; (ii) ensure that global temperature increase is maintained below 1.5°C during the industrialization period; (iii) conserve natural ecosystems; (iv) ensure financial funds for climate change; (v) develop a detailed plan for implementing the 2015 Paris Agreement; (vi) discuss possibilities for cooperation in responding and adapting to climate change. COP26 brings great hope to humanity of keeping the global average temperature increase to no more than 1.5°C and achieving net-zero by the middle of the 21st century with promising commitments from leaders. To date, 137 countries made commitments to net-zero; 77 countries, localities and corporations signed the Global coal to clean power transition statement; 45 countries made commitments to transition to green, sustainable agricultural investment; many car companies announced that they will stop producing gasoline-powered vehicles by 2040 at the latest; the US and China released the Joint statement on enhancing cooperation to address the climate crisis... This treaty calls for accelerating efforts to gradually phase out coal power that does not use carbon capture technology and ineffective fossil fuel subsidies, and at the same time acknowledge the need for support towards a just transition. This is considered an important turning point, because for the first time fossil fuels were mentioned in an agreement during a UN climate summit.

In Vietnam, over the past many years, our country has gained encouraging achievements in socio-economic development, in which the energy sector has made a positive contribution to overall development of the country, but it also faces many challenges, especially dependence on fossil fuels, leading to environmental pollution and GHG emissions. Therefore, to address challenges of climate change mitigation as well as sustainable supply and use of energy sources, a transition to a low-carbon economy,

towards net-zero emissions is a necessary and urgent task for our country in the current context. According to the Vietnam Institute of Strategy and Policy for Industry and Trade (Ministry of Industry and Trade), markets are pushing the world towards the highest level of fossil fuel use. The International Energy Agency (IEA) predicts that coal, oil and gas will peak before 2030, therefore, the development and expansion of the use of renewable energy such as solar power, wind power, hydropower and bioenergy are important steps to reduce dependence on fossil energy in Vietnam.

On the other hand, according to data from Vietnam Electricity (EVN), by the end of 2022, there were 8,908 MW of solar power, 7,660 MW of rooftop solar power, 5,059 MW of wind power, 395 MW of biomass power and solid waste power in total power capacity. According to the Power development plan VIII, by 2030, renewable energy sources (including hydropower, solar power, wind power, biomass power) will increase from 38.2 GW (2020) to 73.78 GW; the proportion of renewable energy sources in the capacity structure accounts for 50.3%, although the proportion of hydropower is estimated to decrease from 30% to 20% due to low potential; electricity produced from renewable energy sources accounts for 36%. By 2050, the total capacity of renewable energy sources will be nearly 400 GW, accounting for 69.8% of total power capacity, so Power plan VIII will be the foundation for energy policy in the coming years.

2. VIETNAM'S STRONG COMMITMENT TO IMPLEMENTING NET-ZERO

Sustainable development is a vital factor, determining the fate of human civilization in the new era. In fact, Vietnam has been aware of this issue quite early, as shown in the 11th National Congress of the Communist Party (2011), that approved the Socio-economic development strategy for the 2011-2020 period, with a consistent view of rapid and sustainable development. Next, the UN Summit on sustainable development held on 25th September 2015 in New York (USA) adopted the document "Transforming our world: The 2030 Agenda for sustainable development" with 17 sustainable development goals (SDGs) and their 169 targets. Among the SDGs set for 2030, there are 5 goals directly related to natural resources, environment and climate change issues: (i) Ensure availability and sustainable management of water and sanitation for all (SDG 6); (ii) Ensure sustainable consumption and production patterns (SDG 12); (iii) Take urgent action to combat climate change and its impacts (SDG 13); (iv) Conserve and sustainably use the oceans, seas and marine resources for sustainable development (SDG 14); (v) Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (SDG 15). Implementing the Party's guidelines and the UN's 2030 Agenda, the Government of Vietnam has issued the sustainable development strategy for the 2011-2020 period; National action plan to implement the 2030 Agenda for SDGs... which define the development model as green economy, green society, green lifestyle, promoting sustainable consumption, greening the transition process towards equitable, inclusive development and enhanced resilience.

In particular, at COP26, Vietnam officially committed to gradually phasing out coal-fired power by 2040 and achieving net-zero emissions by 2050. After COP26 and COP27, with the drastic direction of the Prime Minister, the National Steering Committee implemented the commitment; relevant ministries, sectors and agencies advised and submitted to the Prime Minister to promulgate many schemes, strategies, master plans and action plans, including the National strategy on climate change; National strategy on green growth; National action plan on green growth; Action program on green energy transition, reduction of carbon and methane emissions; Program on sustainable forestry development; Power development plan VIII towards renewable energy as the main focus; development of 1 million hectares of high-quality, low-emission rice; development and implementation of the nationally determined contributions; promulgation of the Plan for the implementation of the just energy transition partnerships (JETP) mechanism... Next, at COP28, Vietnam once again reaffirmed the determination and efforts of the entire political system, ministries, agencies, sectors, and people in implementing the commitment at COP26, joining hands with the world to fight climate change, at the same time, announced the Plan for mobilizing resources to implement JETP; emphasized that the just energy transition is decisive for achieving Vietnam's national energy development strategic direction, aiming to achieve net-zero emissions by 2050 and sustainable development goals in the spirit of taking people as the centre.

Most recently, in the National strategy on climate change approved in Decision No. 896/QĐ-TTg dated 26th July 2022 of the Prime Minister, Vietnam has declared the goal of ensuring the total national GHG emissions by 2030 decreased by 43.5% compared to the business as usual scenario (BAU), of which the energy sector decreased by 32.6%, emissions not exceeded 457 million tons of CO_2 equivalent (CO_2eq); the agricultural sector decreased by 43.0%, emissions not exceeded 64 million tons of CO_2eq; emissions in forestry and land use sectors decreased by 70% and carbon absorption increased by 20%, total emissions and absorption reached at least -95 million tons of CO_2eq; the waste sector decreased by 60.7%, emissions not exceeded 18 million tons of CO_2eq; the industrial processes

sector decreased by 38.3%, emissions not exceeded 86 million tons of CO_2eq; establishments with annual GHG emissions of 2,000 tons of CO_2eq or more must reduce emissions. By 2050, ensure the total national GHG emissions reached the net-zero emissions; emissions peaked in 2035, then decreased rapidly, of which the energy sector decreased by 91.6%, emissions not exceeded 101 million tons of CO_2eq; the agricultural sector decreased by 63.1%, emissions not exceeded 56 million tons of CO_2eq; emissions in forestry and land use sectors decreased by 90%, carbon absorption increased by 30%, total emissions and absorption reached at least -185 million tons of CO_2eq; the waste sector decreased by 90.7%, emissions not exceeded 8 million tons of CO_2eq; the industrial processes sector decreased by 84.8%, emissions not exceeded 20 million tons of CO_2eq; establishments with annual GHG emissions of 200 tons CO_2eq or more must reduce emissions.

3. OPPORTUNITIES AND CHALLENGES TO IMPLEMENT NET-ZERO IN VIETNAM

3.1. Opportunities

Reality shows that Vietnam has many advantages in natural, social and human factors, which is great potential to promote the implementation of green growth such as: Abundant carbon reserves from natural forest resources, accounting for more than 40% of the country's total terrestrial area; hot and humid weather in the equatorial region, which is the condition for the development of tropical forests with large carbon reserves; strong renewable energy development resources thanks to its prime geographical location in the near-equatorial area, with lots of sunshine and a long, windy coastline... On the other hand, in recent times, the topic of green growth and sustainable development has always been an issue of concern for the Party and the State, right after the COP26, the Prime Minister approved the National strategy on green growth for the 2021-2030 period, with a vision to 2050. To realize the Strategy, the Prime Minister has issued the National action plan on green growth, aiming at 4 important target groups, including reducing GHG emission intensity per GDP; greening economic sectors; greening lifestyles and promoting sustainable consumption; greening the transition process on the principles of equality, inclusion, and enhanced resilience. Accompanying the action plan, there are a series of solutions and policies to concretize goals associated with innovating growth models, ensuring harmonious development in all three aspects: economic prosperity, environmental sustainability and equitable society. This is a fairly comprehensive plan, which is important in realizing the commitment to achieving net-zero emissions by 2050 as well as Vietnam's determined contributions.

Particularly, the Ministry of Planning and Investment, as the national focal point for green growth, has coordinated with ministries, sectors and local authorities to focus on implementing the action plan to promote green, clean, sustainable energy transition and strengthen the management and development of industrial parks and clusters; convert regular buses to electric buses, at the same time research, negotiate and implement new mechanisms to mobilize resources from outside; strengthen international cooperation activities to exchange experiences in promoting green growth... In particular, the Ministry is urgently completing and submitting to competent authorities to develop a set of scientific criteria on national green classification, ensuring harmony with international practices, this is an important legal framework in implementing green growth, helping agencies have a specific legal basis in selecting investment projects in ministries, sectors and local authorities; quantifying and evaluating the progress of green growth.

In addition, Vietnam's strong commitments and responsible contributions at COP26 were highly appreciated by the international community, opening up many opportunities for cooperation on low-emission growth, promoting development of circular economy, adapting to climate change. In other words, Vietnam is following the mainstream of the global development trend along with developed countries having economic and high-tech potential. The commitment to the achievement of net-zero emissions has sent a strong signal to the international community, opening up and creating favourable conditions for the country to take advantage of the shift of global financial resources for low-emission development and effective response to climate change. In particular, thanks to many advantages in switching to renewable energy, Vietnam can attract green finance from the committed financial package provided by countries with 100 billion USD per year for the development of green economy, circular economy and renewable energy, staying ahead of investment and credit flows from credit and financial institutions around the world... at the same time, take advantage of cooperation opportunities on low-carbon technology transfer, reducing dependence on fossil fuel sources, unlocking the potential of renewable energy, including developing offshore wind energy...

3.2. Challenges

According to the BAU scenario, Vietnam's total emissions by 2030 are expected to be 932 million tons, of which the energy sector accounts for 680 million tons, so achieving the net-zero goal is a very huge challenge. Furthermore, the GHG emission reduction roadmap proposed at COP26 requires all countries to strongly transition to low-emission development and to achieve this goal, energy transition towards ending the use of coal is an issue that Vietnam needs to make great efforts, in which energy is the sector that must be given top priority, because this is the sector with the largest emissions. According to calculations by the MONRE (2020), in the energy sector, 60% of emissions come from the energy industry - mainly from electricity production, and according to the

BAU emission scenario of Vietnam, it is expected that by 2050, 81% of emissions will come from the energy sector, so energy will be the sector that determines Vietnam's net-zero goal.

The Global Wind Energy Council (GWEC) believes that to achieve the net-zero goal, it is necessary to stop implementing new coal projects, as well as provide a roadmap to phase out current coal projects. With the global trend shifting away from fossil fuels, the coal era is ending and new coal projects will face many difficulties in mobilizing finance. Currently, our country's coal power capacity reaches about 21.3GW, contributing 50% of total electricity output, this number will also increase to 40.9GW in 2030 and up to 50.9GW in 2035 (According to the Power plan VIII). In particular, with 15.8GW of estimated power source capacity that has not yet been financed in Power plan VIII, it will be a big challenge when Vietnam sets the net-zero goal by 2050 because there are more than 100 financial institutions announced to withdraw from coal mining projects and coal power plants to achieve the goal of reducing carbon emissions. Experts say that, on the path to achieving the net-zero goal, Vietnam is facing two big challenges: Firstly, in terms of capital sources, according to the World Bank, by 2040, Vietnam will need 368 billion USD to achieve the net-zero goal, but the State Bank's statistics show that Vietnam's green credit balance as of 30th June 2023 only reached nearly 528.3 trillion VND, accounting for a proportion of about 4.2% of total outstanding public debt of the entire economy. On the other hand, international financial capital for green development is no longer cheap, while interest rates of the Federal Reserve (US Central Bank - FED) and European countries are at very high levels, therefore finding capital for green development in Vietnam is no small challenge, because capital from international financial institutions is still important in the long term to move towards green bonds and green credits. The second includes innovation capacity with green development, infrastructure and production conditions; training human resources and workers; governance standards and information disclosure standards. This leads to the fact that not all businesses are willing to participate in the transition process, especially in terms of investment capital and operating activities.

4. THE KEY SOLUTIONS FOR THE COMING TIME

To achieve the net-zero goal by 2050, Vietnam needs to focus on implementing the following key solutions:

Firstly, it is necessary to continue to improve the policy and legal system to promote green growth and develop the circular economy; guide and effectively implement provisions on responsibilities, roadmaps, and methods to reduce GHG emissions of the Law on Environmental Protection 2020 as well as documents under the Law. In particular, special attention should be paid to developing the domestic carbon market and expanding, connecting with the international carbon market; implementing emission quota allocation; developing carbon exchange & offset mechanism, and credit certification mechanism... to encourage businesses, people, especially rural areas, to implement many carbon recovery solutions through economic activities such as afforestation, greening of bare land, waste treatment to recover carbon... This is not only a simple economic activity but also makes an important contribution to carbon recovery, reducing net emissions, moving towards net-zero.

Secondly, promote propaganda, awareness raising for businesses, people and the whole society about the important role of reducing GHG emissions and protecting the atmosphere, first of all by strengthening capacity for state management officials in all sectors, moving forward to universalizing knowledge about GHG emissions through the national education system, training and fostering programs for officials at all levels. At the same time, organize forums, conferences, seminars, cultural and artistic programs to integrate advocacy and propaganda; organize exhibitions displaying products and

▲ *Vietnam's commitment to achieving net-zero by 2050 affirms its determination to implement global goals*

technology, launch creative competitions on GHG emission mitigation... thereby calling, mobilizing businesses, organizations and people to actively participate in GHG emission mitigation activities.

Thirdly, Vietnam needs to plan the national power grid until 2030 and a roadmap to 2050, which prioritizes public investment, strengthens the power transmission network, has alternative energy solutions, and attracts private projects on wind energy, solar energy, hydrogen energy, biomass energy... Synchronously invest in infrastructure and technology in the energy sector, gradually reduce towards ending dependence on foreign technology in the new energy sector, at the same time, have preferential policies to encourage and create favourable conditions for businesses to develop and use new energy in production and business.

Fourthly, research to establish a national renewable energy centre to develop human resources, transfer technology, share experiences and national governance in this sector. At the same time, it is necessary to promote climate diplomacy, mobilize to attract international resources (public and private financial sources, technology, knowledge, experience...) through exchanges and high-level visits, working programs of ministries, sectors and local authorities with foreign partners and Vietnamese representative agencies abroad; take advantage of all the opportunities that JETP offers; focus on creating a favourable legal environment and strengthening governance capacity to effectively use loans and investments for clean energy and renewable energy development. In addition, it is necessary to improve policies to promote innovation, technology transfer, digital transformation and human resource development, which are important factors for the green transformation process, towards the net-zero goal by 2050.

5. CONCLUSION

From net-zero commitment to specific, practical actions is a long journey for a developing country like Vietnam, requiring a clear awareness of green transformation, development and implementation of low-emission production and business models, but this will also be a time and opportunity for Vietnam to enhance its position in the international arena, affirming its determination to act together to realize the global goals; an opportunity for our country to restructure the economy, transform the growth model based on knowledge, digital transformation, green transformation, high-quality human resources, science and technology, leading the country to develop along the "green path", with high income by 2045. In this journey, the joint coordination between the Government, people and businesses is a key factor, making an important contribution to ensuring economic development associated with environmental protection, towards the sustainable development goals ▪

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The Environmental Performance Index (EPI), developed by Yale University (USA) since 2006 and published every 2 years, integrates various indicators in different fields to assess the efforts of countries in achieving environmental goals. According to the latest EPI report released in June 2024, Vietnam's score has continued to decline. This article focuses on updating the methodology of the EPI and the results of Vietnam's EPI performance for 2024.

THE ENVIRONMENTAL PERFORMANCE INDEX (EPI)

The first Environmental Performance Index (EPI) framework was constructed based on two main environmental objectives: (i) environmental protection for human health, also known as environmental health, and (ii) protection of the natural habitats, also known as ecosystem vitality. However, since 2022, the EPI framework has been adjusted to consist of three policy objectives: (i) Environmental Health, (ii) Ecosystem Vitality, and (iii) Climate Change.

The EPI 2024 utilizes the latest data, science, and technology to provide the most comprehensive assessment of global sustainability. In total, the EPI integrates data on 58 performance indicators grouped into 11 environmental issue categories to rank 180 countries based on progress in mitigating climate change, protecting ecosystem vitality, and promoting environmental health. The 11 issue categories include: (1) Biodiversity and habitat; (2) Forests; (3) Fisheries; (4) Air pollution; (5) Agriculture; (6) Water resources; (7) Air quality; (8) Sanitation & Drinking water; (9) Heavy metals; (10) Waste management; and (11) Climate change mitigation. This broad set of metrics is a powerful tool to track progress towards the UN Sustainable Development Goals, the climate mitigation targets in the 2015 Paris Climate Change Agreement, and the biodiversity protection goals in the Kunming-Montreal Global Biodiversity Framework.

Vietnam's Environmental Performance Index (EPI) 2024

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Regarding the calculation method, the EPI 2024 continues to use the "proximity-to-target" approach. This method involves measuring the actual (quantifiable) performance of policies and comparing it to the target levels set. Environmental performance results are determined through the assessment of various indicators used to measure the outcomes of related policies. The indicators and policy categories are integrated and weighted to create a composite EPI score, with the weights ensuring that the contribution of each indicator is accurately reflected. The composite score is used for ranking, with higher scores corresponding to higher rankings.

Overall, the data sources used by EPI 2024 are primarily international publications. To ensure comprehensive and reliable coverage for most countries, these publications often rely on data from international organizations that are focal points of international conventions, such as: IUCN, UNEP, IEA, World Bank, WWF, WHO, FAO, the EU Commission, OECD, the CBD Secretariat, and related researches from these organizations like Map of Life, Global Forest Watch, Sea Around Us, CAIT, WDPA, EDGAR, and GEOBON.

THE CHANGES IN THE SCORES AND RANKINGS OF VIETNAM'S EPI IN 2024

The EPI 2024 report released in June 2024 indicates that Vietnam is ranked 180th out of 180 countries, with a composite score of 24.5/100. Compared to the last two years, Vietnam's ranking has been continuously declining. In 2020, Vietnam's rank dropped by 37 places, from 141st out of 180 countries. In 2022, it fell by 2 places, from 178th. The composite EPI score also decreased from 33.4/100 in 2020 to 20.1/100 in 2022, and then to 24.5/100 in 2024.

In 2024, countries in the region experienced changes in their rankings. The highest-ranked country in the region is Thailand, positioned 91st out of 180 countries (an increase of 17 places compared to 2022). Countries experiencing significant declines in ranking include Laos (down 29 places), Cambodia (down 16 places), and the Philippines (down 10 places).

Score and ranking of Vietnam's EPI in 2024

No.	Index 2024	Rank	Score	10 –Year Trend
		2024	2024	2024
	EPI	**180**	**24.5**	**-4.6**
A	**Ecosystem vitality**	**174**	**27.7**	**-5.7**
A1	Biodiversity & habitat	160	25.4	-2.1
A2	Forests	85	48.5	1.5
A3	Fisheries	133	29.4	-2.9
A4	Fisheries	180	7.5	-34.8
A5	Agriculture	16	73.0	-1.0
A6	Water resources	136	14.9	0.0
B	**Environmental health**	**142**	**26.6**	**3.1**
B1	Air quality	167	15.5	3.5
B2	Sanitation & drinking water	94	53.7	2.6
B3	Heavy metals	97	43.3	2.9
B4	Waste management	33	46.1	0.0
C	**Climate change**	**175**	**17.9**	**-9.4**
C1	Climate change mitigation	175	17.9	-9.4

Source: EPI 2024

Upon review, there are 2 out of 11 issue categories assessed by EPI 2024 for Vietnam that have higher scores than the average, and 9 out of 11 issue categories with scores lower than the average. Specifically, the 2 issue categories with scores above the average are Agriculture (73.0) and Water and sanitation (53.7). Among the 9 issue categories with scores below the EPI 2024 average, the most prominent is air pollution, which has the lowest score.

The EPI 2024 has undergone significant changes in its indicator set compared to EPI 2022. While EPI 2022 used 40 indicators, EPI 2024 employs 58 indicators for evaluation, an increase of 18 indicators from 2022. Consequently, some indicators have been adjusted and added, particularly in the ecosystem vitality policy area (which now uses 34 indicators, nearly doubling the number of indicators used in 2022).

The changes in the scores and rankings of Vietnam's EPI in 2024 are primarily due to modifications in the calculation methods and weighting used by the EPI. The data sources for the indicators are now based on independent studies. In 2020, climate change was evaluated as part of the ecosystem vitality policy area. However, since 2022, it has been established as an independent policy objective, accounting for 38% of the total score, and it has also been the policy objective for which Vietnam has the lowest score. By 2024, although the weighting for this component has decreased to 30% and Vietnam's score has improved (17.9/100), the overall assessment for this group of indicators has not shown significant improvement.

Additionally, the replacement of the acidification issue area with the air pollution issue area has also affected Vietnam's score. Overall, the score for the air pollution issue area in 2024 is the lowest among the 11 assessed issue areas, with a score of 7.5 out of 100.

In reality, the EPI has undergone changes in evaluation indicators, calculation methods, and data sources over the years. Therefore, it is not advisable to compare EPI rankings across different years directly. Instead, EPI provides trend assessments by evaluating data from a baseline year (primarily using data from 10 years prior to the assessment). Accordingly, Vietnam's evaluation score has decreased by 4.6 points compared to the reference from 10 years earlier. This score indicates a trend of declining environmental quality in Vietnam. Consequently, Vietnam needs to make substantial efforts to achieve climate change and ecosystem vitality goals; otherwise, it will be at a disadvantage compared to other countries globally.

CONCLUSION

The Environmental Performance Index (EPI) reflects the efforts of countries in achieving environmental goals. However, the results of the EPI can vary across reporting periods due to changes in evaluation indicators, weightings, the number of indicators, data sources, and assessment methods. Therefore, comparing EPI results across different years can lead to inconsistencies and a lack of clarity. A notable feature of EPI 2024 is the addition of many indicators in the ecosystem vitality category, including the replacement of the acidification issue with air pollution. Vietnam has the lowest score in air pollution among the 11 assessed issue categories (7.5/100). The EPI score indicates that Vietnam is facing significant environmental challenges, particularly in air pollution, biodiversity loss, and climate change mitigation capacity.

To achieve the country's sustainable development goals, Vietnam will need to implement comprehensive measures to halt the increasing trend of pollution, gradually improve environmental quality, enhance climate change adaptation capacity, prevent biodiversity loss, and promote a low-carbon and circular economy. This requires continued enhancement of the institutional, policy, and legal frameworks for environmental protection; improving the effectiveness and efficiency of state management, accountability in implementation oversight, and developing databases to monitor environmental performance indicators.

In particular, it is crucial to propose solutions for providing accurate information and data to international organizations for calculating and ranking environmental performance indicators across countries ▪

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Reduction of plastic waste in tourism in Ninh Binh

Ninh Binh is one of the two leading localities nationwide in reducing plastic waste in tourism activities, according to the United Nations' assessment. The province has become a must-see destination for both domestic and foreign visitors thanks to its strategy on developing green, sustainable and community-based tourism associated with promoting the natural, historical and cultural values of the locality.

REDUCING PLASTIC WASTE TOWARDS GREEN TOURISM

In recent years, the rapid and strong development of tourism has significantly contributed to the country's economic growth. But tourism activities also increase the amount of plastic waste, putting great pressure on the environment and threatening sustainable development. How to solve this challenge is an urgent requirement for the Vietnamese tourism sector, especially as green growth is becoming the trend of the global "smokeless industry".

Most plastics are not biodegradable and take 100 or even 1,000 years to decompose. In the environment, plastic will decompose into microplastic pieces that pollute water sources and soil and enter the human food chain, endangering the lives of about 800 species of animals living in the ocean.

Plastic waste will pollute the view for tourism, affecting the tourist experience. Plastic waste has reduced tourist arrivals and revenue, affecting the livelihoods of millions of people who depend on tourism.

In Vietnam as well as in the world, nearly 50% of plastic products are designed and manufactured for single use. Of which, only a portion is recovered for recycling or destruction, while a large amount is washed into the system of rivers, canals, and then into the sea.

The amount of plastic waste and plastic bags in Vietnam accounts for about 10-12% of daily-life solid waste. In some cities with developed tourism activities, each tourist discharges an average of 5-10 plastic bags per day, 2-4 plastic bottles, milk cartons into the environment each day, not to mention the products and personal items made with disposable plastic.

The existence of plastic waste not only creates negative impacts on the landscape and environment, reducing the attractiveness of the destination, but also causes objections among tourists, leading to a decrease in the number of visitors and directly affecting the local economy.

In fact, the high growth in the number of tourists and the trend of mass tourism in Vietnam in the past period is one of the reasons why many tourist resorts have been facing the phenomenon of waste pollution, especially plastic waste. This situation makes the problem of reducing plastic waste in tourism more urgent than ever.

TOWARDS PLASTIC-WASTE-FREE TOURISM

Recently, the Vietnam Tourism Association (VTA) has cooperated with the Institute of Strategy and Policy on Natural Resources (ISPONRE) and Environment and the United Nations Development Programme (UNDP) in Vietnam to pilot a project on minimising plastic waste in tourism activities in Ninh Binh and Quang Nam provinces.

Accordingly, the main goal is to ensure that by 2025, 100% of tourist resorts, accommodation establishments, and hotels will not use non-degradable plastic bags and single-use plastic products.

To achieve this, the VITA also sets out several tasks, such as participating in developing, disseminating, and monitoring the implementation of policies and laws on reducing plastic waste in tourism; Implementing a set of criteria for recognizing plastic waste-free tourism businesses and applying plastic waste management for tourism businesses; Build and develop green tourism products without plastic waste; Promote tourism promotion activities associated with reducing plastic waste, etc.

Ninh Binh is one of two localities piloting a project on reducing plastic waste in the Vietnamese tourism sector sponsored by the United Nations Development Program (UNDP), led by the VITA and the Institute of Strategy, Policy on Natural Resources and Environment preside over the implementation.

However, the application and implementation of this project in the tourist area still have some difficulties and limitations, such as High initial investment costs and no synchronization between minimizing plastic waste in and out of the resort. In addition to tourist areas, tourists come from many places and bring plastic waste to their travel schedules. Some residential waste collection points affect the beauty of tourist areas.

It is necessary to increase the implementation of some suitable applications and models to raise environmental protection awareness and reduce plastic waste in tourism activities. In addition, it is essential to focus on training knowledge and skills to train officials and workers to become pioneers and role models so that each destination will be a typical bright

spot in reducing plastic waste, contributing to the reality of plastic waste and realizing the goal of developing green, sustainable tourism.

The active participation of the tourism industry, businesses, and tourist attractions has contributed to raising awareness among people and tourists about reducing plastic waste, protecting the environmental landscape, and bringing Ninh Binh tourism to green and sustainable development. The project's initial results in reducing plastic waste in Vietnam's tourism industry in Ninh Binh are also the basis for replicating the model nationwide.

Experts from the Institute of Strategy and Policy on Natural Resources and Environment also suggested several solutions to minimize plastic waste, such as bringing a person's water bottle and refilling instead of using bottled water which will be discarded later, bringing a shopping bag or using a reusable bag when shopping, using leaves to wrap food, dispose of garbage in the right place, collect and classify garbage at homes, workplaces, event venues.

Ninh Binh was selected for carrying out the project because it has defined tourism as a spearhead economic sector, developing green, sustainable tourism as a foundation for green growth of other sectors and fields.

POLICES AND STRATEGIES FOR SUSTAINABLE DEVELOPMENT

In different phases of development, Ninh Binh has adjusted its polices and strategies to match with real conditions and available resources, under which tourism has always been defined as a priority field.

In recent years, Ninh Binh has issued numerous resolutions, decisions and programmes on tourism development. In particular, the Resolution of the 22ndCongress of the provincial Party Organisation for the 2020-2025 tenure has defined developing infrastructure for tourism as a spearhead economic sector, and it will be one of the three strategic breakthroughs to create strong economic structuring, switching from construction material exploitation to tourism development in a bid to build a green economic growth model. To date, localities in the province have always paid due attention to protecting the natural landscape and historical relic sites, and zone off areas for prohibiting the exploitation of limestonesand special use forests.

These viewpoints have helped lure more investors to Ninh Binh, thereby turning it into a safe, friendly and attractive destination with many attractions such as Trang An ecological site, Tam Coc - Bich Dong, Van Long Natural Wetland Reserve; Cuc Phuong National Park, Thung Nham Bird Sanctuary and Bai Dinh pagoda.

▲ *Ninh Binh has stepped up communication work to raise awareness among local people and enterprises of protecting the environment*

▲ *Ninh Binh has been named among top cities and provinces nationwide in ensuring security, safety and environmental hygiene*

Besides, the province has paid more attention to ensuring social order and security, environmentalsanitation, food safety and hygiene, andcivilized tourism at destinations, restaurants, hotels and tourism service establishments.

Thanks to these efforts, Ninh Binh has been named among top cities and provinces nationwide in ensuring security, safety and environmental hygiene.

Developing tourism sustainably has created momentum for other sectors to develop and turned Ninh Binh into a self-budget-balancing province, therefore reducing burden for the central government.

Bui Van Manh, Director of the Ninh Binh Department of Tourism, said the province's consistent strategy is to develop green, sustainable and community-based tourism. To realise this goal, it must depend on three main pillars namely local people, businesses and state. We have built a specific strategy to carry out the goal gradually. While making investment in tourism, we must respect the natural, cultural and historical values of each locality in a bid to develop sustainable tourism products.

Currently, Ninh Binh has stepped up communication work to raise awareness among local people and enterprises of protecting the environment. It has established a model of effective, close cooperation between the State, enterprises and local people in exploiting the nature. In which, the responsible and actively participation of local people is highly acknowledged.

The development of community-based tourism at some popular destinations like Trang An, Tam Coc - Bich Dong and Van Long must ensure the harmony between the environment, landscapes, and tourism. Local people and enterprises benefit from the nature and heritages and they must hold responsible for protecting the nature amd heritages. While serving tourists, boat rowers at Trang An, Van Long and Tam Coc always prepare waste baskets and remind tourists not to throw trashes into the environment.

Typically, the Thung Nham tourist area, Hoa Lu district, has focused resources on investing in infrastructure development in a synchronous direction, harmoniously combining business activities with protecting the ecological environment and landscape to reduce waste.

The tourist area has invested in pure drinking water production technology with a capacity of about 500 m3 per day and night, meeting the needs of tourists and minimizing the use of plastic bottled drinking water. In addition, focus on propaganda and training for officials and workers operating in the field of tourism services on environmental protection and minimizing plastic waste; Actively replace plastic products with environmentally friendly wood, china, and porcelain products.

At Trang An Ecotourism Area, they are currently focusing on propaganda and training for officials and workers operating in the field of tourism services on environmental protection and minimizing plastic waste. Environmental protection activities have received good feedback and impressions from service users.

The development of green tourism or experience tourism have helped tourists to enjoy and experience daily activities of local people and helped Ninh Binh to revive and develop traditional craft villages such as Kim Son sedge making, Van Lam embroidery village, and Ninh Van stone carving village.

Ninh Binh set a target of welcoming 8 million visitors and earn 8 trillion VND by 2025. To achieve the targets, the tourism sector will focus on investing synchronic and high-quality technical infrastructure; diversifying tourism products to meet tourists' demand; and launching new tourism products that bears unique and attractive cultural and historical values.

Moreover, the province will enhance cooperation between departments, sectors, localities and enterprises in tourism activities; increase state management of tourism; ensure security, order, food safety and environmental sanitation; and organise regular inspections to promptly handle violations of construction in the core areas of Trang An and other destinations ▪

NGUYỄN THẮNG

환경부
Ministry of Environment

KEITI
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■ Promote and enhance the cooperative activities in the field of environment between Vietnam and Korea;

■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.

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