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Some understandings and interpretations of the 1288 Bach Dang Victory from the geological-geomorphological and meteorological-hydrological perspectives

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Abstract:
The Bach Dang Victory in 1288 has been studied by many scientists, both domestic and international, for several decades from cultural, historical and archaeological perspectives, but not much on geological, meteorological-hydrological and paleo-environmental aspects. Based on existing data and results of recent investigations, this article gave a broader analysis on this historic victory, especially from a geological-geomorphological point of view, aiming at highlighting the tradition of using rivers and waterways of the Vietnamese people.

Key words: *The Bach Dang Victory; geological; meteorological - hydrological.*
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1. INTRODUCTION

The 1288 Bach Dang Victory has been the subject of many studies, including interpretation on the natural characteristics and conditions of the area where the battle took place, mainly conducted by historians and archaeologists. There are only a few studies from the perspective of geology-geomorphology and meteorology-hydrology-oceanology. Whereas these characteristics have undergone many changes for 700 years both due to natural processes and human activities. Reconstructing them at the time of the battle is therefore challenging and inconsistent. Nevertheless, there is also some consensus, especially the Trần Dynasty's army and people's understanding, mastering, and fully exploiting the natural features and conditions to ensure the victory of battle. The article below reviews some current research results and interpretations from the geological-geomorphological and meteorological-hydrological-oceanographical perspective about this historical battle.

2. RESEARCH METHODS AND TECHNIQUES USED

Traditional methods and techniques of the natural and social sciences will be applied such as collecting, synthesizing, analyzing, processing existing documents, sociological investigation, surveying, mapping, analysis and processing data, and additional sample analysis...

Specialized research methods on tectonics - geomorphology, Meteorological and oceanographic and modern research methods such as analyzing remote sensing images, building databases...

3. RESEARCH RESULTS

3.1. Some research results and interpretations from the geological geomorphological and meteorological-hydrological-oceanographical perspectives

From the geological-geomorphological and meteorological-hydrological-oceanographical perspectives, there are basically research works of Nguyễn Ngọc Mến [12], Nguyễn Ngọc Thùy [13], and Trần Đức Thành [20]. In addition, it can be mentioned a few excavations and geophysical drills, measurements... in the framework of archaeological research tasks (Lê Thị Liên et al. [4, 5, 6, 7, 8], Sasaki et al. [17, 18]…). This specialized information is also mentioned in several other studies. For example, Nguyễn Việt et al. [20] made a number of suggestions to answer the question why the area at the intersection of Gia - Bach Dang - Chanh rivers was chosen by the Trần Dynasty as the place to ambush and intercept the Yuan army. Accordingly:

- Geologically, Coc Rapids is the determining factor of the topographic landscape here.

- The authors also agree with meteorological-hydrological-oceanographical scientists that the tidal range in the area is quite high, about 3m, higher or lower depending on the season. Waterway ambushes with the support of stake yards require high tidal ranges.

- The authors further pointed out that every estuary area has very complex and unrecognizable creeks that are always covered by mangroves, which is very convenient for ambush and creation of underwater stake yards. In addition, at that time, the Dong Trieu area from Pha Lai to Uong Bi was a forest rich in precious wood species.

According to Trần Đức Thành [20], the battle of Bach Dang was not limited to Bach Dang River and the mountains on both sides of the River. Not to mention some of the descriptions, for example on the tides, the depth of the riverbed, and the main stake battlefield... more than 700 years ago, are somehow different from today. The author made some comments as follow based on his analysis of archaeological documents on the Chanh River stake yard together with his and his colleagues' studies:

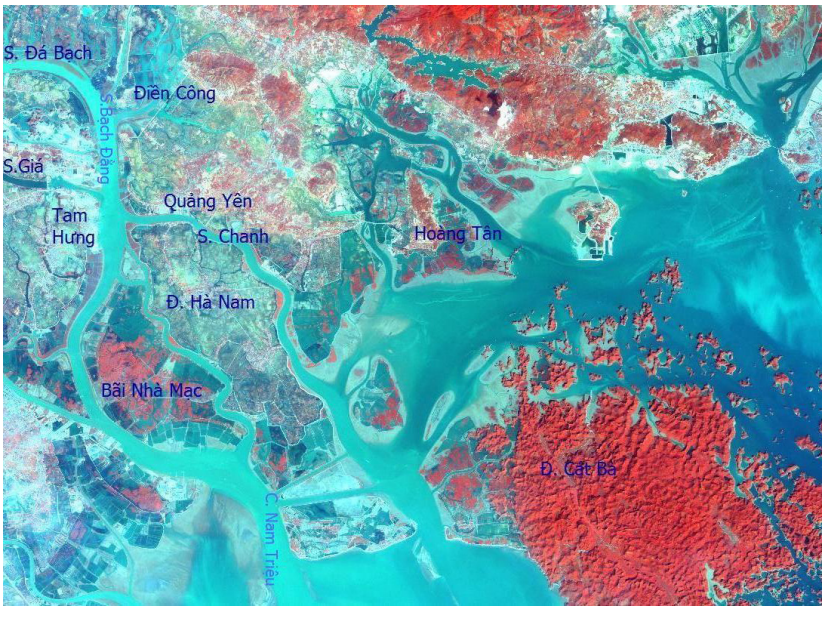
- *Regarding location and topographical characteristics,* the stake yard was on the left bank of the current Chanh River, in a low - lying field in Yen Giang Commune, on the old Chanh Riverbed. The changed position of the riverbed is a process of gradual movement to the South rather than a large sudden change.

- *Regarding stratigraphy*, the soil within the depth of 3m of the excavation pit is divided into 4 layers. The 0.5m thick top layer was accumulated at the development stage of the estuary under the condition of a low-tide or high-tide flat that has recently emerged above the average tide. Three blow layers were accumulated at the development stage of the delta estuarine. According to the author, the three top layers were formed after the Bach Dang battle in 1288.

- *Regarding the old tidal range and the protrusion of the stakes*, the depth from the old riverbed to the old mean tide level was only about 1.4m. However, this is probably not the deepest point of the river cross-section. Currently, in this area, the maximum tidal range is about 4m, and the average tide level is 2m higher than the lowest tide. If the sea level here in 1288 was 1.1m lower than today (compared to the mean tide level) and at that time the environment of Bach Dang estuary was a delta, it can be predicted that the tidal range was most likely 3m. If this prediction is correct, the old riverbed in the stake yard may be exposed when the tide is at its lowest and the stake yard at the deepest part of the riverbed may not have been discovered yet. Then, the stakes always protruded 0.6 - 0.9m above the old mean tide level and only at the high tide would they be completely flooded. Therefore, this was mainly a raised stake yard for camouflage, and Trần Hưng Đạo's army must have "covered grass on top" as stated in the Complete Annals of Dai Viet.

Regarding the highest and lowest tide level at midnight on the 8th and in daytime on the 9th of April 1288, which was 3.2m and 0.9m, respectively, [13] the author said that they were calculated based on the assumption that the topographical features and the tidal propagation conditions from the sea to the Bach Dang estuary have basically remained unchanged over the past 7 centuries while the topographical conditions and the structure of Bach Dang estuary have changed quite profoundly. Therefore, the tidal propagation conditions and the maximum tidal range were not the same as they are today. Nevertheless, tidal conditions then were a beneficial natural factor and successfully exploited.

Trần Đức Thành [20] attempted to reconstruct natural conditions of the Bach Dang battlefield in 1288. Accordingly, it lied at the center of Bach Dang estuary where was the transitional place between the Dong Trieu arc and the Red River - Thai Binh River Delta (Figure 1). Over 250km of coastline from the Vietnam - China border, this was the first estuary to have a waterway connecting with Thang Long citadel. Due to the location and transitional nature as well as its special shape and structure, Bach Dang estuary has a special position in terms of geopolitics and geo - military.



▲ *Figure 1. Bach Dang estuary (Spot satellite image dated March 1st, 2008) (Trần Đức Thành [20])*

- *Regarding geological structure*, Bach Dang estuary is funnel - shaped, formed as a result of the interaction between a neo - tectonic collapsing graben and the eustatic sea level rise, the lack of sediment and the large tidal range, shielded by Cat Ba archipelago in the East and Do Son peninsula in the West, so it has a semi - en closed form, relatively separated from the sea and only connected to the sea in the South and underground at a depth of 6m.

- *Regarding formation and evolution process*, Bach Dang estuary in the Holocene (from 11.7 Ka to today) went through three periods and six stages including [19, 35, 36] (For more details, please the article in this specialized journal):

+ *First period:* Early-Middle Holocene (11.7 - 2.5 Ka.). The post-Last Glacial Maximum transgression caused flooding and changed the environment from the mainland to the nearshore one. At the end of this period, the sea level rose slowly, the sea receded.

+ *Second period:* Late Holocene (2.5 Ka. to 700 - 500 years ago). Late Holocene transgression began and ended soon after that.

+ *Third period:* Late Late Holocene (about 700 - 500 years ago to the present), consisting of only one period, the modern transgression.

- *Regarding topographical morphology,* Bach Dang estuary is also distinctive from the area along the banks of the Red River Delta, including tidal marshes with dense natural mangrove vegetation, tidal creek system, dense tidal channel, tidal sandbars along the channel shores, abrasive terraces developing in the low-tide zone on the loose sediment basis... [20].

- *Regarding hydrology - oceanography,* due to the semi - enclosed structure, the waves were generally not strong, except during storms. The eustatic sea level about a thousand years ago was approximately 1m lower than today, and during the war in 1288 it could be about 0.5m lower than today. Meanwhile, the current tidal range is larger than that of thousands of years ago. Perhaps the diurnal tide regime and the law of tidal oscillation according to the lunar calendar were not different from today, but the tidal magnitude during the war in 1288 might be about 0.2 - 0.5m less than today [20].

- *Regarding climate,* the estuary was in the tropical monsoon area. In the summer, it was hot and humid. It rained a lot in May - August, which coincided with the season of the Southwest monsoon blowing in the prevailing East and Southeast directions, and storms and tropical depressions often occurred. The rest of the year coincided with the Northeast monsoon season in which the North and Northeast winds prevailed in September - November and the East winds prevailed in December - April, often accompanied by cold, wet, and rainy weather, drizzle and fog, very low visibility, some times down to a few meters, causing many difficulties to traffic [20]. According to the author, in addition to the role of tides that was reasonably fully applied to ensure a successful battle, other factors, especially flows and winds, though mostly unreported, certainly played important an important part.

- *Regarding ecosystem,* the characteristics of an estuarine ecosystem are different from those of delta estuary, such as better mixing of river-sea water, higher salinity, stable biomes, and higher biodiversity. Mangroves had two typical plant populations: Đước *(Rhizophora stylosa Griff)*, vẹt *(Bruguiera gymnorhiza)* in brackish - salt water and bần chua *(Sonneratia caseolaris)* in brackish - fresh waters [20].

In brief, located at the Northeastern edge of the modern Red River Delta, Bach Dang estuary has a typical estuary structure and is relatively independent of the modern Red River Delta estuary. But about 700 - 500 years ago, it was still a part of the Red River Delta and had an accretionary shore extended further out into the sea than it is today [20]. In this context, the naval battle of Bach Dang in 1288 happened in the brackish-fresh water delta environment, not a saltwater and brackish - salt estuary with a shallower and narrower river like today. The dominant plant community at that time were hardy sugar canes *(Saccharum arundinaceum)*, reeds *(Phragmites)* and mangrove apples *(Sonneratia caseolaris)*, often growing in swamps, freshwater or rather brackish flood lands, not belonging to the group of mangroves, red mangroves *(Rhizophora stylosa Griff)*, and mangrove apples *(Sonneratia caseolaris)* like nowadays. Many natural features and conditions of Bach Dang estuary have been preserved since then while many other factors have changed such as the topography, and the forest ecosystem has also significantly transformed. Overall, many natural features and conditions were fully utilized and significantly contributed to the victory of the battle [20].

3.2. A few more contributions from a geological-geomorphological perspective

The geological - geomorphological descriptions and interpretations in the few works mentioned above still have some differences. Therefore, the following section, along with additional comments and comments, reviews some key geological - geomorphological features of the Bach Dang battlefield as well as the wider surrounding area:

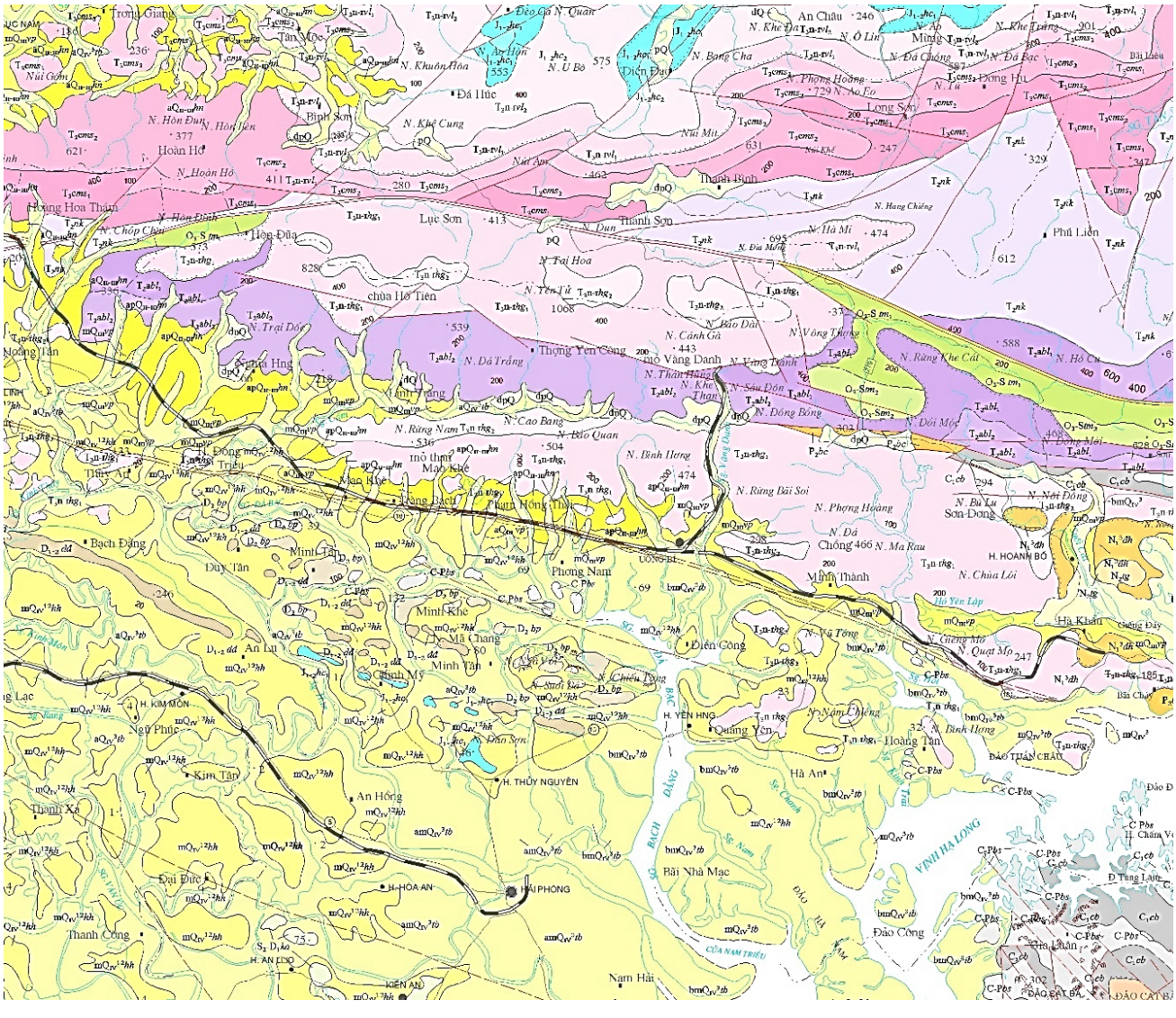
3.2.1. Stratigraphy

In Bach Dang estuary in particular and Dong Trieu arc in general, there are soil and rock of different ages from ancient to young as follows: Song Cau series (D_1sc), Duong Dong formation ($D_{1-2}dd$), Trang Kenh formation ($D_{2-3}tk$), Ba Son formation (C-P*bs*), Hon Gai formation (T_3n-r*hg*), Ha Coi formation ($J_{1-2}hc$), and Quaternary loose sediments (Hanoi formation ($Q_1^{2-3}hn$), Vinh Phuc formation (Q_1^3vp), Hai Hung formation ($Q_2^{1-2}hh$), and Thai Binh formation (Q_2^3tb)). Details of these geological units have been introduced in another studies [2, 9, 10, 19]. This section just reiterates a few notable points as follows:

- The Duong Dong, Trang Kenh, and Bac Son formations are exposed in small peaks mainly in the South of Kinh Thay - Da Bac River, slightly extending in the sub - latitude or the West - Northwest (WNW) - East - Southeast (ESE) direction. The terrigenous rocks of the Duong Dong formation formed lowland hills and mountains; the Trang Kenh and Bac Son formations formed the towering relict karst aiguilles with the same height. Similarly in the same structural direction are the small outcrops extending the cobblestone, gritstone, and sandstone of the Ha Coi formation, exposed mainly to the South of Gia River.

- The exposed terrigenous rocks of the Hon Gai formation are mainly in Yen Tu range, North of Uong Bi City center. There are two other remarkable outcrops: On the left bank of Bach Dang River, the area of Tien mountain and Vu Tuong mountain of Quang Yen Town (Quang Ninh Province); Some smaller outcrops along Kinh Thay River in Chi Linh Town (Hai Duong Province).

- Regarding Quaternary friable sediments: The Hanoi formation (apQ$_1^{2-3}hn$); The Vinh Phuc formation (amQ$_1^3vp$); The Hai Hung formation (mQ$_2^{1-2}hh$) and The Thai Binh formation (a, m, am, bm Q$_2^3tb$).



▲ *Figure 2. 1/200,000 geological map of Bach Dang River and surrounding area [2]*

3.2.2. Tectonic context and geological structure

The study area is the lower part of the Dong Trieu arc with tectonic context and geological structural features that are similar to and closely related with the Dong Trieu arc. The most prominent in this area is the deep fault zone of Road 18 in the sub - latitude direction slightly towards the WNW - ESE (about 90 - 110°). Along this deep fault zone, the Northern wing (Yen Tu Mountain range) is relatively higher than the Southern wing.

During the Neotectonic period, it also developed quite widely throughout the sub-meridian fault system, forming a series of small rivers that cut the Yen Tu mountain range such as Uong River, Sinh River, and Bi River..., especially Bach Dang River - the extension of the Uong River - Sinh River faults (Da Bac River, meeting this sub - meridian fault zone while flowing to Dien Cong area, had to divert towards the South).

Other fault systems, including the relatively developed Northwest (NW) - Southeast (SE) about 330°, and the less developed Northeast (NE) - Southwest (SW) about 70°, also resulted in some river sections flowing along them, such as the beginning parts of Gia River, Bi River, or Hang Ma River... (NW - SE direction), or sections of Duong River, Da Vach River, the short section connecting Kinh Thay River with Da Bac River at Dun confluence (Lai Xuan ferry wharf)...

The activities of sub - latitude faults and WNW - ESE faults controlled the distribution of Paleozoic and Mesozoic sedimentary rocks as well as dissected them into small bands extending in the same direction.

The Bach Dang River sub - meridian fault (and extending further north, possibly along Uong River or Sinh River) is also noteworthy. It creates a difference in the distribution of ancient rock and soil on both sides of the fault, specifically the Hon Gai formation (T_3n-r*hg*) (area of Tien mountain, Vu Tuong mountain) on the left, contrary to Duong Dong, Trang Kenh, Bac Son, and Ha Coi formations (without Hon Gai formation) on the right. Perhaps this fault has played a controlling role from the formation of the Hon Gai formation sedimentary basin, with the left wing relatively lower than the right wing, causing the Paleozoic rock formations on that side to plunge quite deeply, and all were only relatively uplifted in the modern tectonic period.

The existence of the Gia River - Chanh River fault in the sub - latitude to WNW - ESE direction and the small ancient rock outcrops in the same direction as well as the activity of the Bach Dang River sub - meridian fault as presented above can explain the existence of Coc Rapids, Chanh Rapids as well as the mounds on Ha Nam Island, including those that have been described as conglomerates and gritstone of the Ha Coi formation ($J_{1\text{-}2}$*hc*) [6,20], and at the same time explain the above-mentioned researchers' comments [2, 9, 10].

The authors of this article have recently surveyed using a small boat along the river section from the (old) Chanh River bridge to the confluence of the Bach Dang River, collected, and petrographically analyzed some geological samples taken from boreholes of Chanh River bridge pillar, thereby drawing some of the following observations:

- Based on the samples that are believed to be lime clay intercalation in siltstone sand, they were most likely of the Ha Coi formation. However, the detail cited in descriptions about the geological characteristics of the Chanh Rapids [3] that it developed and blocked Chanh River in the NE - SW direction, is unlikely. It's

▲ *Figure 3. Distribution diagram of outcrops and reefs in Chanh River estuary (surveyed at 05:30 p.m. on January 16th, 2022, at low tide)*

simply because the structural direction of the soil and rock in this area is mainly sub - latitude to WNW - ESE. Similarly, the description on Coc Rapids [12] may be reasonable, but the 110° angle is not consistent with the mentioned general structural direction.

- Along the above-mentioned section of Chanh River, dozens of bedrock outcrops float above the River surface during dead tide, and very shallow bedrock, just over 1m, is exposed in many large areas of the riverbed. At dead tide, ships passing through this river section can only navigate in a single fixed channel. Compared with the topographic and hydrographic conditions of more than 700 years ago, this detail shows that at dead tide, in the battle context, and especially for large ships, it is simply impossible to cross the Chanh Rapids (as today). Most likely, the channel of the Chanh River (on which ships could circulate) at that time had to be a little too North and was blocked by the Trần army and people using stakes (Yen Giang stake yard) (Figure 3).

- Together, Coc Rapids, Chanh Rapids as well as the mounds along the Chanh River, Ha Nam island… can be considered as a large bedrock area (some hidden, some exposed), an extension of the Ha Coi Formation ($J_{1-2}hc$) from the right bank - from Yen Phu mountain range (now in Kinh Mon Town, Hai Duong Province) - but has been lowered slightly on the left bank of Bach Dang River, making the last natural barricade of the historic battle of Bach Dang.

3.2.3. Geomorphological features and topographic morphology

One of the unique features of the Bach Dang battlefield is the old karst - non - karst landscape in Duong Nham - Nham Duong - Truc Dong - Trang Kenh strip in Kinh Mon Town and Thuy Nguyen District, basically bordering Kinh Thay - Da Vach - Da Bac River sections to the North and Gia River to the South extending backwards to the Northwest. The old karst landscape has created a system of large and wide caves, mainly developed horizontally. Subsequent transgressions-regressions have expanded these caves and additionally formed a system of tunnel caves, underground cave rivers, closed water and lakes, and interlaced canals that the army and people of the Trần Dynasty fully utilized for the Bach Dang campaign.

Another unique feature in the topographic morphology at the end of Bach Dang River, specifically on Ha Nam Island, which have been mentioned by some historians, archaeologists, and geologists in historical literature or excavation results and may have been erased by human activities, is the system of ancient flows interlaced between mounds and sandbars... in 1288:

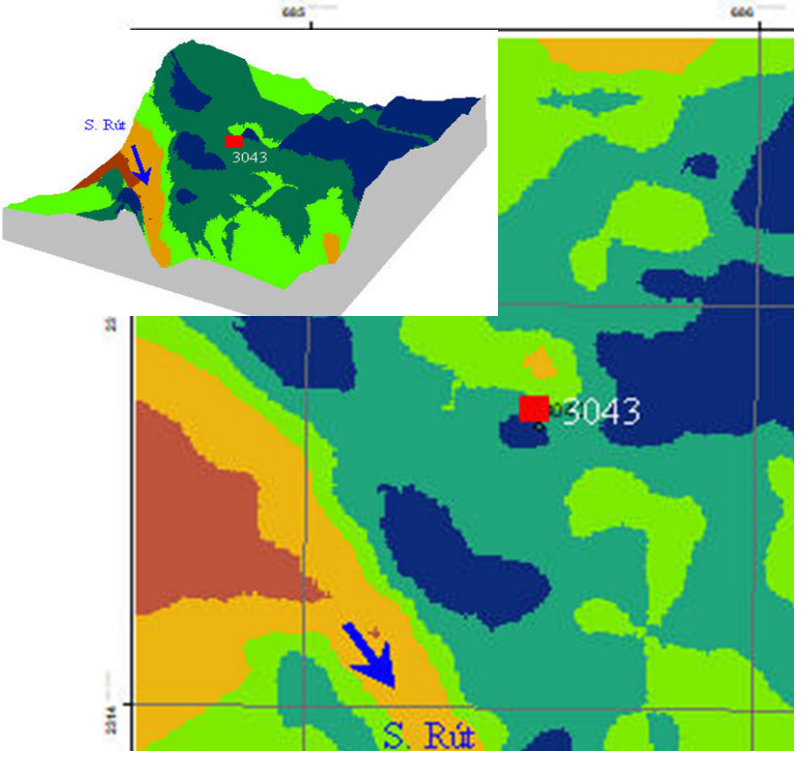
- Many author [3, 5, 4, 20...] identified many ancient mounds and sandbars when describing and commenting on Vua Ba shrine, Tran Hung Dao temple, and the Yen Giang, Dong Van Muoi, and Dong Ma Ngua stake yards. A series of communal houses and temples, including populated areas on Ha Nam Island, is also described as being on high lands that may have fresh water.

- Most of authors believe that the flows have greatly changed, especially since the dyke system was built around Ha Nam Island, and that when the battle occurred in 1288, the Chanh and Rut Rivers were not even named, not to mention Kenh River; the Bach Dang Riverbed was very wide at the time, some main flows have narrowed now, and some minor flows such as Kenh River and its tributaries have disappeared; that the network of ancient flows was complicatedly distributed, weaving between the soil bars and rock mounds; that drilling results show traces of currents in many places, ancient riverbeds, even the "umbilicus" of ancient flows where artifacts drifted to and accumulated. On the contrary, another opinion [20] when referring to Yen Giang stake yard noted that in 1288 the flows in this area were much narrower and shallower than today.

There has not been any research that convincingly depicts the morphological characteristics of the Bach Dang River - Chanh River - Rut River - Kenh River system... in this downstream section. Aggregating the analyses and interpretations above and comparing them with recent investigations and results, the authors of this article suggested that above description of archaeologists and historians may only be exact at spring tide, but at low tide it was still an interlaced system of clear-banked currents, shallower and smaller than today. The sediment load was very large in the context of a delta, regression, and the sea level was about 1.0m lower than today… In the context of a delta river system approaching the sea, it is precisely a "braided river" or "horsetail braided channel" with many small, braided streams weaving between mounds and sand bars... However, the "braided" flow system in the downstream part of Bach Dang River had some differences as follows:

- Although it was a large delta river system, its development space was controlled by fault zones and bedrock outcrops, as described above.

- Although it was a "braided" river system, a majority of islands and mounds in the middle of the stream were made up of bedrock. However, due to the large alluvial load, it still formed some bars and mounds composed of coarse - grained alluvium.



▲ *Figure 4. Topography of Dong Van Muoi stake yard extracted from Google Earth images, clearly showing the location of some surrounding mounds (dark green) [21]*

These mounds and sandbars, along with the creeks weaving between them as well as their two banks, if composed of alluvium instead of bedrock, also often changed their morphologies.

- More importantly, the entire area was still under the strong influence of the diurnal tide; the above-mentioned mounds, bars, and banks of the creeks were only exposed at low tide and still significantly obscured at spring tide, became "part" (but shallow) of the "expanded" Bach Dang River. Bach Dang River could become very wide but included fairly deep "real" creeks and other shallower parts.

Some interpretations drawn from the above characteristics are:

- Could the shifting of Chanh Riverbed assumed by Trần Đức Thành [20] occur? The authors of this article believed that this assumption does not necessarily happen. According to the descriptions of Gan Xuong mound [3], it was one or a series of midstream sandbar(s) - the center of the Bach Dang battle. In other words, both flows or two parts of the same flow, were already in existence - Chanh River - separated by one or a series of midstream sandbar(s). The Northern half of it was blocked by the Yen Giang stake yard, while the Southern half was shallow as described above.

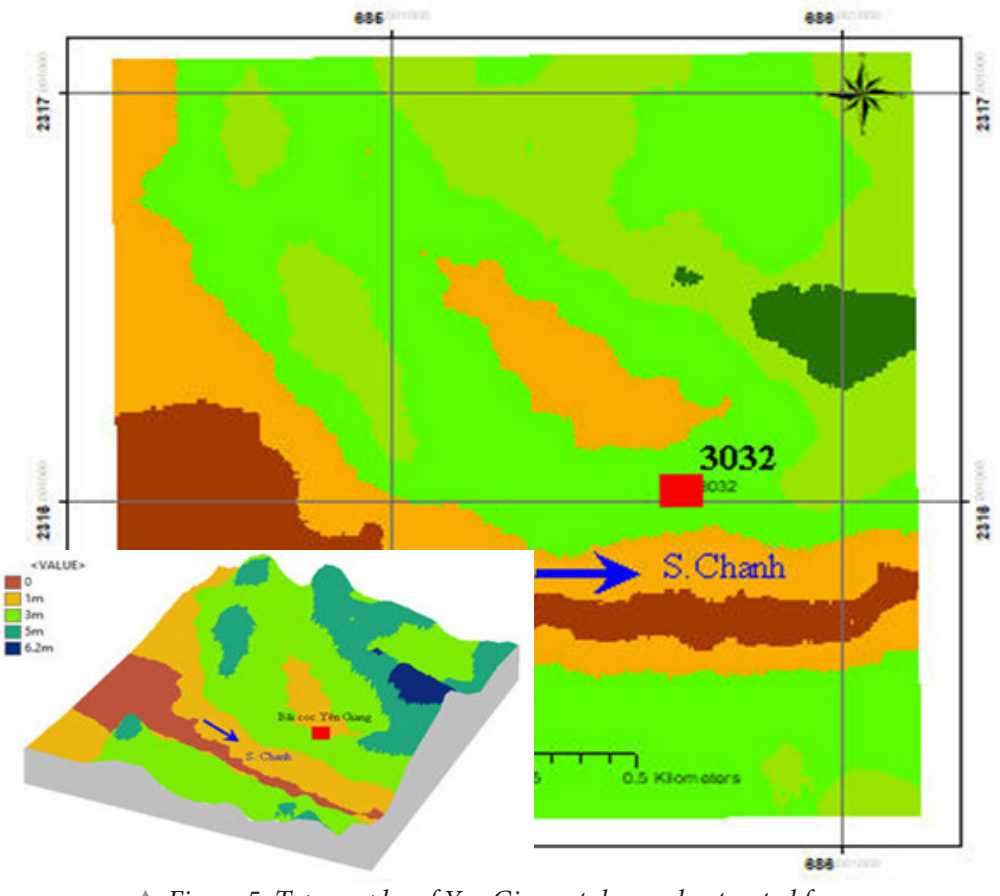
- Two possibilities were pointed out by Trần Đức Thành [20]: The main axis of Bach Dang River did not change, but later the riverbed was widened and deepened; The main axis of the River has shifted hundreds of meters and only revealed Coc Rapids later. The first possibility is more reasonable. It is most likely that the right bank of "Gan Xuong mound" - the ancient midstream sandbar mentioned above - both at spring tide and at neap tide, as being blocked by Coc Rapids, was divert to the left bank, partly flowing into Chanh River and partly towards Rut River (where Coc Rapids was interrupted by the sub-meridian fault, resulting a slit in Bach Dang Riverbed which was narrow (only 6m wide) but deep.

- It is entirely possible that at that time, even though there existed the downstream section of Bach Dang River flowing to Nam Trieu estuary, Chanh River flowing into Lach Huyen estuary was still very important and remained a prioritized waterway route. However, the trend of gradually shifting the main estuary from Lach Huyen to Nam Trieu is still irreversible in the general fluctuation picture of the entire Red River - Thai Binh River system.

- Chanh River and Rut River might then be "component" flows of Bach Dang River but had not been named. Therefore, Bach Dang River, as described and currently understood as the current Bach Dang River, could be a collection of rivers, including Bach Dang, Chanh, Rut, and Kenh… The ability to "intercept the battleships" was probable, but that was of "the expanded Bach Dang River" (but shrunk naturally by rock rapids) as well as shallow water spaces among them.

- The ability to confront [14, 15] a fleet of hundreds of enemy ships perhaps would be possible if there were both natural and artificial "barriers". Because enemy ships were bigger, stronger, more solid and, at the same time, had a great advantage downstream with the receding tide, nothing could stop them without these "barriers".

- Therefore, the argument on the possibility of another stake yard, along with Coc Rapids, blocking the Bach Dang River [20] is probably more reasonable. This river was not wide and deep (as it is now) and the flow was slightly inclined to the left bank towards Rut River, focusing on the place that is now a deep but narrow creek (only about 6m wide), so the staking as well as blocking the enemy's warships was not too difficult as in the case of today's deep and wide Bach Dang River.



▲ *Figure 5. Topography of Yen Giang stake yard extracted from Google Earth images, clearly showing the possible traces of an ancient flow just Northwest of the stake yard (orange) [21]*

- As mentioned above, at high tide, Bach ang River expanded to include "true" creeks, mounds, sandbars, and shallow water areas that might be completely exposed or remained swamps at dead tide. In the naval battle ambush of the Trần Dynasty army and people, in addition to the "real" creeks with stakes or protected by underground rapids and emerged mounds and sandbars ambushed and captured by the Trần army and people, the shallows mentioned above surprisingly played an important role - they became waterways for boats, including the smaller warships of the Trần army, to move between the upstream and the downstream, the stake yards and rapids while preventing the enemy ships, which were larger and heavier, from retreating. Possibly not all the shallows would be left vacant for boat traffic. A part of their cross - sections could also be staked to narrow and limit the ability of enemy ships to flee. In that case, unlike the "real" creeks where large and deep stakes were required, perhaps only smaller, shorter, and "denser" stakes in the form of a "citadel" as seen in Dong Ma Ngua stake yard were appropriate.

3.2.4. Tide levels and flow depths

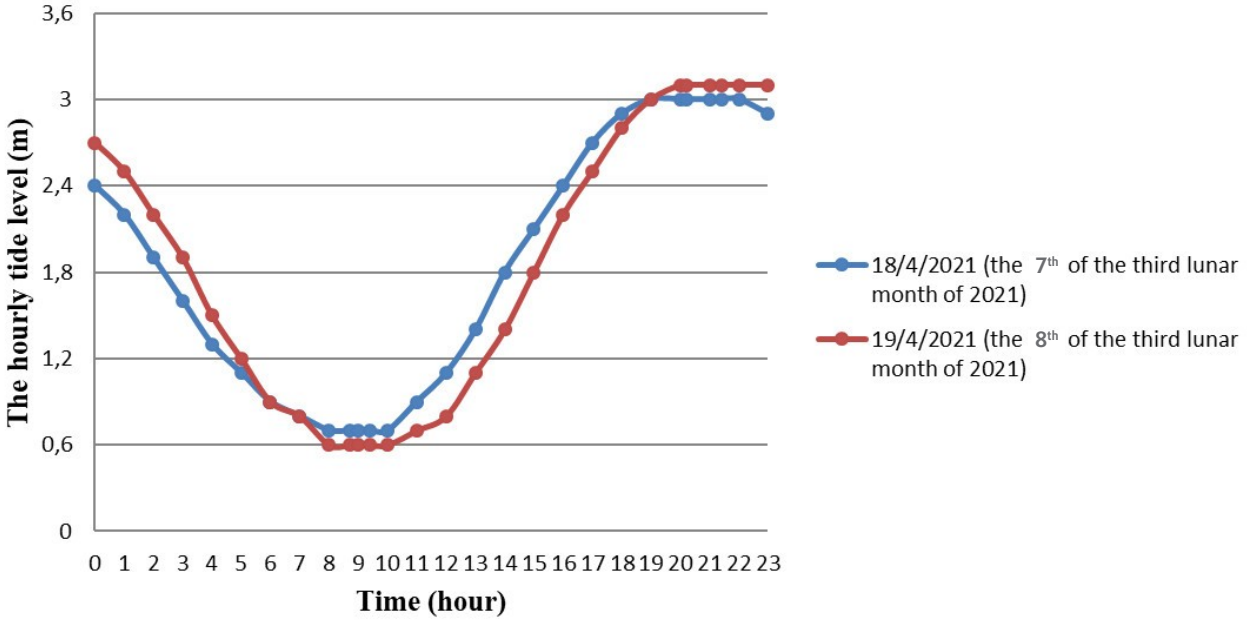
Information obtained from existing studies on tide levels and flow depths, and thereby some other relevant information such as stake length, staking depth..., is also quite different [3, 8, 12, 13, 16, 20...]. Below are some inferences of the authors of this article:

- Assuming the sea level then was about 1.0 - 1.5m lower than now but the difference between spring tide/dead tide on April 9th, 1288 (8th of the third lunar month) was still 3.0m.

- Assuming the draft of the Yuan army's ships was 2.5m [15].

- Assuming the stakes were driven at around dead tide about 1.0m or a little more above the low tide level (so that in spring tide, the stakes would be submerged about 2.0m or less, which could block ships of the Yuan army with a draft of 2.5m and definitely it was able to stop enemy ships when the tide was receding until the dead tide at noon). If the stakes were 1m higher than the dead tide, it would be more difficult to drive, and they must be longer. The stakes were assumed to be about 3.0m long (about 1.0m in the riverbed, 1.0m (or less) in the water and 1.0m above the water (at dead tide, or a little more to ensure just 2.0m or less low than the spring tide level)).

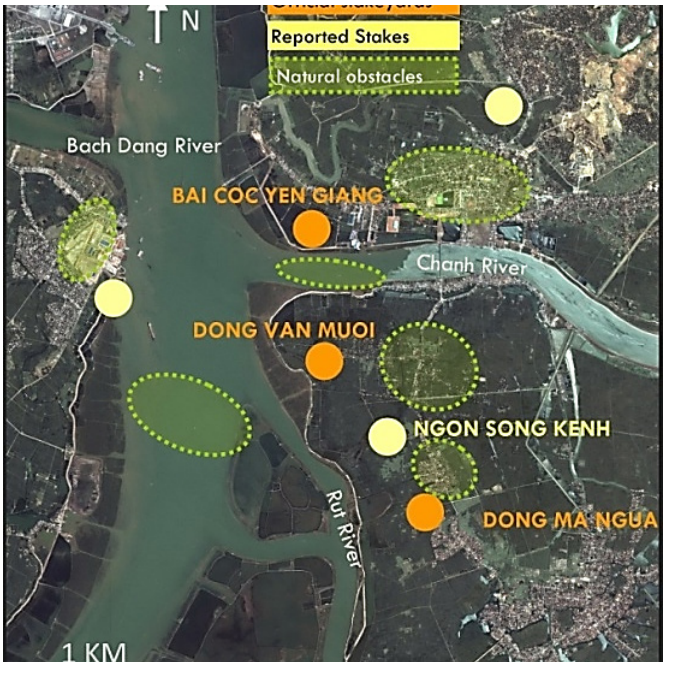
- Assuming the ground was only equal to the dead tide level and would be flooded at 3m high tide. If that was the case, without the stakes, the Yuan ships could have gone anywhere at spring tide. So, it is more likely that the ground, for example in Ha Nam Island area, would then be higher than the dead tide level (emerging above the water surface at least about 0.5m) so that at spring tide it was flooded about 2.5m. The mounds could be higher, for example about 1.0m higher, to be submerged about 1-2m or less, even some places could emerge above the water surface even in spring tide. Then large battleships of

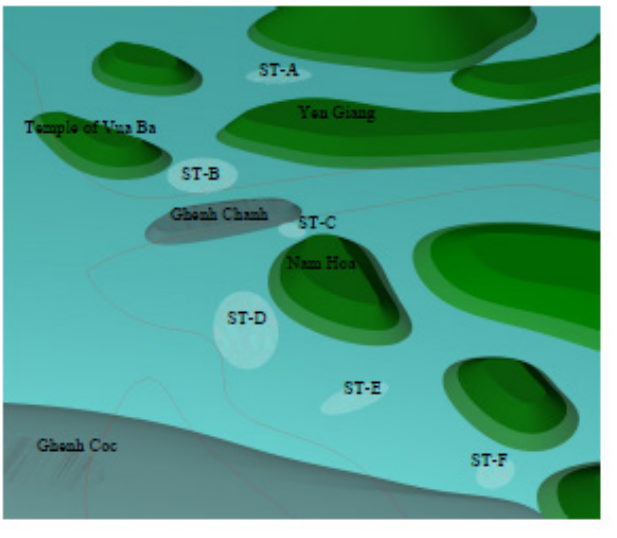


▲ *Figure 6. Illustration of the tide level changes on the 18th and 19th April 2021 (according to data from Hon Dau station), in particular the high tide in the early morning on the 19th is about 3m, the low tide on the same day is about 0.5m, the tidal difference is about 2.5m*

the Yuan army would run aground while small ships of the Trần army could still travel. Such places did not require staking.

- For the creeks, assuming that in dead tide, ships, including warships of the Yuan army, could still navigate, then the riverbed must have been at least 2.5m lower than the dead tide level, that is, about 5.5 meters lower than the spring tide level. Driving the stakes to the bottom of the creeks at that time was not easy, people had to wait until the dead tide, and had to keep the stakes about 1.0m higher than the dead tide level. Assuming that the stakes were driven into the riverbed to the depth of 1.0m, the minimum length of the stakes must be about 4.5m - which was too long and difficult to arrange. However, the staking was still required, and suitable wood still had to be found, but with limited number. Therefore, the role of Coc and Chanh rapids was even more important in that they had significantly narrowed the beds of Bach Dang River or Chanh River, Rut River, and Kenh River… And because they were placed on the stream, right after the Victory, perhaps the Trần army and people removed them to enable traffic on Van Don - Thang Long waterway.





▲ *Figure 7. Conceptual arrangement of stake yards and obstacles on the Bach Dang battlefield (Randall S. 2009) [29]*

- What stakes yards did the Trần army and people leave behind (forget)? After the above-mentioned midstream stake yards had been removed, the stream edges where the riverbed was a bit shallower may have had stakes which were left behind (forgotten) after the battle (boats could pass through these places (lower than the ground but higher than the riverbed at its deepest) when the tide was rising (not yet at its maximum) or receding (not yet at its minimum). These stakes were submerged at high tide and slightly exposed at dead tide, and generally had little impact on daily life. They could also be slightly shorter, for example about 2.5 - 3.0m long.

- Thus, assuming these remaining stakes were about 1.0m higher than the dead tide level at that time, about 2.0m lower than the high tide level at that time, and area now buried 1.5 - 2.5m underground, it means that the ground of the stake yard is now almost equal to the high tide level at that time (only about 0.5m lower), 2.5m higher than the dead tide level at that time, and 3.5m higher than the riverbed at that time. In other words, today's ground is about 1.5 - 2.0m higher than the ground at that time (or less for the mounds at that time). Therefore, the possibility of finding traces of the old mounds is low (without drilling and excavation). Besides, the sedimentation rate is remarkable, about 1.5 - 2.0, even 3.5m within nearly 700 years, including 500 years in which transgression and washout prevailed. If so, the sedimentation rate must have been faster in the last 200 - 300 years of regression at that time.

- The discovery of an oar, pieces of coal, and a layer of black mud with high organic matter content in Dong Ma Ngua stake yard (Lê Thị Liên et al. [15]) shows that this could have been the area of fierce fighting as recorded in the legend of Tau Chim (shipwreck) mound and the local proverb "Bach Dang River is the frontier river/ Tong Ha Nam is the battlefield". A close combat occurred when the tide was still low, and Ha Nam Island was like a swamp. Enemy ships were blocked from moving back and forth and additionally attacked by fire, some ran into the stake yard, some crashed into each other..., the Yuan Mong army must have rushed to the Ha Nam peninsula to escape. Certainly, the Trần army and people had surrounded and only left them a way to run into Ha Nam peninsula. The Trần army and people at that time were still able to ride light boats or ambushed on the mounds to destroy them.

4. CONCLUSIONS

Based on analysis and aggregation of existing documents and additional investigations, surveys, and studies, mainly from a geological - geomorphological perspective, the authors of this article have once again attempted to reconstruct the natural characteristics and conditions of the Bach Dang battlefield area in 1288 and come to the following conclusions:

- As a part of the Dong Trieu arc and used to be the most important waterway of Dai Viet, the Duong - Kinh Thay - Bach Dang River system in 1288 was still one of the two most important waterways of the country (along with the Red River system and its tributaries), and it is still an important waterway of the Northeastern of Vietnam. Since ancient times, perhaps at least since the time of Ha Long Culture, the Vietnamese have had a tradition of exploiting and using this river system as part of the tradition of exploiting and using the Dong Trieu arc in all aspects of life, including in the resistance wars against foreign invaders.

- In terms of geology - geomorphology, the Kinh Thay - Da Bac - Bach Dang River system has formed and developed for at least hundreds of thousands of years and often follows the sub-latitude (WNW - ESE) axis belonging to the Road 18 deep fault system. In the past, this river section used to flow basically in this direction but slightly shifted northward; along this strip are Chi Linh - Dong Trieu - Mao Khe -Uong Bi urban centers. The uplift process of Yen Tu range (in the Dong Trieu arc) and relative recession of the Southern flank of Road 18 deep fault have caused these rivers to gradually move down to their present position. Similarly, the Gia River - Chanh River fault also exhibits an uplift in the Northern flank and a recession on the Southern flank with small outcrops of sediments of the Ha Coi formation ($J_{1-2}hc$) having tectonic relation with the sediments of the Duong Dong formation ($D_{1-2}dđ$) on the right bank of Bach Dang River, and the mounds of Ha Nam Island are relatively submerged as compared to the sediments of the Hon Gai formation (T_3n-r*hg*) on the left bank of Chanh River.

- The development of the sub - meridian fault system has divided Yen Tu mountain range into a number of blocks with relatively different uplift and recession amplitudes. Da Bac River flowing here had to change to the sub - meridian direction to become Bach Dang River. One of the obvious consequences is the current Yen Tu block (with Yen Tu peak with an altitude of 1,068 m asl), while Bao Dai block is only about 875m high. Similarly, on the right bank of Bach Dang River, only rocks of up to Permo - Carboniferous are exposed (excluding some small outcrops of the Ha Coi formation of Jurassic age of river, lake, and swamp origin), while on the left bank exposed mainly Triassic terrigenous rocks of the Hon Gai formation (T_3n-r*hg*).

- The consequence of the above faulting activities is that the bedrock in Ha Nam Island has been generally submerged compared to the bedrock on the right bank of Bach Dang River and left bank of Chanh River, and slightly exposed in the form of low mounds above the tidal level.

- As a part of the Hong River - Thai Binh River Delta, the downstream section of Bach Dang River in 1288 had the typical morphological characteristics of a "braided river" with interlaced streams and creeks interspersed between mounds, sandbars,... both permanent and temporary, thus it frequently changed, especially under the significant influence of the tidal regime. The creeks showed clear shorelines at low tide and in places between bedrock mounds and firmly attached ancient sandbars. The stream was considerably widened at high tide and in places where it was interspersed with temporary banks composed of weak sandy mud, but it was possible to distinguish between the "real" deep creeks and the "temporary" shallower flows. Along with the mounds, sandbars, rapids, and the system of stake yards, these "temporary" flow sections also played an important role in the battle of Bach Dang in 1288 in preventing the Yuan ships while still allowing the Dai Viet boats and ships to travel easily▪

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Assessment of the emission of air pollutants and greenhouse gases in the flue gas from coal-fired power plants in Vietnam

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Abstract:
Coal-fired power plants (CFPPs) are an important energy source in Vietnam and the major source of air pollutants as well as greenhouse gases (GHGs) in Vietnam. The emission data of air pollutants and GHGs are an important base for setting up control strategies and management policies. This study assesses the emissions of $PM_{2.5}$, PM_{10}, SO_2, NOx, CO, CH_4, N_2O, and CO_2 from CFPPs in Vietnam in 2019, and 2021 and predicts those in 2030 based on coal consumption and emission factors. A method to estimate $PM_{2.5}$ and PM_{10} emission based on the emission of PM and size distribution was proposed to overcome the difficulty of lacking data and difficult to measure those parameters in the flue gas.

Keywords: *Coal - fired power plants, emission inventory, $PM_{2.5}$.*
JEL Classification: *Q51; Q53; Q54.*
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1. INTRODUCTION

CFPPs are one of the main sources to air pollutants as well as GHGs emissions in Vietnam. In recent years, air pollution has been a major environmental concern in Vietnam (Huy and Oanh, 2017). For example, the concentration of $PM_{2.5}$ in many provinces and cities in Vietnam has exceeded the allowable limit of the national standards on ambient air quality and is several times higher than the recommended levels of World Health Organization guidelines (Hien et al., 2019; Thanh et al., 2019; Ly et al., 2018).

In 2019, Vietnam had 28 CFPPs in operation with an installed capacity of 19,744 MW, accounting for 35.83% of the total installed capacity of the power system (EVN, 2022). The total capacity of electricity produced from CFPPs has developed rapidly over the past decade. CFPPs have been projected to be the main power source (Roy et al., 2021, 2022). However, currently, Vietnam has issued a new National Electricity Development Plan for the period 2021 - 2030, vision to 2050 (Power Development Plan VIII - PDP8), which significantly reduce the percentage of CFPPs to 20% of the power source structure in 2030, corresponding to a capacity of 30,127 MW. This adjustment is considered as one of Vietnam's efforts to decrease GHGs emissions by 8% in 2030 as agreement made in COP21.

Assessing the emissions of CFPPs is very important to develop strategies and plans to control air pollution and minimize the contribution to global warming. There were three publications on air pollution emission of CFPPs in Vietnam, in 2010 (Huy and Oanh, 2017), 2015 (Roy et al., 2021), 2019 (Roy et al., 2022) and emission scenarios according to PDP7 revised (Roy et al., 2022). The emission scenarios according to PDP8, which has a significant reduction of contribution of CFPPs in power source structure, are not yet available. This study aims to develop an emission inventory in 2019 (based year), in 2021, and forecast emissions according to PDP8 in 2030. Compared with Roy et al., 2022, the overall methodology in this study is similar, but as this research is conducted later the data on coal consumption, coal characteristics are more updated. Besides, there are some different approaches in the selection of calculation parameters.

2. METHODOLOGY

2.1. CFPPs and activity data

a. CFPPs

Twenty-eight CFPPs were operating in Vietnam in 2019, of which 19 plants use pulverized coal (PC) boilers and nine plants use circulating fluidized bed (CFB) boilers. The total installed capacity of CFPPs using CFB and PC technology is 3,420 MW (24%) and 15,638 MW (76%), respectively. Most of the CFPPs are located in the significant coal mines and key economic zones of the Northern, only seven and three plants are in the Central and Southern regions of Vietnam.

b. Activity data

Activity data of CFPPs are critical information to estimate annual emissions from each CFPPs using a bottom-up approach. Besides, emissions from coal combustion depend on coal type and its composition, the design type and capacity of the boiler, the firing conditions, load, the types of control devices, and the level of equipment maintenance (US - EPA, 1996).

Most of the activity data used in this study were collected from local and national sources. Location, installed capacity, boiler technology, and total electricity output (GWh) were obtained from local reports. The coal consumption and coal properties including net calorific value (NCV), ash content, and sulfur content were mainly extracted from CFPPs reports. In case, data on coal consumption is not available (2019), the number was calculated based on electricity capacity and coal consumption rate. The activity data for operated CFPPs in 2019 and 2021 are summarized in Table 1 and Table 2.

It is important to note that the electricity production in 2020 and 2021 were affected by COVID-19. Therefore, the yearly increase in electricity production is lower than in the previous period. The electricity productions in 2019 and 2021 are almost the same.

For the prediction of 2030 emissions, the total electricity production is chosen following PDP8 (designing value of electric production). The emission rate of all pollutants and GHGs per electricity production of total CFPPs in 2019 was multiplied by the electricity prediction to obtain the emission in 2030.

Table 1: Summary of boiler technologies of operating CFPPs in 2019 and 2021

	Technology						Total	
	CFB		PC					
			Sub Critical		Super Critical			
	2019	2021	2019	2021	2019	2021	2019	2021
Number of plants	9	10	16	16	3	4	28	30
Installed capacity[a], MW	3,390	4,590	12,598	12,598	3,040	3,728	19,028	20,916
Coal consumption, 10^3 tons	9,846[b]	15,395[c]	34,729[b]	32,437[c]	8,649[b]	7,318[c]	53,224	55,150
Amount of coal per electricity production[d], ton MWh	0.459	0.596	0.437	0.493	0.424	0.448	0.440	0.512
Electricity production, 10^3 MWh	20,705[e]	29,149[c]	77,605[e]	74,340[c]	20,000[e]	16,874[c]	119,310	120,362

▲ ***Note:*** ***a, c*** *– EVN, TKV, CFFPs reports (2019, 2022);* ***b*** *- Annual fuel consumption = Total annual actual electricity produced (kWh)*3600 (kW/kJ)/(Boiler efficiency (%) * NCV (kJ/kg));* ***d*** *– Amount of coal per electricity production = Coal consumption (ton/yr)/Electricity production (MWh/yr);* ***e*** *– Electricity production = Installed Capacity * 320 (h/yr)*

Table 2: Summary of coal types of operating CFPPs in 2019 and 2021

	Anthracite		Bituminous/ Subbituminous		Lignite	
	2019	2021	2019	2021	2019	2021
Number of plants	21	22	6	7	1	1
Coal consumption amount, 10^3 tons	37,229[a]	41,078[b]	15,571[a]	13,566[b]	424[a]	506[b]
Amount of coal per electricity production, ton/MWh	0.59	0.55	0.45	0.47	0.61	0.67
Electricity production	63,460[d]	74,381[b]	34,850[d]	29,107[b]	700[d]	756[b]

▲ ***Note:*** ***a*** *- Annual fuel consumption = Total annual actual electricity produced (kWh)*3600 (kW/kJ)/(Boiler efficiency (%) * NCV (kJ/kg));* ***b*** *- Collected;* ***c*** *– Amount of coal per electricity production = Coal consumption (ton/yr)/Electricity production (MWh/yr);* ***d*** *– Electricity production = Installed Capacity * 320 (h/yr)*

2.2. Emission calculation

2.2.1. Equation

The amount of polluted gas emitted by CFPPs was calculated according to Equation 1:

$$E = EF \times R \times \frac{(100\text{-}EC)}{100} \qquad [1]$$

Where: E is the amount of emissions (tons/year); R is activity data (coal consumption (tons/year), for air pollutant estimation; the heat of burned coal (KJ/year) for GHGs estimation); EF is emission factor corresponding to the amount of activity (kg/tons) for pollutants; (kg/TJ) for GHGs; and EC (%) is the efficiency of control systems.

2.2.2. Emission factor of gaseous pollutants

For air pollutants including PM (filterable particulate matter), NOx, SO_2, and CO, EFs were extracted from the AP-42 document (EPA, 1998). For GHGs including CO_2, CH_4, N_2O, EFs from the IPCC-2006 document (IPCC, 2006) were applied as presented in Table 3. The EFs of $PM_{2.5}$ and PM_{10} were discussed and determined in Section 3.1.

2.3. Pollutant control efficiency

Unlike activity data, data about treatment efficiencies for air pollutants are not available in terms of operating values but only designing values. However, not all design treatment efficiencies are available. Therefore, we reviewed the current treatment systems and determined the best guess numbers for operating treatment efficiencies based on the types of installed devices or design efficiencies. This method is subject to large uncertainty but is considered to be the most suitable method for the time being.

2.3.1. Particulate matter treatment and efficiency

All CFPPs in 2019 installed electrostatic precipitator (ESP) systems with design efficiency of particulate matter treatment higher than 99.7% (Luong, 2018); 99.6% (EVN, 2019) or 99.19% in some plants (gathered from our communication). The operating efficiencies can be affected by several factors (such as the electric voltage, physical conditions of ESPs, fly ashes characteristics, and the shifting of operation temperature after a long time operation) and normally lower than designing one depending on the maintenances. In this study, the treatment efficiency for PM of 99.2%, which is equal to US.EPA-AP.42, was applied for all plants (Table 4). Unfortunately, there is no local available information regarding the treatment efficiencies of $PM_{2.5}$ and PM_{10}.

2.3.2. SO_2 control and efficiency

SOx emissions in current CFPPs in Vietnam were controlled by two types of technologies: controlling in the boiler (applying for CFB boiler); flue gas desulfurization (FGD) (mainly divided into two solutions: SO_2 absorption by slurry limestone and SO_2 absorption by sea water). All CFB plants remove SO_2 in boilers by injecting limestone ($CaCO_3$) into the fire chambers, where SO_2 reacts with limestone to form $CaSO_4$ which can be discharged as ash and slag. Some plants have additional FGD for further treatment of SO_2. Most PC plants apply SO_2 treatment technology with limestone/$Mg(OH)_2$

Table 3: Uncontrolled gaseous pollutants EFs of CFPPs

No.	Parameters	EF[1]		EF[2]	Unit
		PC boiler	CFB boiler	-	
1	PM	5A[a]	5A[a]	-	kg/tons coal
2	SO_2	19.5S[a]	1.45[a]	19S (for anthracite and bituminous)[c], 15S (for lignite)[c]	kg/tons coal
3	NO_x	9[a]	0.9[a]	5.02 - 6.79 (for anthracite)[c], 7.74 - 8.2 (for bituminous)[c], 9.03 (for lignite)[c]	kg/tons coal
4	CO	0.3[a]	0.3[a]	0.33 - 0.45 (for anthracite)[c], 0.34 - 0.36 (for bituminous)[c], 0.14 (for lignite)[c]	kg/tons coal
5	CO_2	98,300[b]	98,300[b]	98,300 (for anthracite) 94,600 (for bituminous) 101,000 (for lignite)	kg/TJ
6	CH_4	1[b]	1[b]	1	kg/TJ
7	N_2O	1.50[b]	1.50[b]	1.50	kg/TJ

▲ ***Note:*** *A - ash content of coal (%); S - the percentage of sulfur content in coal; a - AP42 (EPA, 1995); b - IPCC (IPCC, 2006), c: Calculated from the research of Roy et al. (2022); 1 - EFs used in this study; 2 - EFs used in Roy et al. (2022).*

Table 4: Summary treatment efficiencies of PM, SO_2 and NO_x of previous CFPPs emission inventory research

Sources	Year	Emission control efficiencies (%)				
		PM	PM_{10}	$PM_{2.5}$	SO_2	NOx
Huy and Oanh (2017)	2010	-	94%	94%	90% for all CFPPs except 2 CFPPs	0%
Roy et al. (2022)	2019	-	98.4%	98.5%	90% for Hai Phong 1 and 2 plant; 92.28 -95.96% for others	30% for LNB (including all CFB) 65 - 88.4% for LNB + SCR (6 CFPPs)
This study	2019; 2021	99.2%	-	-	90% for all PC CFFPs (except 2 CFPPs); 0% for CFB CFFPs	30% for PC-CFPPs (except 7 plants of 65 -88.4%); 0% for CFB

or seawater. The method of treating SO_2 with limestone is very popular in the world and has been tested through manufacturing and operation. This method has a high efficiency of up to or over 90%. The seawater absorption method is a modern technology, currently applied to new CFPPs in Vietnam such as Vinh Tan 2, Duyen Hai 1, Vung Ang 1, Vinh Tan 4, Duyen Hai 3, etc. This technology uses cooling seawater from condensers to absorb and neutralize SOx in exhaust smoke. The SOx removal efficiency of this technology can be up to over 90% (EVN, 2018; Luong, 2018).

The treatment efficiency of 90% for SO_2 was applied for all PC CFPPs and 0% for CFB CFPPs.

2.3.3. NO_x control and efficiency

There are two main methods for controlling NOx emissions in CFPPs in Vietnam: controlling NOx emissions in boilers and treating NOx in exhaust gas. Currently, NOx treatment methods at PC CFPPs in Vietnam vary from using low NOx emission nozzles/burners to equipping selected catalyst reactor (SCR) equipment. The processing efficiency of the SCR device for NOx treatment can reach about 75 - 80%. For CFB plants, NOx treatment devices are not installed due to low combustion chamber temperatures, but emissions can still comply with the National Technical Regulation on Emission (EVN, 2018; Luong, 2018).

The treatment efficiency of NOx was chosen of 0% for CFB CFPPs and 30% for PC CFPPs, except for seven plants with SCR (Vinh Tan 1, 2, 4 and 4 extension, Mong Duong 2, Duyen Hai 1 and 3 with efficiency of 65 - 88.4% extracted from Roy et al., 2022).

2.3.4. CO, CH_4, CO_2 control and efficiencies

There is no CO, CH_4, CO_2 treatment for CFPPs in Vietnam. Therefore, the treatment efficiencies of those compounds are considered as 0%.

3. RESULTS AND DISCUSSIONS

3.1. Determination of emission factors of $PM_{2.5}$ and PM_{10}

a. Proposal of emission assessment methods for $PM_{2.5}$ and PM_{10}

In Section 2, it was noted that there is no designing treatment efficiency for $PM_{2.5}$ and PM_{10} in Vietnam. Obtaining information about the emission of $PM_{2.5}$ and PM_{10} in Vietnam is challenging and costly due to the sophisticated monitoring methods. However, research on PM emission in Vietnam has yielded controlled emission factors for new CFPPs and a trouble happened CFFP (Dung et al., 2014). To address the difficulties in estimating $PM_{2.5}$ and PM_{10} in Vietnam, a method utilizing the EF of PM and the PM_{10}/PM and $PM_{2.5}$/PM ratios was proposed. The uncontrolled EF from the US.EPA - AP42 and unified emission control efficiencies of 99.2% for PM were chosen for all treatment processes, including ESP - FGD, SCR - ESP - FGD, and ESP - FGD. The size distributions of particulate matter were determined based on relevant research comparisons (Table 5).

Table 5 shows a wide variation in the size distribution of PM of different coal types and boiler technology with different control devices. It is noted that the data for certain technologies such as PC burning of anthracite with ESP treatment is not available. The lack of size distributions also means a lack of emission factors and treatment efficiency information for $PM_{2.5}$ and PM_{10} as data of PM are more available and the size distribution can be calculated from the emission of $PM_{2.5}$ and PM_{10} (if available). It can be observed from Table 5 that with additional treatment devices (higher efficiency) the percentage of $PM_{>10}$ reduces followed by an increase of PM_{10} and $PM_{2.5}$. Therefore, for the current study the size distribution for particulate matter after ESP treatment of PC using bituminous coal of

Table 5: Particulate matter size distribution (%) in air pollution control devices (APCDs) of flue gas

Source	Country	Boiler technology/ Type of coal	APCD	$PM_{2.5}$ /PM	PM_{10} /PM	$PM>_{10}$ /PM	$PM_{2.5}$/ PM_{10}
US. EPA - AP42 (1998)	US	PC/Bituminous -Subbituminous	Uncontrolled	6	23	49	26.09
			ESP	29	67	33	43.28
		PC/Anthracite	Uncontrolled	23	28.5	71.5	23.91
			Baghouse	65	95	5	46.15
Jeong et al. (2021)	Korea	PC/ Bituminous - Subbituminous	Uncontrolled	19.4	54	46.1	35.93
			SCR+APH+ESP	83.1	93	7	89.35
			SCR + APH + ESP + WFGD	86	95.7	4.3	89.86
Wu et al. (2018)	China	PC/Bituminous	Uncontrolled	5.8	21.7	78.3	26.73
			ESP	34	69	31	49.28
			ESP + WFGD	64	72.5	27.5	88.28
		CFB/Bituminous	ESP	32.4	67.6	32.4	47.95
Yi et al. (2008)	China	PC/Anthracite	Uncontrolled	1.7	16.7	83.3	10.17
			Baghouse	8.6	71.3	28.7	12.06
Roy et al. (2021)	Vietnam	PC+CFB/Anthracite - Bituminous	Controlled	-	-	-	24.46*
Huy and Oanh (2017)	Vietnam	PC+CFB/Anthracite - Bituminous	Controlled	-	-	-	42.34*

▲ ***Note:*** *The treatment efficiencies were calculated from the EFs*

US.EPA - AP42 (removal percentage of 99.2% for PM) were chosen as representatives for both anthracite/ bituminous coals and PC/CFB technologies. Size distribution can be upgraded in the future based on the available data.

b. Comparison of emissions based on proposal method using different PM size distributions

The calculated emissions of PM_{10} and $PM_{2.5}$ emission of CFPPs in Vietnam based on size distribution reviewed in Section 3.1.a are presented in Table 6. We chose the size distribution in Korea of PC/Bituminous – Subbituminous with treatment system of SCR+APH+ESP and in China of PC/Bituminous with treatment of ESP for comparison. The two options were chosen as they are the most relevant data. The treatment efficiency of the Korean system is considered higher and the treatment efficiency in China is closer to the Vietnamese condition.

The calculation results are based on size distribution US.EPA-AP42 was in the same range as those after ESP in the research in China of Wu et al. (2018) but 2.9 times lower than when calculated with the size distribution in Korea by Jeong et al. (2021) for $PM_{2.5}$ and 1.3 times lower than when calculated with the size distribution in Jeong et al. (2021) for PM_{10}. The high sensitives of $PM_{2.5}$ emissions with size distribution are comparable with the high sensitivity of emission with treatment efficiency. A small change in efficiency (at a high rate) can also lead to a significant change in emission. For example, changing from the removal of 99% to 98% can lead to an increase of 100% in emissions.

Table 6: PM emissions from flue gas in CFPPs in Vietnam calculated based on different size distribution (Gg/year)

	2019		
	US. EPA - AP42 (1998)	Jeong et al. (2021)	Wu et al. (2018)
PM	60.045		
PM_{10}	40.23	55.84	41.43
$PM_{2.5}$	17.41	49.90	20.42

3.2. Emission of air pollutants

3.2.1. Particulate matter

Table 7 summarizes the emission of PM_{10} and $PM_{2.5}$ from previous and current studies for the CFPPs in 2010, 2019 and forecasts for 2030. The number of CFPPs increased over time (from 12 CFPPs in 2010 to 28 CFPPs in 2019), leading to a significant increase in the amount of coal burning, increasing emissions of air pollutants (Huy and Oanh, 2017; Roy et al., 2022).

According to the results presented in Table 7, our study has revealed higher levels of PM_{10} and $PM_{2.5}$ emissions in 2019 compared to those reported by Roy et al. (2022). It is important to note that both studies are based on local activities of CFPPs and other selected factors such as EFs, removal rate, or size distribution. Therefore, we cannot claim that our data is better. However, emissions calculated by our proposed methods can be easier updated in the future. It is also noted that corresponding with the selected PM size distribution removal efficiency in this study were 97.65% and 96.00% for PM_{10} and $PM_{2.5}$, respectively whereas those in Roy et al. (2022) are 98.4% and 98.5%.

Table 7: Comparison of particulate matter inventories from CFPPs in Vietnam

No	Coal consumption/ Pollutants	2010	2015	2019		2021	2030
		Huy and Oanh (2017)	Roy et al. (2021)	Roy et al. (2022)	This study	This study	This study *
1	Coal consumption (10^3 tons)	10,000	-	56,625	53,224	55,150	-
2	PM_{10} (Gg/year)	19.3	12.18	26.47	40.23	44.27	61.39
3	$PM_{2.5}$ (Gg/year)	8.01	4.82	10.49	17.41	19.16	26.57

▲ ***Note:*** *Projected based on PDP8*

3.2.2. Gaseous pollutants

The results of estimating gaseous pollutants (SO_2, NOx, and CO) emissions of CFPPs in Vietnam are shown in Table 8. The values in 2019 are compared to evaluate our data set. The total coal consumption amount of CFPPs in this study and the study of Roy are only slightly different (this study is 6% lower). The emission of SO_2 from Roy et al. 2022 is 35% lower than this study mainly because of the lower treatment efficiencies in this study, especially there are two plants with no treatment system. Besides, the conversion rate of sulfur in the coal to SO_2 in flue gas (which affects emission factors) in this study is higher than that in Roy et al. (2022). The NOx emission in this study is comparable with those in Roy et al. (2022). The CO emission in this study is 31.4% lower than in Roy et al. (2022), mainly due to the use of lower emission factors and 6% lower coal consumption in this study.

Despite an increase in coal consumption, the emissions of SO_2 and NOx were reduced compared to 2019. This is because of the increasing use of CFB boilers, which have lower emission factors for SO_2 and NOx than PC boilers.

If the exhaust gas treatment system continues to develop at its current rate and no improvements are made, it is predicted that by 2030, most pollutants will be aproximately 1.5 times as high as those in 2019 (Table 8).

3.3. Emissions of GHGs

Table 8 displays the emissions of greenhouse gases (CH_4, N_2O, and CO_2) from CFPPs in 2019, 2021, and projected for 2023. The calculation of GHG emissions was based on emission factors derived from the heat of burned coal. In comparison to the study conducted by Roy et al. (2022), the total heat of burned coal in this study is 19% lower. As a result, the emissions of CH_4 and N_2O in this

Table 8: Gaseous pollutants and GHGs emissions from flue gas from CFPPs in Vietnam (Gg/year)

No.		Compounds	2010	2015	2019			2021	2030
			Huy and Oanh (2017)	Roy et al. (2021)	Roy et al. (2022)	MONRE (2022)	This study	This study	This study *
1	Gaseous pollutants	SO_2	142	50.09	50.64	-	78.48	78.42	119.76
2		NO_x	141	117.99	193.68	-	199.21	188.07	303.97
3		CO	11.3	11.58	23.28	-	15.97	16.54	24.36
4	GHGs	CH_4	0.60	0.60	1.30	-	1.09	1.10	1.66
5		N_2O	0.53	0.89	1.94	-	1.63	1.65	2.49
6		CO_2	44,776	58,388	126,058	106,428	106,808	108,393	162,978

▲ ***Note:*** *Projected based on PDP8*

study are also 19% lower than those in Roy et al. (2022), as the emission factors for these gases are similar between the two studies.

The CO_2 in 2019 of this study and the number reported by the Vietnamese Ministry of Natural Resources and Environment (MONRE, 2021) are similar. Both are approximately 18% lower than the figure reported by Roy et al. (2021). This difference is primarily due to the disparity in the total heat of burned coal.

If CFPPs continue to operate without GHG emissions controls or technological advancements as outlined in PDP8, GHG emissions are projected to increase by 52.6% by 2030 compared to 2019.

4. CONCLUSIONS AND RECOMMENDATIONS

This study has calculated the emission of main air pollutants ($PM_{2.5}$, PM_{10} …) in flue gases of CFPPs in 2019 and 2021. Three GHGs (CH_4, N_2O, CO_2) were also estimated. The projected emission of those air pollutants and GHGs based on PDP8 was done for the first time.

Even though this study was based on available local data about coal consumption and coal characteristics of CFFPs, large uncertainties of the emission existed mainly because of the lack of national emission factors. Besides, the lack of information about treatment systems, design treatment efficiencies, and especially operation treatment efficiencies also increases the uncertainties of the results.

The following additional actions are recommended to reduce the uncertainties of emission inventory data of CFFPs: (1) Collection of information about air pollution treatment systems and designed treatment efficiencies of all CFFPs; (2) Determination of controlled emission factors of all CFFPs; (3) Assessment of operation treatment efficiencies of typical treatment devices in different treatment systems; (4) Surveying the technologies of boilers and coal size, consumption rates, and characteristics of additives to the boilers ▪

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Relationship between agricultural waste and greenhouse gases in Dong Thap Province

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Abstract:
Based on the assessment of the status of greenhouse gas (GHG) emissions in each field of agricultural production in Dong Thap Province according to IPPC and related studies, Project has proposed solutions to reduce GHG emissions in each respective field and estimate the effectiveness of GHG emission reduction. The results show that the total GHG emissions in 2021 and 2022 are 8,697.91 and 8,872.88 thousand tons of CO_2 equivalent/year; GHG emissions is mainly from farming activities (accounting for 73% to 78%), followed by agricultural waste (16% to 20%), aquaculture (about 6%) and livestock farming (< 1%). However, when applying the proposed solutions, the effectiveness of reducing GHG emissions reaches 73,4%. If afforestation is applied and maintained, Dong Thap Province will continue to reduce GHG emissions by about 80%. Besides, to be effectively and successful in GHG emissions reducing, it is necessary to have financial support from the Government and people's awareness in environmental protection.

Keywords: *Dong Thap Province; greenhouse gas emissions; agriculture sector; agricultural waste.*
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1. INTRODUCTION

Vietnamese agriculture accounts for about 30 percent of national GHG emissions. The main types of GHG emissions in the agricultural field include CH_4, N_2O and CO_2. Quantifying emissions of each type of GHG in agricultural production show that agricultural activities are also the cause of global climate change.

In Dong Thap Province, the agricultural sector accounts for about 8.62 percent GRDP, the agricultural land accounts for about 75.39 percent of the natural area of the Province [3]. To be able to evaluate the status of GHG emissions as well as the potential and effectiveness of reducing GHG emissions in agriculture, Dong Thap Province needs to deploy GHG emissions calculations in agricultural production sectors. Estimating GHG emissions can help the Province set quantitative emissions reduction targets in the next period, monitor and evaluate efforts to reduce GHG emissions compared to usual emissions scenarios according to timelines consistent with the national GHG inventory activity.

2. DATA COLLECTION

2.1. Overview of agriculture in Dong Thap Province in 2022 [3]

Dong Thap Province's agriculture sector has proactively implemented many production transformation solutions to promote growth, ensure food security and bring high economic efficiency to farmers.

Livestock farming: The Province's livestock industry has prospered, with many large-scale investment projects applying high technology in the form of production chains have been built and operated. The livestock industry is continuing to shift from small-scale farms, not ensuring biosecurity and low efficiency to medium and large-scale farms ensuring biosecurity.

Fishery: Aquaculture production and fishery catching reached 616.9 thousand tons, an increase of 1.05% compared to 2021, of which aquaculture production reached 596.7 thousand tons, accounting for 96.7%. Aquaculture area is concentrated in Tam Nong, Cao Lanh and Chau Thanh districts.

Crop production: Total production cereals reached 3,270.5 thousand tons, a decrease of 104.3 thousand tons compared to 2021, of which paddy production reached 3,235 thousand tons, a decrease of 104 thousand tons (Spring paddy production reached 1,384.8 thousand tons, a decrease of 50.2 thousand tons; Autumn paddy production reached 1,850.2 thousand tons, a decrease of 53.8 thousand tons). Perennial crops and fruit crops (oranges, tangerines, mangoes, longans) increased compared with in 2021.

Pesticides (plant protection chemicals) [13] : Dong Thap Province's paddy area ranks third in the country and its fruit tree area is quite large. Therefore, every year, people use many pesticides to prevent pests and diseases. According to the report of Dong Thap Plant Protection and Cultivation Sub-Department, the total amount of fertilizer used is 350,642 tons per year, and pesticides are 8,974 tons per year.

Fertilizers: Farmers are used to using chemical fertilizers for crops and are not used to using organic fertilizers. The amount of fertilizer used for rice cultivation is gradually decreasing with area; For other crops such as vegetables, corn, potatoes... the amount of fertilizer used gradually increases over cultivated area.

2.2. Agricultural waste

By-products in farming: According to statistics from the Institute for Agricultural Environment (2018), The amount of by-products from paddy is the largest with over 45 million tons of straw/year, followed by sugarcane with the amount of sheaths and old leaves is over 20 million tons/year, next leaf stalks of corn, cassava plant, vegetables and coffee husks[11]. Agricultural by-products are being left over and burned. They are not used effectively, causing emissions and environmental pollution. With the ratio of straw/paddy is 1.05/1 (Trần Anh Tuấn et al., 2019), the estimated number of straw by-products generated is about 3,396.75 thousand tons in 2022.

Livestock waste: livestock waste is mainly manure, dead animal carcasses, leftover animal food, bedding materials and other waste, with moisture from 50% to 83% and high NPK ratio. With the emission coefficient referenced from the study of Vũ Chí Cường (2013), the total amount of livestock waste is 1,531.75 tons of solid waste and 1,170 tons of liquid waste.

Aquaculture waste: Waste in aquaculture is wastewater, sludge... formed mainly from shrimp and fish feces, leftover food, algae, chemicals (lime, zeolite...) used in the farming process, with solid waste generated from shrimp farming is 123 tons/crop/ha and wastewater is more than 5,000 m^3/ha, the amount of solid waste generated from pangasius farming is about 33.3 tons of sludge/ha (including mud and water)[4]. Meanwhile, resources for aquatic environmental protection activities (including finance and human resources) are still limited.

3. POTENTIAL GHG EMISSIONS FROM AGRICULTURAL ACTIVITIES IN DONG THAP PROVINCE

3.1. GHG emissions due to agricultural activities in Dong Thap Province

In this report, CH_4, CO_2 and N_2O was chosen to calculate the ability emissions in 2021 and 2022 in Dong Thap Province. The GHG emission coefficient is calculated according to the guidance of The Intergovernmental Panel on Climate Change (IPCC) (2006), domestic and foreign research related to the field of agriculture and agricultural waste.

3.1.1. GHG emissions in livestock farming

According to the guidance of IPCC (2006), based on number of livestock, GHG emissions are calculated as follows:

Total CO_2 emissions = Number of livestock x emission coefficient x conversion factor

- CH_4 emission coefficient from food digestion (intestinal fermentation) of Cow is 27 (kg/head), Pig is 1(kg/head) and Buffalo is 49(kg/head).
- CH_4 emission coefficient from waste management process of Cow is 2.4 (kg/head), Pig is 7 (kg/head), Buffalo is 2.8 (kg/head), Poultry is 0.02 (kg/head).
- N_2O emission coefficient from waste management process of Cow is 39.59 (kg/head), Pig is 13.49 (kg/head), Buffalo is 44.38 (kg/head), Poultry is 0.02 (kg/head).

Table 1: GHG emissions in livestock activities

Pet type	Number of livestock (thousands) [3][10]		CH_4 emissions from food digestion (thousand tons/year)		CH_4 emissions from waste management process (thousand tons/year)		N_2O emissions from waste management process (thousand tons/year)	
	2021	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
Cow	37.5	40.8	1.01	1.10	0.09	0.10	1.48	1.62
Pig	90.8	108	0.09	0.11	0.64	0.76	1.22	1.46
Buffalo	2.6	2.7	0.13	0.13	0.01	0.01	0.12	0.12
Poultry	6,841	6,485	-	-	0.14	0.13	-	-
Total			**1.23**	**1.34**	**0.87**	**0.99**	**2.82**	**3.19**
Aerobic treatment							**0.017**	**0.020**
The conversion factor to CO_{2eq} (IPCC, 2013)			28		28		265	
CO_{2eq} emissions (thousand tons of CO_{2eq}/ year)			**34.46**	**37.57**	**24.35**	**27.75**	**4.60**	**5.20**

▲ ***Note:*** *Total GHG emissions from livestock activities in 2021 is 63.41 thousand tons of CO_{2eq}/year, in 2022 is 70.52 thousand tons of CO_{2eq}/year*

3.1.2. GHG emissions in aquaculture

- Based on aquaculture area, GHG emissions are calculated as follows:

CH_4 emission coefficient from shrimp, fish is 0.63 kg CH_4/ha.day (Hiraishi et al.,2013), aquaculture time of about 210 days/year for shrimp and 240 days/year for fish.

CO_2 emission coefficient from shrimp, fish is 60.4 ± 1.45 kg CO_2/ha/day (Nam., 2016)[6], aquaculture time of about 210 days/year for shrimp and 240 days/year for fish.

- Based on aquaculture production and N_2O emission coefficient is 0.00169 kg N_2O - N/kg seafood: total N_2O emissions = aquaculture production x 0,00169 x 44/28.

Table 2: GHG emissions from aquaculture activities

Types of aquacultures	Aquaculture area (thousand hectares) [3][10]		CH_4 emissions (thousand tons/year)		CO_2 emissions (thousand tons/year)		N_2O emissions (thousand tons/year)	
	2021	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
Shrimp	0.9	0.9	0.12	0.12	11.42	11.42	0.005	0.01
Fish	4.8	5.1	0.73	0.77	71.25	71.25	1.49	1.57
Total			**0.84**	**0.89**	**82.67**	**87.12**	**1.50**	**1.57**
The conversion factor to CO_{2eq} (IPCC, 2013)			28		-		265	
CO_{2eq} emissions from aquaculture (thousand tons of CO_{2eq} / year)			**23.66**	**24.93**	**82.67**	**87.12**	**396.97**	**417.29**

▲ ***Note:*** *Total GHG emissions from aquaculture activities in 2021 is 503.30 thousand tons of CO_{2eq}/year, in 2022 is 529.34 thousand tons of CO_{2eq}/year*

3.1.3. GHG emissions in farming

* *Rice cultivation:* Estimated CH_4 content released into the environment from paddy fields as follows.

Table 3: Estimated CH_4 content released into the environment from paddy fields

Rice cultivation	2021	2022
Land area for rice cultivation (ha) [3][10]	504,400	482,200
CH_4 emission coefficient of 1 ha/year (kg/ha)	382.77	382.77
CH_4 content released in rice cultivation (kg/year)	193,069,188	184,571,694
CO_{2eq} emissions from rice cultivation (thousand tons/year)	**5,405.94**	**5,168.01**

* *GHG emissions due to fertilizer use:* Report calculated for two main types: Urea fertilization and lime.

- Emission coefficient of lime is kg 0.12 kg CO_2/kg lime (GL, 2006), average demand of lime 3,1kg/ha, thus CO_2 emissions from using lime is 0.37 kg CO_2/ha.

- According to research by Chojnacka et al. (2019), the CO_2 emission coefficient of urea is 3.47 kg CO_{2eq}/kg urea, average demand of urea 240kg/ha thus CO_2 emissions from using urea is 832.8 kg CO_2/ha.

Table 4: GHG emissions from fertilization in farming

Activities use fertilizer	2021	2022
Fertilized area (paddy + other crops) (ha)	541,319[3]	522,899[10]
Emission coefficient (kg CO_2/ha)		
+ Lime	0.37	0.37
+ Urea	832.8	832.8
CO_2 emissions from fertilizers (thousand tons/year)		
+ Lime	0.2	0.19
+ Urea	450.81	435.47
Total (thousand tons of CO_{2eq} / year)	**451.01**	**435.66**

** GHG emissions from pesticide:*

To calculate emissions from pesticides, it is necessary to estimate the amount of GHG emissions from agricultural pesticide production. Williams et al (2009) [1]used a linear regression method combined with an average energy value of types for pesticide production according to Green (1987), has calculated the global warming potential (100 years) is 0.069 kg CO_{2eq} per MJ of pesticide energy. Total CO_2 emissions from specific pesticides are as follows.

Table 5: GHG emissions from pesticides

No	Name of active ingredient commonly used in farming	GHG emissions (kg CO_{2eq} /year)	
		2021	2022
1	**Pesticides, spiders**		
	Abamectin	4,210,347	4,067,074
	Cypermethrin	39,308,264	37,970,649
	Chloryphyos ethyl	94,863,167	91,635,081
	Profenofos	37,890,092	36,600,736
	Pyridaben	9,767,513	9,435,136
	Other	16,143,825	15,594,469
2	**Fungicides**		
	Metalaxyl	4,885,949	4,719,686
	Mancozeb	21,418,596	20,689,746
	Carbendazim	220,521	213,017
	Hexaconazole	5,839,496	5,640,784
	Copper hydroxide	95,586,985	92,334,270
3	**Herbicide**		
	Glyphosate	367,118,567	354,625,941
	Paraquat	180,309,203	174,173,486
Total		**877,562,525**	**847,700,075**
Total (thousand tons of CO_{2eq} / year)		**877.56**	**847.70**

3.1.4. GHG emissions from agricultural waste

In currently, no research to calculate GHG emission from waste biomass from farming as well as sludge from aquaculture. Therefore, emission coefficient of garden waste in the composition of domestic waste and wastewater (IPCC, 2006) was applied.

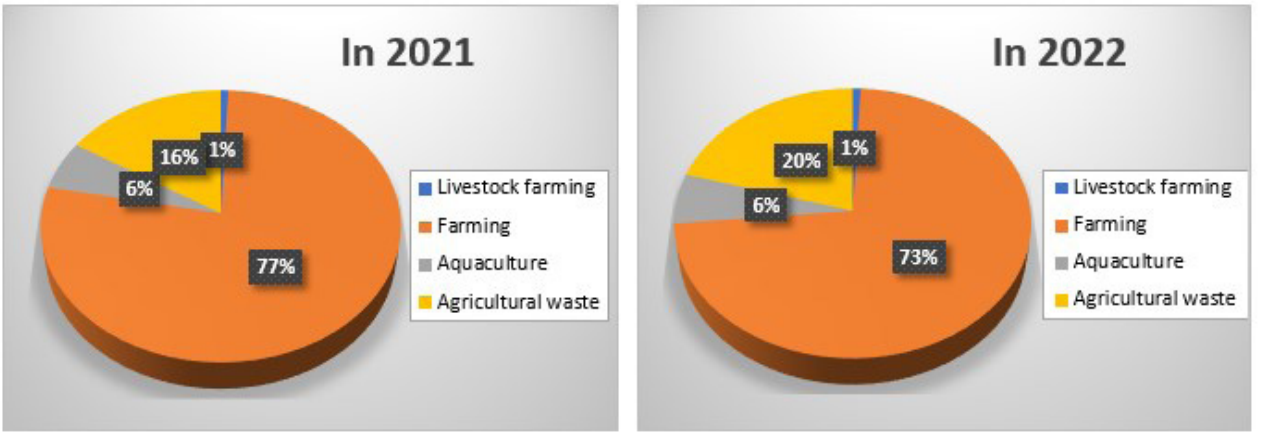
Table 6: GHG emissions in the waste sector in 2021 and 2022

Waste	Unit	2021			2022		
		CH_4	N_2O	Total	CH_4	N_2O	Total
Disposal of solid waste into landfills	Thousand tons of CO_{2eq}/year	1,389.61	-	1,389.61	1,815.62	-	1,815.62
Wastewater (untreated)	Thousand tons of CO_{2eq}/year	6.43	0.65	7.08	5.29	0.74	6.03
Total		**1,396.04**	**0.65**	**1,396.69**	**1,820.91**	**0.74**	**1,821.65**

3.2. Synthesize and compare GHG emission calculation results

Table 7: Summary of GHG emissions in the agricultural field in 2021, 2022

Sector	GHG in 2021 (thousand tons of CO_{2eq}/year)				GHG in 2021 (thousand tons of CO_{2eq}/year)			
	CO_2	CH_4	N_2O	*Total*	CO_2	CH_4	N_2O	*Total*
Livestock farming	-	58.81	4.60	**63.41**	-	65.32	5.20	**70.52**
Farming (rice growing, fertilizers, pesticides)	877.76	5865.75	-	**6734.51**	847.89	5603.48	-	**6451.37**
Aquaculture	82.67	23.66	396.96	**503.3**	87.12	24.93	417.29	**529.34**
Agricultural waste		1,396.04	0.65	**1396.69**	-	1820.91	0.74	**1821.65**
Total	**960.43**	**7335.26**	**402.22**	**8697.91**	**935.01**	**7514.64**	**423.23**	**8872.88**



▲ *Figure 1: GHG emission rate in the agricultural sector in 2021 and 2022*

▲ ***Note:*** *GHG emissions are mainly from farming activities accounting for 73% to 77%, followed by agricultural waste generation activities, accounting for 16% to 20%, emissions from aquaculture are low and livestock farming has the lowest proportion*

4. PROPOSED SOLUTIONS

4.1. Solutions to reduce emissions in farming

For rice cultivation

Applying the Alternate Wet and Dry paddy planting technique (AWD): Paddy fields are watered intermittently except for the rooting and flowering stages to reduce the time of flooding, which will reduce CH_4 emissions approximately 51% compared to the traditional [9]. However, this solution requires quite a large investment cost for irrigation pumping systems and dikes; therefore, if the Government does not support, it will not be attractive to farmers

Converting land from 2 to 3 paddy crops to 1 paddy crop and 1 vegetable crop: The conversion has contributed to reducing the GHG rate by 25% [9]. This is also a solution has been applied in some localities and has potential to be replicated because it brings higher economic efficiency than specialized rice cultivation. However, this solution requires specific planning on land, markets and investment costs to renovate irrigation systems and processing facilities.

Reuse 100% of biomass waste from farming activities: Limit burning of waste biomass and completely reuse them, such as composting from straw to fertilize plants and produce fuel from husk, waste from fruit trees is fermented to produce feed containing probiotics for livestock.

Solutions to reduce emissions in managing and using fertilizers and pesticides

Use fertilizers appropriately: There should be specific recommendations on using fertilizers for soil, should not fertilize too much urea, leading to high NO_x concentrations in the soil, that causing direct and indirect emissions of N_2O, NO_x, NH_3 and GHG effects; should use slow-release Nitrogen to reduce Nitrogen loss when fertilizing plants, while also helping to reduce GHG emissions into the environment. At the same time, people could use garden waste, sewage sludge and other organic

waste from agriculture to compost, create organic fertilizer. According to the project "Sustainable paddy production and reduction of GHG emissions AgResults", using organic fertilizer in rice cultivation has helped cut 50% of GHG emissions into the environment.

Using biosafe pesticides, which are currently encouraged, including herbal pesticides and microbial pesticides...

+ *Herbal pesticides*: A type of pesticide that uses toxins which was extracted from plants or vegetable oils to inhibit and kill pests, such as: Neem tree juice (kill pests and aphids), solution from chili, garlic, ginger (kill pests and insects), Chrysanthemum tea (kill endothermic animal, insects and invertebrates), solution from nicotiana rustica (kills pests, butterfly pupae, aphids and mollusks such as slugs), millettia pachyloba drake (kill Taiwania circumdata, Empoasca sp., and mango hopper).

+ *Microbial pesticides*: active ingredients include microorganisms such as bacteria, viruses, fungi, algae or protozoa, which excrete fluids containing antibiotics, capable of eliminate pests. This bacterium secretes proteins that help repel insects to protect plants, especially potatoes and cabbage. Other types of microbial pesticides use the principle of competition for survival, bringing non-harmful microorganisms to plants and being natural enemies of harmful microorganisms to take over the habitat and repel micro-organisms from plants.

According to the results of the model "Rice cultivation reduces GHG emissions", the "1 right - 6 reduction" technical process has reduced the number of pesticides used in paddy fields by 30%.

Provide land management policies: It is necessary to advise people to manage well cropland, keep clear soil, avoid flooding, clean up plant and animal residues, and apply properly manure to limit decomposing Nitrogen into GHGs by bacteria.

Although many solutions to reduce GHG emissions in the agricultural field have been researched and proposed; However, the applicability and replication of each technology depends largely on the economic efficiency that the technology can bring to farmers in addition to its environmental efficiency. Therefore, the Government needs to have supportive policies to continue researching these solutions in each specific area to ensure that people continue to apply and replicate GHG emission reduction technologies in agriculture.

Maintain forest ecology

Tree planting activities will increase the ability to absorb CO_2 and help exploit and use 100% of bio-

Table 8: GHG emissions from forest ecosystems in 2022

No	Planting forests	Unit	2022
I	***The amount of C absorbed***		
1	Forest land area (including forestry land and land for perennial crops) [3][10] **(A)**	Thousand hectares	54
2	Ratio C of dry matter **(CF)**	ton C/ton dry	0.47
3	Average annual biomass growth **(G_{total})**	Dry tons/ha/year	188.49
4	CO_2 absorption and emission from intact forest land with respect to annual increase **($C_{gain} = A \times G_{Total} \times CF \times (-44/12)$)**	Thousand tons of CO_2/year	-691.13
II	***Amount of C lost***		
5	Wood yield **(H)**	Thousand m^3/year	120.7
6	Biomass conversion factor into expansion factor **($BCEF_R$)**	$(m^3 loss)^{-1}$	10
7	Ratio of below ground biomass to above-ground biomass (R)	(dry tons of above-ground biomass) $^{-1}$	0.2
8	Annual loss carbon due to tree loss **($Lwood_{-removals} = H \times BCEF_R \times (1 + R) \times CF$)**	Thousand tons of CO_2/year	68.25
9	Volume of firewood lost **(FG_{trees})**	m^3/year	
10	Base wood density **(D)**	Dry tons/m^3	6.8
11	Annual loss carbon due to wood collection **($L_{wood-removals} = [FG_{trees} \times BCEF_R \times (1 + R) + EG_{part} \times D) \times CF$)**	Thousand tons of CO_2/year	78.28
12	Amount of C lost due to intervention **($L_{other\ losses}$)**	Thousand tons of CO_2/year	0.00
	Total loss (8+11+12) (C_{loss})	**Thousand tons of CO_2/year**	**146.53**
		$\Delta (C_{gian} - C_{loss})$	***-544.60***

mass from forests... so afforestation will be highly effective in reducing GHG emissions. Applying the calculation of GHG emissions according to IPCC (2006), the amount of CO_2 will be reduced by about -544.60 thousand tons of CO_2/year (2022).

4.2. Solutions to reduce emissions in livestock farming

CH_4 emissions from the rumen of cattle: There should be a program to provide nutritional cakes or other nutritional products to reduce the amount of methane produced from the digestive activities of cattle. According to Van Zijderveld et. al. (2011), digestive products could convert nitrate into NH_3, reducing CH_4 production in the cow's rumen by up to 50%.

Model for utilizing by-products from livestock farming:

+ Model of utilizing livestock waste to produce organic fertilizer and biogas as cooking fuel; treating livestock wastewater with a biogas tank not only reduces odors but also collects gas for cooking.

+ Model of utilizing animal manure to raise earthworms: Cow manure, pig manure and fillers such as grass, straw, water hyacinth, potato plants, peanut stems... or dry leaves are used as a substrate for earthworm farming. Cinnamon is used to produce organic food, anaerobic decomposition creates biogas, and produces bioenergy.

Table 9: Estimated GHG emissions reduction from agricultural activities

Emissions	GHG reduction plan (% GHG reduction)	Calculate GHG emissions in 2022		
		Initial GHG emissions (thousand tons of CO_{2eq}/year)	Applying mitigation options (thousand tons of CO_{2eq} / year)	Forest ecosystem (thousand tons of CO_{2eq}/ year)
(1)	(2)	(3)	(4)	(5)
I. Cultivation				
Rice Cultivation	+ Planting alternate wet and dry paddy (reduce 51%) + Plant rotation of 1 rice crop and 1arable crop (reduce 25%)	5,168.01	1,240.32	
Fertilizer	Use organic fertilizer from agricultural by-products (reduce 50%)	435.66	217.83	
Pesticides	Herbal pesticides, microbial pesticides (reduce 30%)	847.70	593.39	
II. Livestock farming				
Castle raising	Using digestive products to reduce CH_4 emissions from food digestion (reduce 50%)	65.32	32.66	
Waste management	Collect biogas to generate electricity and reduce CH_4, N_2O emissions from waste management (reduce 100%)	5.20	0	***- 544.60***
III. Aquaculture				
Aquaculture activities	+ Closed circular model (reduce 47.13%) + Recover P, N (reduce 30%)	529.34	279.86	
IV. Agricultural waste				
Solid waste and wastewater	+ Production compost from crop waste and livestock waste (reduce 100%) Collect biogas to generate electricity and reduce CH_4, N_2O emissions from waste management (reduce 100%)	1,821.65	0	
Total		**8872.88**	**2364.07**	**-544.60**
Total GHG reduction (3) - (4)		**6508.82**		

▲ ***Note:*** *The efficiency of reducing GHG emissions is about 73,4%. When applying and maintaining afforestation, GHG emissions will be reduced to about 80%*

4.3. Solutions to reduce emissions in aquaculture

Pond wastewater treatment: Recirculating water in aquaculture to reduce eutrophication is a sustainable method to reduce environmental impact by both reducing wastewater discharge and helping to control disease. This solution contributes to reducing the eutrophication rate compared to traditional farming by 43.66% - 47.13%[12].

Treatment of sludge from aquaculture ponds

+ Sludge from ponds is used to fertilize agricultural land. Currently, pond areas use settling ponds to remove suspended solids in waste quite effectively; however, it is necessary to have attention to the residue of dissolved nutrients in the waste source.

+ Phosphorus recovery: Current trends show that phosphorus resource regeneration is mainly implemented to reduce operating costs. Nutrient recovery is recognized to help control fouling in the sludge pipeline, improve sludge dewatering, reduce polymer consumption, treatment sludge volume, energy recovery. At the same time, with demanding high livestock farming and lacking land area for sludge treatment can be solved thanks to Phosphorus recovery techniques.

+ Nitrogen recovery: The main goal of Nitrogen recovery (reactive Nitrogen recovery) is to shorten the nitrogen cycle and convert Nitrogen in the waste stream into artificial fertilizer (precursor form). About 30% of the Nitrogen in the waste stream, representing 4% of the Nitrogen in the wastewater, can be recovered. Although Nitrogen recovery less than agricultural fertilizer needs, but Nitrogen recovery can be part of a sustainable solution.

5. CONCLUSION

The report analyzed and evaluated the situation and trends of GHG emissions in each field of agricultural production and agricultural waste, thereby providing analysis and assessment of opportunities and challenges for reducing GHG emissions in Dong Thap Province. The potential to reduce GHG emissions in the agricultural sector is huge. However, the biggest challenge comes from limited funding to invest in waste reduction technology; in addition to the awareness, consciousness, responsibility to protect the environment and reduce GHG emissions of local people are still limited.

Specific measures to reduce GHG emissions for each type of agricultural production in Dong Thap Province are as follows: Review and issue technical guidance documents on GHG inventory for departments and relevant units to refer to before implementing contents on GHG emission mitigation in agriculture; Expand cooperation with strategic partners such as C40 Organization, JICA, World Bank.... to seek funding sources; issue handbooks to guide actions to reduce GHGs in each production fields in agriculture ■

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Developing "zero energy" buildings to effectively implement the Vietnamese Government's commitment to responding to climate change

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1. INTRODUCTION

According to the Report of the Ministry of Construction, currently, the energy used in construction projects accounts for nearly 35% of the country's total energy. Therefore, the development of "Zero Energy Building" (ZEB) with design, construction and operation that meets the criteria and standards of economically and efficiently use of energy will contribute to reducing emissions into the environment and fulfilling the commitment of Vietnam to reach net zero emission by 2050. The article presents an overview of the ZEB, criteria, technical solutions and experience in developing ZEBs in Japan, basing on that, we would like to make recommendations on developing ZEBs in Vietnam to respond to climate change in the current period.

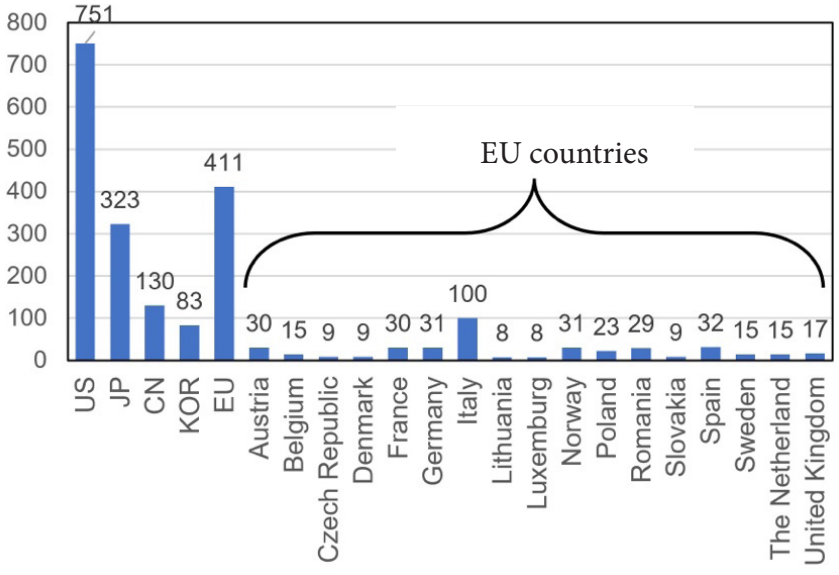
2. ZEB AND DEVELOPMENT TREND

A ZEB is a building that generates its own renewable electrical energy equal to or greater than its actual effective energy consumption, without using traditional energy from fossil fuels, reducing greenhouse gas (GHG) emissions, ensuring environmental quality in the building that meets comfort requirements [1]. In order to the ZEB can be achieved the criteria of being a ZEB, when designing and constructing the building, it is necessary to thoroughly and successfully apply the following 3 groups of innovative technical solutions: (1) The ZEB uses advanced technology solutions to self-generate renewable electrical power from natural resources (mainly from solar radiation energy), this self-generated renewable power source is equal to or greater than the reality demand for electricity consumption of the project; (2) The ZEB is designed and installed with systems of ventilation, air conditioning, electric lighting, water supply and drainage and other equipment... using energy most economically and efficiently to minimize the actual electricity consumption of the building as much as possible; (3) The ZEB has a shell with the best sun shading, best thermal insulation, taking advantage of natural ventilation and natural lighting to reduce the building's heat load to the lowest possible level. Reality has shown that the ZEB construction is the absolute pinnacle of the development of projects that use energy efficiently and effectively.

According to estimates by the World Bank (WB), construction and operation of construction projects globally consumes nearly half of natural raw materials and about one-sixth of clean water and consume about 40% of the world's total energy production and emit about 30% of the GHGs that cause climate change. Therefore, in the 90s of the last Century, when humanity faced the risk of increasingly scarce natural resources, the living environment was increasingly polluted, and oil energy was in the second crisis, climate change is increasingly threatening the survival of humanity, countries around the world, including a number of developed countries, have issued regulations and policies policy on economical use of energy, to cope with climate change. According to calculations by scientists, due to the construction industry consumes about 40% of the entire energy source that humanity has exploited and produced, in most countries when making the policy on "use energy efficiently and economically" must first be applied to the construction industry, thereby forming and developing the movement to design and construct buildings that use energy efficiently and economically.

However, a summary of experience in developing buildings that use energy efficiently and economically in the world in recent times shows that the development of new green buildings only achieves energy savings of about 10 - 30% compared to traditional construction projects, unable to meet the requirements of minimizing GHG emissions to limit climate change according to Vietnam's commitment at the 26th United Nations Climate Change Conference (COP26), reducing net emissions to "zero" by 2050. Thus, for energy efficient buildings to meet the level of response to climate change, in addition to developing green buildings, it is necessary to develop ZEBs in the construction industry in Vietnam. Currently, many countries around the world have

promoted the development of ZEBs to meet the requirements of COP26. Specifically, Figure 1 introduces the statistical results of the number of ZEBs that have been actually built in these countries around the world in the last 10 - 15 years.



▲ *Figure 1. Number of ZEB constructions were built in the world (2022). (Source: References [4])*

From Figure 1, it shows that the 5 countries with the largest number of ZEBs in the world include: United States of America (751 ZEBs), Japan (323 ZEBs), China (130 ZEBs), Italy (100 ZEBs) and Korea (83 ZEBs).

The following are images introducing some typical actual ZEBs from some countries around the world (USA, Japan, China, Korea, Singapore and Thailand) (Figure 2).

3. EXPERIENCE IN DEVELOPING ZEBS IN JAPAN

In Japan, green buildings and energy efficient buildings began to develop in the 90s of the last century and since 2015, ZEBs have been developing. To gradually develop ZEBs in Japan, the concept of expanding "ZEB Family" has been introduced: The first step is to aim for ultra-low-energy buildings (buildings save about 50% energy compared to the reference energy consumption) which are defined as "ZEBs Ready", then aim for "nearly ZEB" (buildings save about 75% of

▲ *Figure 2a. A ZEB of USA (Source: References [5])*

▲ *Figure 2b. A ZEB of Japan (Source: References [5])*

▲ *Figure 2c. A China's ZEB (Source: References [5])*

▲ *Figure 2d. Olympic Stadium in Tokyo 2020. Total area 194,000m², 68,000 seats (Source: References [6])*

▲ *Figure 2e. A ZEB in Singapor (Source: References [1])*

▲ *Figure 2f. Khonkean International Convention Center. A ZEB in Thailand (Source: References [3])*

▲ *Figure 2. Introducing images of some typical ZEBs in some countries*

energy compared to the reference energy consumption level), and the next step is to develop a building that meets 100% criterion, ZEB (a project that generates its own renewable energy by approximately 100% balanced with reference energy consumption (Net ZEB).

According to references [3, 4, 5, 6], some experiences on developing ZEBs in Japan can be drawed as follows: To begin the strong development of the ZEB in 2015, Japan started from amending and completing relevant laws, regulations, standards and technical instructions for these projects. The program uses energy effectively and saves energy in accordance with promoting the implementation of the "ZEB Family" development plan. Specifically, in 2015, the revised Energy Law was promulgated and introduced the concept of "ZEB Family" and truly began the development phase of ZEBs in Japan.

- Japan has created a specific and detailed plan for the development of "ZEB Family" and resolutely implemented the set plan. In 2002, in Japan, the State Management Agency issued a notice mandating the application of energy saving measures for all types of new construction, expansion and reconstruction: Since 2006, it was applied for buildings with a total floor area of 2,000 m^2 or more and from 2010 for buildings with a floor area of 300 m^2 or more. Since 2015, the initial phase of the ZEB construction development plan has focused on applying mandatory ZEB construction standards and regulations for large construction projects (with a total floor area of the building from 10,000 m^2 or more), because the number of the new large buildings accounts for only about 1% of the total number of new buildings were built in Japan, but the annual energy consumption of these large buildings account for 36% of the total energy consumption of the construction industry. The plan is that by 2025, all types of commercial buildings, public houses and newly built houses must comply with mandatory regulations applying ZEB construction. By 2030, ZEB development must achieve the goal of using energy economically and effectively to contribute to reducing the country's total energy consumption by about 62 million kj by 2030. In that case , industries reduced by 13.5 million kj (including LED lighting: 1.08 million kj, industrial heat pumps: 0.88 million kj, efficiency motors and inverters: 1.66 million kj, energy management according to the FEMS system is 0.74 million kj); Housing sector reduced by 12.1 million kj (including LED efficient lighting: 1.93 million kj, improved energy efficiency of household appliances: 1.73 million kj, economical home Zero Energy House (ZEH) energy: 3.44 million kj); Commercial sector reduced 13.8 million kj (of which LED lighting reduced 1.95 million kj, improving equipment efficiency reduced 3.42 million kj, energy management through Building Energy Management System (BEMS): 2.38 million kj, ZEB energy-saving buildings decreased by 5.46 million kj); The transportation sector decreased by 23.1 million kj (including the advanced generation cars decreased by 9.90 million kj, effective freight transportation decreased by 8.52 million kj, effective passenger transportation decreased by 4.63 million kj).

- Accurately identify 4 key areas of technical innovation and creativity to achieve ZEBs: (1) Minimize energy consumption in areas related to architectural planning, building shapes, reasonable layout of rooms and spaces in the building, construction methods, selection of materials to build the structure covering the building...; (2) Areas related to energy efficiency of equipment systems in buildings; (3) Establish and utilize renewable energy (mainly solar radiant energy) to provide electricity for the project; (4) Energy saving related to methods of operating, controlling and managing the building's equipment system.

- Japan has proposed policies to encourage and preferentially develop ZEBs, label ZEBs, and provide technical guidance on the design and construction of ZEBs. Conduct evaluation, selection, recognition, and awarding star for actual ZEBs.

- Promote propaganda and dissemination of knowledge and improve awareness and skills of designing and constructing ZEBs in Japan, with special attention being given to investors in society and architectures, engineers, construction engineers and engineers in related fields at Institutes and Centers for design and research in construction and architecture.

4. SOME RECOMMENDATIONS ON DEVELOPING ZEB IN VIETNAM

In Vietnam, since the first decades of the 21st Century, legal documents have been issued such as: Decrees of the Government, regulations and standards on the development of buildings that use energy efficiently and economically. Currently, there are a number of architectural constructions that have been evaluated and recognized as efficient and energy-saving projects, or as green buildings, green urban areas, but there is almost no information or plans on construction and development of ZEBs. Meanwhile, the Government announced a commitment at the COP26 Conference to reduce GHG emissions to reach "net zero" emissions by 2050, therefore Vietnam must urgently develop ZEB projects in the near future. From experience developing ZEB in Japan, there are some recommendations on developing ZEBs in Vietnam as followings:

Firstly, the Government needs to issue regulations on the development of ZEBs. Currently, the State has issued legal documents on economical and efficient use of energy, such as: Decree No. 21/2011/NDCP - Detailing the Law on Economical and Efficient use of energy and measures for its implementation; Decree

No. 134/2013/ND-CP stipulates regulations on sanction against administrative violation in the field of electricity, safety of hydroelectric dam, thrifty and effective use of energy; Decree No. 15/2021/ND-CP on elaborating certain regulations on management of construction projects; Decision No. 280/QD-TTg, dated March 13th, 2019 on approval of the National Energy Efficiency Program for the period of 2019 - 2030 was issued by the Prime Minister; National technical regulations on buildings that use energy economically and efficiently (QCVN 09: 2017/BXD)... These are important legal bases for promulgating regulations on the development of ZEB.

Secondly, it is recommended to establish a specialized department at the Ministry of Construction to manage the development of energy efficient buildings and ZEBs. This organization will closely coordinates with relevant organizations such as the Ministry of Industry and Trade, Ministry of Natural Resources and Environment to manage the development of energy efficient buildings, green buildings and ZEB. It is necessary to overcome the current situation of loose management and development of energy efficient and green buildings.

Thirdly, build and plan the development of energy efficient buildings and ZEBs until 2030 and a vision to 2050 in a detailed and specific manner similar to the Development Plan for ZEB in Japan.

Fourthly, promulgate preferential policies and encourage the development of green buildings and ZEBs: The private sector is an important factor promoting the development of green buildings and ZEBs. However, many private investors do not understand the benefits of green buildings and ZEBs, so they do not invest in construction of green and ZEB buildings, because it will incur more costs or risks. Therefore, it is necessary to develop and issue policies and mechanisms to remove barriers and obstacles for green buildings and ZEB development; Develop monetary and non-monetary incentives for private economic sectors investing in green buildings and ZEB construction (monetary incentives such as: green buildings or ZEB investors are given priority loans with low interest rates, tax deductions and other financial incentives; non - monetary incentives such as: Labeling with green buildings and ZEB; or Selection, recognition and certification for buildings that meet the criteria of green buildings and ZEB; The State rewards the investor of the project and the design consultancy for special constructions and zeb buildings). At the same time, it is necessary to issue regulations, standards, design standards and construction of green bulding and ZEB.

Fifthly, promote propaganda and dissemination of knowledge and improve awareness and skills in designing and constructing ZEBs. The subjects of special attention are investors in society and architects, construction engineers and engineers in related fields at Institutes and research centers for construction and architecture.

Sixthly, focusing on training and improving the capacity of human resources for design and construction technology, developing energy efficient buildings, green buildings and ZEB. International experience shows that to develop energy efficient buildings, green buildings and ZEB quickly and firmly, it needs to tried to re-train and complement knowledge for architects and construction engineers, and engineers of related industries who are currently operating in the construction industry, as well as training generations of future architects and construction engineers on skills and design principles and technology for green buildings and ZEB, including the following specific activities: (1) Organize training courses for experts on design and construction of green and ZEB buildings for architects, construction engineers and engineers of other relevant industries (environment, energy, materials, equipment indoors...) who are currently working in the construction industry; (2) Organize training courses to enhance the management and appraisal of green and ZEB constructions for state management agencies; (3) Complementing knowledge about green buildings and ZEBs and renovating university and university training programs for related industries, to have human resources for developing green and ZEBs, in order to effectively implement the country's sustainable development goals ▪

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Developing a scheme for the development of the carbon market in Viet Nam

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The carbon market is considered one of the important tools in reducing greenhouse gas (GHG) emissions at low costs to businesses and society, promoting the development of low-emission technology, contributing to improving competitiveness of businesses and contributing to achieving net zero emissions in Vietnam by 2050. The Scheme for the Development of the Carbon Market in Viet Nam is developed to assign tasks to Ministries, sectors and local authorities associated with specific progress and deadlines to implement legal regulations on organization and development of the domestic carbon market.

Climate change has become an irreversible trend, the biggest challenge for humanity, and has been affecting all aspects: global economics, politics, diplomacy, and security. Each country must proactively adapt to limit negative impacts, and at the same time have the responsibility to reduce GHG emissions according to Nationally Determined Contributions (NDCs) to implement the Paris Agreement on climate change from 2021 onwards to hold the increase in global average temperature at 1.5°C by the end of this Century compared to the pre-industrial global average temperature.

Achieving net zero emissions by 2050 is an inevitable development goal for the world, mainly through strong energy transition and low-emission development. This is also the new "rule of the game" for global trade and investment that has been established since the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26). To achieve the goal of reducing GHG emissions, in addition to applying advanced, low-emission technology, and many countries apply carbon pricing tools. Commonly applied carbon pricing tools are carbon taxes, GHG emission quota trading systems (domestic carbon market), and carbon credit mechanisms. To date, there are about 70 countries and territories in the world applying carbon pricing tools. These carbon pricing tools control about 23% of total global emissions in 2023.

Viet Nam sent the United Nations Framework Convention on Climmate Change (UNFCCC) Secretariat its NDC in 2015 and the first updated NDC in 2020. At the COP26 at the end of 2021, Viet Nam became one of the signatories of Global Methane Pledge and committed to reduce methane emissions by 30% by 2030 compared to the base year of 2020; signed the global coal to clean power transition statement, the Glasgow Leaders' Declaration on Forests and Land Use to prevent and reverse deforestation and land degradation by 2030; joined the Global Adaptation Action Coalition to mobilize resources for climate change adaptation. In particular, Prime Minister Phạm Minh Chính has declared to achieve net zero emissions by 2050. To concretize these statements, Viet Nam sent the UNFCCC Secretariat the second updated NDC on 8th November 2022 at the COP27 in Egypt.

Viet Nam identifies the carbon market as one of the effective carbon pricing tools in implementing activities to reduce GHG emissions, contributing to its commitment to reduce GHG emissions under the NDC and especially contributing to achieving net zero emissions by 2050.

REGULATIONS ON THE ORGANIZATION AND DEVELOPMENT OF THE CARBON MARKET IN VIETNAM

Create financial mechanisms and policies to form and operate the carbon market in Vietnam, the Law on Environmental Protection (LEP) 2020 stipulates the organization and development of the carbon market as a tool to promote the reduction of domestic GHG emissions, as a part of the contribution to GHG emission reduction committed by Vietnam when participating in the Paris Agreement on climate change. In particular, the Law stipulates that domestic carbon market includes activities of exchanging GHG emission quotas and carbon credits obtained from the mechanism of exchanging and compensating domestic and international carbon credits in accordance with the provisions of international laws and treaties to which the Socialist Republic of Viet Nam is a member. Establishments that emit GHG must conduct inventory of GHG in the list of allocated GHG emission quotas and have the right to exchange, buy and sell in the domestic carbon market.

To detail the implementation of the LEP 2020 on GHG emission reduction and ozone layer protection, on 7th January 2022, the Government issued Decree No. 06/2022/NĐ-CP. The Decree stipulates participants, development roadmap, and time to deploy the domestic carbon market; confirms that carbon credits are traded in the domestic carbon market exchange; stipulates the exchange of GHG emission quotas and carbon credits in the domestic carbon market exchange; stipulates documents, order and procedures for project implementation according to the carbon credit exchange and offset mechanism; stipulates responsibilities of agencies in developing carbon market. Roadmap to develop the domestic carbon market includes 2 stages:

(1) Period from now until the end of 2027: Focus on developing regulations on carbon credit management, activities of exchanging GHG emission quotas and carbon credits; guide the implementation of domestic and international carbon credit exchange and offset mechanisms in accordance with the provisions of international laws and treaties; pilot carbon credit exchange from 2025; develop regulations for operating the carbon credit exchange; implement capacity building and awareness raising activities; stipulate the principles of activities of exchanging GHG emission quotas and carbon credits in the market as well as the organization and operation of the domestic carbon market;

(2) Period from 2028: Organize the operation of an official carbon credit exchange; stipulate activities of connecting and exchanging domestic carbon credits with the carbon markets of regional countries and the world carbon market.

Regarding participants in the domestic carbon market, including:

- Establishments in the list of sectors, establishments that emit GHG must conduct GHG inventory issued by the Prime Minister with Decision No. 01/2022/QĐ-TTg dated 28th January 2022. The list is updated every two years according to the criteria stipulated in Decree No. 06/2022/NĐ-CP. These are establishments with annual GHG emissions of 3,000 tons of CO_2 equivalent or more or in one of the following cases: (1) Thermal power plants, industrial production establishments with total annual energy consumption of 1,000 tons of oil equivalent (TOE) or more; (2) Freight transportation companies with total annual fuel consumption of 1,000 tons of oil equivalent or more; (3) Commercial buildings with total annual energy consumption of 1,000 tons of oil equivalent or more; (4) Solid waste treatment establishments with annual operating capacity of 65,000 tons or more.

- Organizations participating in the implementation of domestic and international carbon credit exchange and offset mechanisms in accordance with the provisions of international laws and treaties to which the Socialist Republic of Viet Nam is a member.

- Other organizations and individuals related to investment activities and trading of GHG emission quotas, carbon credits in the carbon market.

Regarding the allocation of GHG emission quotas:

- Based on the goals and roadmap to reduce national GHG emissions and the results of the GHG inventory in the most recent inventory period of establishments emitting GHG that must conduct GHG inventory in the list of GHG emissions issued in Decision No. 01/2022/QĐ-TTg dated 18th January 2022 of the Prime Minister, the Ministry of Natural Resources and Environment (MONRE) submits to the Prime Minister for promulgation of total GHG emission quota, reserve and auction quota rates for the period 2026 - 2030 and annually.

- Based on the results of inventory of the national GHG, of the sectors and of the GHG emitting establishments themselves that must carry out GHG inventory on the list issued in Decision No. 01/2022/QĐ-TTg dated 18th January 2022 of the Prime Minister, the MONRE presides and coordinates with Ministries managing relevant sectors to develop and promulgate GHG emission norms per product unit for all types of production and business establishments, organize the allocation of GHG emission quotas to establishments for the period 2026 - 2030 and annually.

Regarding implementation of programs and projects under the carbon credit exchange and offset mechanism:

The Decree stipulates that organizations wishing to develop and implement programs and projects in the territory of Viet Nam according to the carbon credit exchange and offset mechanism within the framework of the UNFCCC, international treaties and agreements that the Socialist Republic of Viet Nam is a member, submit documents under the guidance of the MONRE. The MONRE organizes the evaluation and sends a notification to the organization regarding the decision to approve or disapprove the program or project within a maximum of 38 working days.

Organizations implementing programs and projects under the carbon credit exchange and offset mechanism outside the framework of the UNFCCC, international treaties and agreements to which Viet Nam is a member in the territory of Viet Nam are responsible for sending registration information and annually provide information on implementation status to the MONRE.

In recent times, many carbon credit exchange and offset mechanisms have been implemented such as the Clean Development Mechanism (CDM) within the framework of the Kyoto Protocol, and the Joint Crediting Mechanism (JCM) within the framework of cooperation on low carbon growth between Viet Nam and Japan, a number of voluntary mechanisms. In the near future, Viet Nam will implement carbon credit exchange and offset mechanisms according to Article 6 of the Paris Agreement.

To date, there have been nearly 300 programs and projects under the CDM registered by the United Nations and implemented in Viet Nam, of which about 150 programs and projects have been granted more than 40.2 million carbon credits and traded in the world carbon market. There are 14 projects under the JCM of cooperation with Japan. Projects are focused on activities of energy efficiency and saving in the sectors of industry, agriculture, waste treatment...

Regarding the exchange of GHG emission quotas and carbon credits in the domestic carbon market:

- The Decree stipulates that the exchange of GHG emission quotas and carbon credits is carried out in the carbon credit exchange. Activities in the carbon credit exchange include: auction, transfer, borrowing, payment of GHG emission quotas, and use of carbon credits to offset GHG emissions. Accordingly: (1) Establishments can bid to own additional GHG emission quotas in addition to the GHG emission quotas allocated during the same commitment period; (2) Establishments can transfer unused GHG emission quotas from the previous year to subsequent years within the same commitment period; (3) Establishments can borrow GHG emission quotas allocated for the next year to use in the previous year within the same commitment period; (4) Establishments can use carbon credits from projects under carbon credit exchange and offset mechanisms to offset for GHG emissions that exceed GHG emission quotas allocated in one commitment period. The amount of carbon credits to offset emissions must not exceed 10% of the total GHG emission quotas allocated to the establishments.

- The allocated GHG emission quotas will automatically be revoked by the MONRE when establishments stop operating, dissolve or go bankrupt.

- The State encourages establishments to voluntarily pay back unused GHG emission quotas to contribute to achieving the national GHG emission reduction goal.

- At the end of each commitment period, establishments must pay for GHG emissions exceeding the allocated GHG emission quotas after applying the forms of auction, transfer, borrowing, and use of carbon credits for offsetting. In addition to payment, GHG emissions exceeding the allocated quotas will be deducted from the allocated quotas for the following commitment period.

Regarding carbon credit certification, GHG emission quotas are traded in the domestic carbon market exchange:

To be able to trade in the carbon credit exchange, GHG emission quotas and carbon credits need to be certified. Accordingly, organizations and individuals wishing to have GHG emission quotas and carbon credits certified for transactions shall submit certification requests to the MONRE via the online public service system. The MONRE organizes verification and issues certification to organizations and individuals within 15 working days.

Regarding responsibility for developing the domestic carbon market:

- The Ministry of Finance (MOF) is the agency in charge of developing and establishing a carbon credit exchange and promulgating a financial management mechanism for carbon market operations.

- The MONRE presides and coordinates with line Ministries to organize pilot operation and official operation of the carbon credit exchange to serve the management, monitoring and supervision of the carbon market; regulates activities connecting the domestic carbon credit exchange with regional and world carbon markets; regulates the implementation of carbon credit exchange and offset mechanisms; develops propaganda materials and carries out capacity building activities for carbon market participants.

- Ministries, ministerial-level agencies, and Provincial People's Committees are responsible for coordinating with the MONRE and the MOF to implement regulations and activities to promote carbon market development; organize dissemination and propaganda on mass media to raise community awareness about the carbon market.

SCHEME FOR THE DEVELOPMENT OF THE CARBON MARKET IN VIET NAM

Specify the roadmap and responsibilities for Ministries, sectors and local authorities associated with specific progress and deadlines to establish and operate the domestic carbon market in accordance with the provisions of the LEP and Decree No. 06/2022/NĐ-CP, the Prime Minister directs the MOF to preside over and coordinate with the MONRE, relevant Ministries and sectors to develop and submit to the Prime Minister for promulgation of the Scheme for the Development of the Carbon Market in Vietnam.

In recent times, the MOF has presided over the development of the Scheme in Viet Nam with the following main contents: Perspectives; target; market model, tasks, solutions; organization for implementation.

The content of the market model will focus on clarifying: Goods in the market; Participants in the market; Market organization; Market management, monitoring and supervision.

Tasks and solutions include 3 groups: Group of tasks and solutions related to developing and perfecting the legal framework; Group of tasks and solutions related to the organization and operation of the domestic carbon market; Group of tasks and solutions related to raising awareness and strengthening capacity. Attached to the Decision approving the Scheme is a list of tasks and solutions for implementing the Scheme for the Development of the Carbon Market in Vietnam.

It is expected that the MOF will submit to the Prime Minister for approval of the Scheme for the Development of the Carbon Market in Viet Nam in the fourth quarter of 2023 ▪

Overview of progress in implementing sustainable development goals related to natural resources and environment in Viet Nam

NGUYỄN THỊ THANH NGA
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1. INTRODUCTION

Sustainable development is an urgent need and an inevitable trend in the development process of human society and is also orientation throughout the development process of Vietnam. At the United Nations (UN) Summit held in September 2015 in New York (USA), the 2030 Agenda and 17 sustainable development goals (SDGs) were agreed upon by UN member countries, providing a shared blueprint for peace and prosperity for people and the planet now and in the future.

Vietnam has strongly committed to Agenda 2030 and SDGs. The country has issued the National Action Plan to implement the 2030 Agenda for SDGs (National Action Plan 2030) with 17 SDGs and 115 specific targets. A set of 158 indicators on sustainable development has been established to monitor, supervise and evaluate the implementation of the SDGs. The SDGs have been integrated and mainstreamed into the national, sectoral and field policy systems, with a focus on the aspect of "leaving no one behind" and implemented with all stakeholders participation at the Central and local levels.

In the global context of having passed halfway in implementing SDGs, the article evaluates the SDGs implementation related to natural resources and environment in recent times in Vietnam with a view to achieving SDGs by 2030, including the following contents: SDG 6 on clean water and sanitation; SDG 7 on clean and sustainable energy; SDG 11 on sustainable urban and rural development; SDG 12 on sustainable consumption and production; SDG 13 on climate action; SDG 14 on conservation and sustainable use of oceans and seas; SDG 15 on biodiversity conservation and sustainable forest development.

2. SOME RESULTS OF SDGS IMPLEMENTATION RELATED TO NATURAL RESOURCES AND ENVIRONMENT

According to the global ranking of SDGs implementation, in general, Vietnam has had quite good development since 2015. In 2017, Vietnam ranked 69th, increasing to 49th in 2020. However, in 2022, Vietnam is ranked 55th. In the Asian region, Vietnam is evaluated quite well in terms of overall progress in implementing SDGs, however, maintaining this level of progress remains challenging. According to Vietnam's Voluntary National Review of Implementation of SDGs in 2023, some results of implementation of SDGs related to natural resources and environment in the past 5 years of Vietnam can be stated as followings:

Ensure adequate and sustainable management of water resources and sanitation systems for all (Goal 6)

As a country with a dense river system and with focuses on agricultural development, Vietnam has made efforts to ensure adequate and sustainable management of water resources, along with sanitation systems for all of the people. In particular, in the period 2018 - 2022, the proportion of the urban population provided with clean water through the water supply system increased from 86.7% to 94.2%; The proportion of households with hygienic water sources increased from 95.7% to 98.3% and the proportion of households using hygienic toilets increased from 90.3% to 96.2%; The proportion of industrial parks and export processing zones in operation with centralized wastewater treatment plants meeting environmental standards increased from 80.1% to 91%. It can be said that progress in implementing goal 6 is achieving positive progress in the period from 2018 to present. However, in the context of pressure from socio-economic development, access to clean water and sanitary conditions that meet the standards of the Ministry of Health are still limited; the impact of climate change is becoming more and more serious. Vietnam needs to continue to drastically implement policies and solutions to control wastewater; increase investment in water and sanitation projects for remote, mountainous areas; Promote integrated management of water resources by river basin and strengthen international cooperation and benefit sharing with countries sharing the same water source.

Ensure access to sustainable, reliable and affordable energy for all (Goal 7)

With the implementation of the National Targets Program on providing electricity to rural, mountainous and island areas, the rate of households accessing electricity tends to increase and reach 99.5% by 2022 with the gap between urban and rural areas has been significantly narrowed, from a difference of 1.3% to only 0.1% in the period 2018 - 2022. Installed capacity and output of power projects from renewable energy sources exceeded the set level, the proportion of renewable energy in total final energy consumption in Vietnam tends to increase and reach 21.78% by 2020 thanks to policies promoting investment in renewable power projects, especially wind power, solar power. Besides the above mentioned bright spots, energy consumption compared to total domestic product tends to increase, higher than the average level of the world as well as ASEAN countries. Although the proportion of renewable energy in total final energy consumption has increased, it has not yet reached the set target. The slow process of technological innovation in some energy-consuming industries also leads to high energy consumption.

Sustainable and resilient urban and rural development; ensure a safe living and working environment; reasonable distribution of population and labor by region (Goal 11)

The field of urban development has achieved many important results. The rate of households living in temporary housing across the country has decreased rapidly, from 2.6% in 2016 to 1.7% in 2018 and 0.9% in 2022. The trend is to sharply decrease the rate of households living in temporary housing. Temporary housing is recorded in all criteria, from urban to rural areas, in all regions and population groups. Besides positive results, urban development is facing the problem of environmental pollution. The rate of urban solid waste collected and treated to meet national standards and technical regulations in 2022 will reach 96.23% compared to 86% in 2018, but mainly landfilled. The amount of construction waste, accounting for about 10 - 15% of urban solid waste, has increased rapidly in recent years along with the pace of urbanization and rapid increase in construction projects in large cities of the country. In addition, green areas and water surfaces are not exploited and used properly, causing the quality of the living environment of urban people to decline. In recent years, the socio-economic infrastructure in rural areas has undergone remarkable changes, contributing to changing the appearance of rural areas and essential projects to meet the requirements of production development and people's lives have basically been completed. Rural environmental protection has had a major breakthrough, especially in the issue of waste treatment in residential areas and improving the green - clean - beautiful rural landscape.

Ensuring sustainable production and consumption models (Goal 12)

Vietnam continues to promote the implementation of the National Action Program on sustainable production and consumption; make efforts to effectively manage and use natural resources, strengthen measures and sanctions to treat environmental pollution; Initially develop and apply in practice regulations to promote sustainable public procurement; Complete tax and price policies for fossil fuels and make flexible adjustments to protect the poor and vulnerable groups, especially in the context of the impact of the COVID-19 pandemic. Propaganda and education work to raise awareness about environmental protection continues to be promoted, especially focusing on communication activities and awareness raising to change consumption habits and encourage the use of alternative, environmentally friendly products. By the end of 2021, the rate of hazardous waste collected and treated will reach 90% in 2021 (an increase of 15% compared to 2018); The rate of establishments causing serious environmental pollution treated reached 85.5% (an increase of 19.3% compared to 2018). However, Vietnam needs to make great efforts to implement SDG 12 in the context of environmental pollution and waste generated from socio-economic development activities increasing, in which the rate of collection and treatment of household solid waste in rural areas has only reached 66% and more than 80% of landfills are unsanitary; Resources to promote sustainable production and consumption are increasingly limited; Mineral resources and land have not really been strictly managed and exploited effectively; Business participation in sustainable production and supply chains is limited.

Respond promptly and effectively to climate change and natural disasters (Goal 13)

Vietnam always strives to respond promptly and effectively to climate change and natural disasters through strengthening relevant laws, strategies and policies; Implement international commitments, especially the commitment to reduce net zero emissions by 2050 and promote ministries, branches and localities to actively implement the Paris Agreement on Climate Change. To date, 87.3% of provinces and/or cities directly under the Central Government have issued Action Plans to im-

plement the Paris Agreement on Climate Change. The goals are to proactively and effectively adapt, reduce vulnerability, loss and damage due to climate change, reduce negative impacts of climate change on vulnerable groups, reduce greenhouse gas emissions, and take advantage of opportunities from responding to climate change to shifting the growth model, improving the economy's resilience and competitiveness that have been emphasized in the National Strategy on Climate Change. Furthermore, Vietnam is also actively implementing the National Strategy and Action Plan on Green Growth and promoting the integration of climate change adaptation into national, sectoral and local socio-economic development plans. In 2022, Vietnam will update its Nationally Determined Contribution, closely following Vietnam's commitments at COP26. Vietnam regularly updates its climate change and sea level rise scenarios in 2009, 2012, 2016 and 2020. Despite many efforts, Vietnam is considered one of the countries most severely affected by climate change; weather developments, extreme climate, and natural disasters are increasingly complex and unpredictable, severely affecting people, industries, and sectors. This requires Vietnam to continue efforts to improve the resilience of society and communities to risks caused by natural disasters and climate change.

Conserve and sustainably use oceans, seas and marine resources for sustainable development (Goal 14)

As a country with a long coastline, Vietnam has made great efforts to preserve and sustainably use oceans, seas and marine resources for sustainable development through strategies and policies on marine environment and natural resources protection, and sustainable management of aquatic resources. Vietnam is implementing the Strategy for Sustainable Development of Vietnam's Marine Economy to 2030, with a vision to 2045. Activities to prevent and control all types of marine pollution have maintained the quality of the coastal and ocean water environment within allowable limits. Marine and coastal protected areas, although still quite modest, have contributed to the management and protection of coastal ecosystems, especially mangrove forests. The rapid increase in the proportion of aquaculture also reduces pressure on the exploitation of natural marine resources. In 2020, the rate of coastal sea water quality monitoring sites that meet the requirements of national technical regulations for organic pollutant parameters ($N\text{-}NH_4^+$) is 99% and for total grease parameters is 92%. Vietnam's seafood production increased from 6.5 million tons in 2015 to 8.4 million tons in 2020, with an average increase of about 4.6%/year. However, as a developing country with a low average GDP income, coastal, sea and island ecosystems are under great pressure from socio-economic development and environmental pollution; Fish and seafood reserves are increasingly shrinking due to overfishing. It can be said that achieving SDG 14 is a huge challenge for Vietnam.

▲ *Conserve and sustainably use of oceans, seas and marine resources for sustainable development*

Protect and develop sustainable forests, conserve biodiversity, develop ecosystem services, combat desertification, prevent degradation and restore land resources (Goal 15)

Forest ecosystems, especially those of national and international importance and wetland ecosystems, are increasingly being conserved, used and restored in a sustainable manner. Forest area is maintained at a stable level and increases from 41.65% to 42.02% in the period 2018 - 2022. Many national policies such as policies for payment for forest environmental services, policies for sustainable use of ecosystems and natural ecosystem services has had a positive impact in linking biodiversity conservation with sustainable use of ecosystems and genetic resources and has been integrated into the national strategies and socio-economic development plan. In the period 2018 - 2021, total revenue from forest environmental services reached an average of nearly 2,900 billion VND/year, forestry land was maintained and increased slightly from 14.92 million hectares in 2015 to 15.4 million hectares in 2020. However, Vietnam still faces many difficulties and challenges to achieve Goal 15, requiring more synchronous and drastic solutions in the coming time, including: Organized illegal deforestation and logging activities are complicated; Land degradation; Narrowing of natural habitat and risk of extinction of some endangered species; The exploitation, trade, and consumption of endangered wild animals and plants are still not well controlled; Financial resources to ensure the implementation of state management of ecosystems, protected areas in particular and biodiversity in general are still limited.

3. GLOBAL CONTEXT AND CHALLENGES POSED IN IMPLEMENTING SDGS IN VIETNAM

Global context

According to the latest assessment of progress in implementing SDGs globally by the United Nations, currently only 12% of SDGs targets are on schedule, 50% are behind the schedule and 30% are making no progress or even being pushed backwards compared to 2015. With current implementation progress, about 575 million people in the world will continue to live in extreme poverty; it will take 286 years to close the gender equality gap in the Law and eliminate gender discriminatory laws; There will be about 84 million children who will not be able to go to school and 300 million children who go to school will not be able to read and write by 2030. For the Asia Pacific region, according to UNESCAP's latest announcement, the region has only achieved 14.44% of progress in implementing the SDGs even though it has gone half way and needs several more decades to achieve the SDGs target.

Meanwhile, the world economy is forecast to continue to change rapidly with many complex developments. Many countries around the world are facing the consequences of the COVID-19 pandemic, including a decline in economic growth, political instability, and inflation and rising commodity prices after efforts to stimulus force in many countries. In addition, regionalization trends, extreme nationalist movements, geo-political conflicts, and strategic competition among major countries are creating huge challenges for the global sustainable development process. At the same time, the world is facing the risk of famine, rising inequality, and the global poverty rate increasing for the first time in decades. Ocean and forest ecosystems are threatened; biodiversity is declining at an unprecedented rate; Environmental pollution, natural disasters, and climate change are complicated.

It can be said that the impact of the COVID-19 pandemic, climate change, environmental pollution, stress and conflict... makes the already difficult implementation of the SDGs in the world, and will become even more difficult and requires the international community to make great efforts to achieve the goals on time. Despite this, all countries reaffirm their commitment to fully implementing the 2030 Agenda and see this as the only way to move towards a better and more resilient world against shock from outside.

Difficulties and challenges posed in implementing SDGs in Vietnam

In the coming period, Vietnam must face previous internal difficulties and serious impacts from the COVID-19 pandemic, creating pressure to continue restructuring the economy more quickly and deeply. Although the domestic socio-economic situation has recovered strongly in 2022, the international situation still has many potential uncertainties, continuing to affect the progress of implementing the SDGs in Vietnam in the coming years.

The current economic growth situation is facing challenges such as: productivity, quality and competitiveness of the economy are still not high; The quality of human resources does not meet the needs; Science and technology development is still limited and has not created a driving force for growth; Economic restructuring associated with innovation in growth models is still slow; Growth depends heavily on increased investment, while the need for investment capital for socio-economic development is very large, state capital, preferential capital and aid capital all tend to decrease.

Social management and development still have many limitations and have not kept up with requirements. The gap between rich and poor tends to increase, the lives of a part of the people are still difficult, especially in remote areas, ethnic minority areas, and areas affected by natural disasters; The development gap between localities and regions is still quite large. The rapid increase in population aging leads to pressure on the social security system and impacts economic growth.

The urbanization process continues to take place rapidly, creating great pressure on the need for infrastructure development and environmental pollution treatment. The challenge of effectively and sustainably exploiting and using water, natural resources and land is increasing. Natural disasters and climate change develop rapidly, fiercely and unpredictably, affecting production and people's lives.

Mobilizing resources to meet demand in the coming years will face many challenges, especially in the context of recovery after the COVID-19 pandemic. Compared to the time before the COVID-19 pandemic, the country's budget revenue/GDP tends to decrease. ODA sources have decreased significantly, especially after Vietnam became a low-middle income country in 2010. Vietnam also gradually no longer receives preferential ODA loans like before. On the contrary, Vietnam will have to switch to borrowing at commercial interest rates. Capital mobilized from FDI and remittances continues to remain at a high level but depends on many external factors and the domestic business environment. Investment from the domestic private sector has not yet demonstrated its role as a driving force in economic growth and sustainable development of the country as expected.

Pressures to transform development methods, especially the commitment to net zero emissions by 2050 in the context of resource and energy shortages, low levels of science and technology development... will put Vietnam's economy at risk. However, new development methods and models such as: green growth, ecological economic development, circular economy, sharing economy... along with scientific and technological advances, are giving the Vietnamese economy many choices for rapid and sustainable growth.

4. SOME KEY SOLUTIONS IN THE COMING TIME

Implementing and completing the SDGs by 2030 in Vietnam will face many difficulties and challenges. However, the achievements obtained in the previous period, along with Vietnam's socio-political stability and the increasingly perfect institutional and legal framework for socio-economic development, continue to create a springboard for implementing the SDGs in the coming period. In order to accelerate progress in implementing the SDGs in the remaining half of the journey, Vietnam needs to focus on key groups of solutions:

- Complete and enhance the quality and institutions of a socialist-oriented market economy; enhance the efficiency and effectiveness of policy implementation through public administration reform and continue to promote the participation of disadvantaged groups in the decision-making process;
- Continue to prioritize investment in human resource development, science and technology, innovation and completion of a synchronous and modern economic and social infrastructure system to improve productivity and promote sustainable economic growth;
- Stabilize the macro economy, support recovery after COVID-19; mobilize and effectively use financial resources for sustainable development;
- Continue to promote reform of the social security system to ensure increased resilience to shocks and support for vulnerable groups; develop culture and society, realize progress and social justice;
- Effective management and use of resources; strengthen environmental protection and respond to climate change, prevent, combat and mitigate natural disasters; promote green economic development and circular economy;
- Strengthen international cooperation to promote the implementation of SDGs;
- Continue to improve data availability to increase the effectiveness of monitoring and evaluating the implementation of the SDGs;
- Strengthen awareness raising, promote coordination and cooperation among relevant parties to create diffusion in the implementation of the SDGs. Ensuring implementation of the SDGs is everyone's job ▪

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Green banking in Agribank's development strategy

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In recent years, Vietnam has proactively taken actions in accordance with international commitments and agreements aiming to respond to climate change and heading towards green development. In particular, the Prime Minister made strong commitments at the 26th Conference of Parties to the United Nations Framework Convention on Climate Change (COP26) with the determination to achieve "net zero" by 2050. Accordingly, the implementation of green banking and sustainable development is an inevitable trend in the business strategies of many banks in the world and becoming mandatory criteria in methodology of leading international credit rating agencies. The State Bank of Vietnam (SBV) has issued many policies and guidelines to encourage credit institutions (CIs) in green transformation and environmental risk management in credit extension activities, which include: Green banking development project in Vietnam; Orientation for green banking development in the Banking Development Strategy to 2025, with a vision to 2030. As of June 30th, 2023, outstanding green loans reached nearly VND 528.3 trillion, accounting for approximately 4.2% of the total outstanding loans of the entire banking system. In that context, Agribank has played a pioneering role in the banking industry towards sustainable development and combating climate change. Recently, Agribank has implemented many action programs promoting "For the Green Future", such as: Conducting "greening" credit, prioritizing clean agriculture and high-tech agriculture; implementing many social security activities across the country; issuing regulations on environmental risk management in credit extension activities. There is a strong need to have an appropriate roadmap, especially to integrate the green banking development strategy into Agribank's business strategy to ensure that all employees can implement consistently from policies to specific actions, thereby creating great strength to contribute to environmental protection.

Within the scope of this article, the author focuses on Agribank's role in promoting green banking, supporting sustainable growth and development, analyzing the SWOT model as a basis for integrating green banking strategy into Agribank's business development strategy.

1. Agribank's role in promoting green banking to support sustainable growth and development

As a key role in providing capital and financial services in agricultural and rural areas, Agribank is determined to promote green credit growth and manage environmental and social risks in credit extension activities:

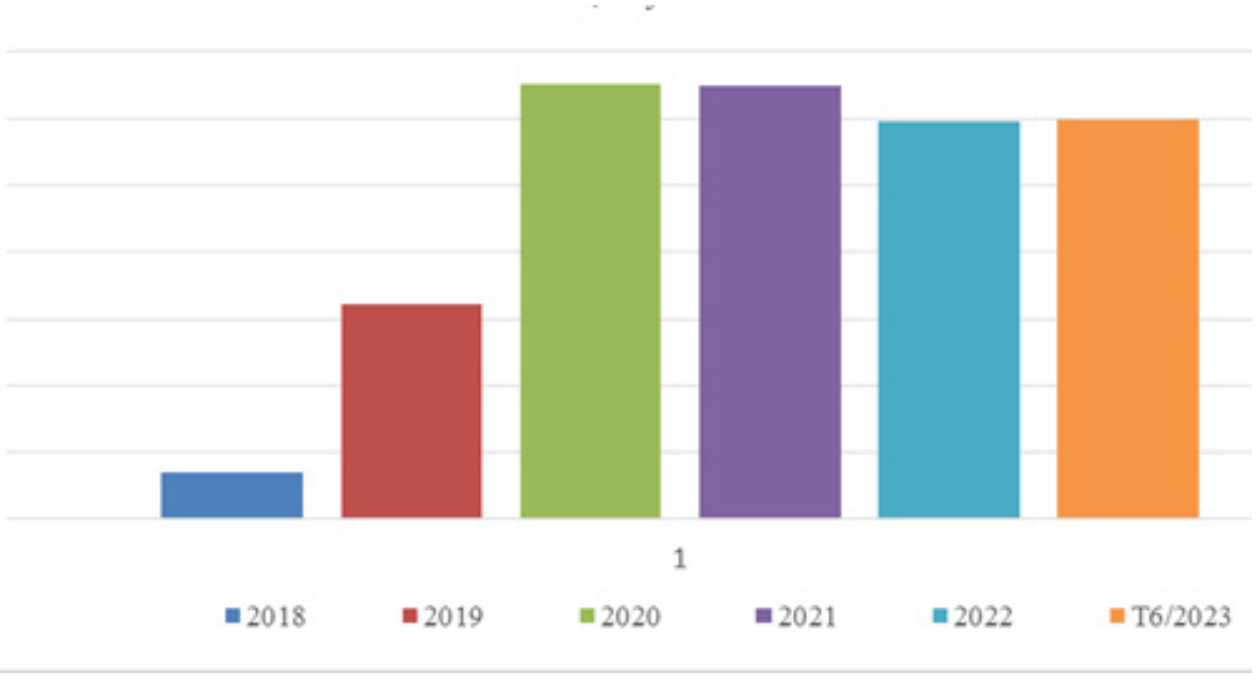
1.1. Effectively deploy seven policy credit programs and loans under two national target programs, specificly as follow:

Seven policy credit programs: (1) Lending under credit policies for agricultural and rural development; (2) Lending to households and individuals through loan/affiliate groups; (3) Lending in the framework of support policy to assist in reducing agricultural losses; (4) Lending for cattle and poultry farming; (5) Lending for coffee replanting; (6) Lending according to fisheries development policies; (7) Preferential credit for "Clean Agriculture".

Two national target programs: (1) New Rural Construction; (2) Sustainable Poverty Reduction.

1.2. Prioritize credit for green projects

With the goal of building a green, circular and environmentally friendly economy, Agribank has been focusing on prioritizing funding sources and effectively expanding lending to projects and programs to develope production and business in agricultural and rural areas, especially on clean energy, high-tech agriculture or added value creation programs and projects, such as: (1) Projects related to environmental protection issues funded by the World Bank and other financial institutions; (2) Preferential credit program with minimum scale of VND 50,000 billion and unlimited fundings to facilitate "clean agricultural" production for public health since 2016. Target customers of these programs are businesses, cooperatives, cooperative unions, farm owners… who participate in one or more stages in the production chain of safe agricultural products. The scale of these programs is large with loan interest rates reduced from 0.5%/year to 1.5%/year.



▲ *Figure 1. Green loan balance in the period 2018 to June 2023, unit: Billion VND*
(Source: Report on green credit situation and summary from the author)

Agribank's outstanding loans for green sectors also have a steady growth from year to year. In the period of 2018 - 2020, green loan balance grew rapidly from 100 - 350%/year. After this period, due to the impact of macro factors such as the Covid-19 pandemic, escalating tensions between Russia - Ukraine and Western countries, the recession of major economies in the world…, which affect Vietnam's economy, the growth rate of outstanding loans has slightly decreased, but is still quite stable in terms of loan amount and number of customers. As of June 30th, 2023, outstanding loans to the green sectors at Agribank reached nearly VND 12 trillion, of which outstanding loans to the sustainable forestry sector accounted for the highest proportion with 54.7% of the total outstanding green loans, the second highest is renewable energy and clean energy with a proportion of 22.6% and the third highest is the green agricultural sector with a proportion of 16.4%. Regarding the number of customers, by the end of 2022, Agribank has maintained the credit institution with the largest number of green customers, of which the sustainable forestry sector accounts for the highest proportion with 99.3% of the total number of customers (44,620 customers), an increase of 0.27% compared to 2021 and 7.3% compared to 2020. In 2023, the customer portfolio does not change significantly, the sustainable forestry sector still maintains a proportion of 99, 3% of total customers, an increase of 0.38% compared to 2022. However, the large-scale funded projects are mainly related to renewable energy and clean energy, including loans to develop large-scale wind power and solar power plants.

From Agribank's fundings, many large-scale high technology agricultural production models have been formed throughout all regions of Vietnam, creating a chain of agricultural production links with high-quality and high-value agricultural products, for examples: growing vegetables, flowers, and fruits (Lam Dong), large sample fields (Can Tho), livestock farming (Bac Ninh, Lao Cai, Ha Nam), investment in agricultural machinery and equipment (Tien Giang, Long An), growing corn (Son La), safe fruits and vegetables in the Central Highlands provinces (Dak Nong, Kon Tum), dragon fruit under VietGap standards (Binh Thuan)...

1.3. Regularly improve lending procedures and methods to facilitate financial services and credit services to people in rural areas, promoting financial inclusion

Accordingly, Agribank has researched and implemented two unique and specific models in Vietnam:

Lending model through loan groups: Agribank has signed a cooperation agreement with socio-political organizations such as the Women's Union, Farmers' Association, Veterans Association... in rural areas to transfer funds, promptly meet people is needs for financial and banking services, reduce difficulties, and solve problems in accessing bank capital. This

is an important initiative of Agribank to open the flow of credit sources investing in "Tam Nong", improve the quality of people's lives; bring benefits to both customers and Agribank. As of June 30th, 2023, Agribank had lent to 63,615 loan groups with more than 1.21 million customers, outstanding loans reached VND 195,712 billion.

Model of mobile transaction points using specialized cars: Since the end of 2017, Agribank has pioneered the implementation of mobile transaction points using specialized cars to expand credit and provide banking services to production households, individuals in rural and remote areas, contributing to the development of commodity production, improving people's income and living standards. As of June 30th, 2023, operations of 68 mobile transaction points were deployed in 486 communes with 26,552 working sessions and 2,458,103 transactions. In addition, mobile transaction points have performed other operations, such as: Payment of remittances, accounts opening, cards issuing, paying to the state budget, insurance...

1.4. Focus on implementing the ESG standards in the entire system

In fact, Environmental - Social - Governance (ESG) standards set is still a new concept in Vietnam. Vietnam's legal framework on ESG is still a work in process; as the definitions/concepts, standards, conditions for green banking as well as assessment indicators for sustainable development are not yet clear. However, the Agribank Board of Directors is deeply aware of the importance of developing the Bank in a green and sustainable direction. Therefore, the Board has determined that applying the ESG standards at Agribank is one of the top goals in the Banking Development Strategy in 2023 - 2025, vision to 2030. Accordingly, Agribank has set up a Steering Committee and Supporting Team to develop a comprehensive ESG implementation project at Agribank in both the short and long term. It shows Agribank's determination to deploy the application of ESG synchronously and effectively throughout the Agribank system. Additionally, Agribank focuses on perfecting internal mechanisms and policies to promote green credit growth and manage environmental and social risks in credit extension activities. Agribank has issued internal documents on promoting green credit growth, guidance on environmental risk management in credit extension activities, and an action program to implement the Banking sector's Action Plan for implementing the National Green Growth Strategy in the period of 2021 - 2030. In the process of lending operations, Agribank's handbook for credit extension activities always engages project appraisal and capital utilization plan with environmental issues, requires an environmental impact assessment report approved by competent authorities in accordance with the Law and resolutely not lending to projects that have the potential to greatly and seriously impact the environment and society.

1.5. Proactively communicate internally and externally on the policy of providing green financing to replicate safe agricultural production models and change consumer's perception of the Vietnamese agricultural products' quality and safety, with the aim to develop sustainable agricultural production, maintain the domestic consumer market and sustain a role in the global value chain, Agribank supports the reality TV show "Clean Agriculture - for Vietnamese people, for the world" that has been broadcasted on VTV1 channel - Vietnam Television to introduce to domestic and foreign audiences about the Vietnamese agricultural products and typical agricultural areas, promote the development of clean agricultural production chains nationwide.

1.6. Modernize information technology, digital transformation; improve quality and service for customers

Agribank has focused on developing products and services on the basis of information technology systems, proactively applying solutions of the 4.0 Industrial Revolution to develop new products and services, gradually digitizing banking activities, improving the quality and safety of E-Banking services such as: Expanding the deployment of automatic capital mobilization products on E-banking, online deposits on EMobile Banking; promote online payment solutions, online payment accounts opening with eKYC to meet customers' online transaction needs, reduce pressure on over-the-counter transactions and reduce the large amount of paper used (more than 90% of payment transactions are made via online electronic channels); developing and diversifying products and services and deploying Agribank Digital banking services; effectively deploy card services in rural markets.

2. Agribank's Green Banking Development Strategy

2.1. SWOT analysis of green banking at Agribank

S Strengths	W Weaknesses	O Opportunities	T Threats
- Receive support from the Government and the SBV. - Nearly 70% of outstanding loans are in agriculture, rural areas and for individual customers. - Execute many activities for the community and financial inclusion development. - Issued regulations on environmental risk management in credit extension activities. - Included ESG as an objective in business strategy.	- A large number of employees and customers, awareness of green banking is not uniform. - Incomplete database and information technology system on green banking. - Investing in green banking transformation will increase operation costs.	- Support from international organizations for green banking and sustainable development. - Inevitable trend, hence receiving attention and direction from the Government, Ministries, branches and the SBV.	- Standards on ESG and sustainable development, green banking is increasingly complex and advanced. - The Government and SBV's regulations on green banking are not complete and consistent. - The application of social criteria is not a mandatory requirement; hence some businesses haven't paid enough attention.

2.2. Agribank Green Banking Development Strategy

On the basis of Vietnam's National Strategy on Green Growth for the period of 2021 - 2030, vision to 2050, National Action Plan for Green Growth for the period of 2021 - 2030, green banking development project in Vietnam and SWOT model analysis, the author proposes solutions to integrate green banking strategy in Agribank's development strategy as follows:

Firstly, completing mechanisms, policies, and organizational structures to effectively deploy green banking: Apply ESG comprehensively and effectively within Agribank, including: identifying specific goals and building roadmap in the short-term and long-term to create a favorable environment for green banking development and attract green and sustainable funding from foreign sources; developing a set of ESG policies (Sustainable development policy; Green finance framework and social finance framework, disclosing information on commitment to ESG...); complete the organizational model, functions and tasks of related units and establishing a department responsible for sustainable development.

Secondly, deploying green credit activities towards international standards: Develop and publicize the exclusion/restriction list on credit extension activities; synchronously deploy environmental and social risk management in credit extension activities; collect information and database for deployment ESG throughout the Agribank networks; continue to prioritize providing capital and financial services to support the development of agriculture, rural areas, farmers, financial inclusion, high technology and clean agriculture; maintain the proportion of outstanding loans for rural from 65 - 70% of total outstanding loans as well as maintaining the mobile transaction points and lending through loan groups models.

Thirdly, completing the information technology system for green banking: Establish a comprehensive environmental and social risk management system including internal guidance on social risk management in credit extension activities; monitor and routinely report on the execution results of the sustainable development policy; quantify and evaluate energy saving results of electricity, water, paper, vehicles...

Fourthly, developing products and services that meet green standards and sustainable development: Research and deploy green banking products, preferential policies, encourage lending to effective and environmentally friendly projects and business plans… in accordance with Agribank's business orientation, customer segments, target markets as well as capabilities and strengths; promote the development of financial products and services to serve agricultural production and business, rural, small and medium enterprises owned by women, cooperatives, production and business households; continue to develop modern financial products and services, digital technology applications based convenient banking, promote non-cash payments in the economy, contribute to "greening" the banking industry, create environmentally friendly habits.

Fifthly, strengthening international integration and cooperation: Frequently update Vietnam's international commitments related to green, sustainable growth, climate change responsive actions and apply international experiences on green banking standards and conditions to improve the legal framework and internal mechanism; proactively apply conditions to issue green bonds and attract green funding from foreign sources… to increase funding support for green projects.

Sixthly, completing Agribank's social criteria: Continue to fully implement legal and fair policies for employees, propagate and encourage the employees to participate in community activities and support the poor and disadvantaged groups; protect the legitimate rights and benefits of consumers.

Seventhly, regularly conducting in-depth propaganda and internal training to Agribank customers on sustainable development: Organize propagandas, trainings to improve awareness of the employees about green banking, the importance of environmental and social risk management; organize events for customers to better understand green banking products and services; introduce products that are environmentally friendly or do not cause negative impacts on the environment; carry out capital construction investments, equipment procurement to promote green banking.

Eighthly, creating an independent report on sustainable development, ESG and having ESG report audited: Consulted to guide in building a system of policies on ESG, ESG reporting and auditing reports to disclose information according to international standards by consulting organizations.

3. Recommendations and suggestions

To facilitate the implementation of Agribank's green banking strategy, the author strongly proposes the recommendations as follows:

Firstly, the Ministry of Natural Resources and Environment and other agencies timely develop and issue a set of environmental criteria and defining criteria for lending to green projects so that CIs have a basis on legal and technical aspects in determining projects that meet green credit conditions.

Secondly, the Government and the Ministry of Natural Resources and Environment issue policies to promote the development of carbon credit market such as: regulations on carbon credit management, activities of exchanging greenhouse gas emission quotas and credits; regulations for operating the carbon credit exchange; deploy activities to strengthen capacity and improve awareness about carbon market development... to accelerate the operation of the carbon credit exchange in Vietnam.

Thirdly, the Government continues to communicate to public the need for sustainable development, green banking, and sectors that meet green credit criteria to encourage green lifestyles and consumption in harmony with nature and Vietnamese traditional cultural values; support domestic CIs to increasingly access financial funds and green financing packages from international organizations.

Fourthly, build and form a data system on compliance and violations of environmental requirements of enterprises, create a basis for CIs to appraise and determine the level of environmental risks when assessing customers, thereby limiting/reducing loans for environmentally harmful activities ▪

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Implementing the Planning for exploration, exploitation, processing, and use of mineral types ensuring sustainable development

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Implementing the Planning Law and Mineral Law, the Prime Minister issued Decision No. 866/QD-TTg dated July 18th, 2023, approving the Planning for exploration, exploitation, processing, and use of minerals in the period of 2021 - 2030, with a vision toward 2050. The implementation of this Planing will make an important contribution to the development of industry and other economic sectors that use minerals as raw materials, creating jobs, and contributing to ensuring social security and environmental protection in Vietnam. The Planning orientates overall long-term development goals, basic management of minerals with large, strategic, and important reserves associated with mobilizing resources and fundamental solutions according to the development roadmap, ensuring sustainable development, effective socio-economic benefits, and environmental protection, ensuring security, national defence, and harmony between national, local and business interests.

Some results of implementing the Planning for exploration, exploitation, processing, and use of minerals until 2020

The Planning Law in the period from 2017 to 2020, planning in the mineral sector in Vietnam was organized and implemented by the Ministry of Industry and Trade (MOIT), relevant Ministries, agencies, and localities and achieved remarkable results in mineral planning management as follows:

Contribute to perfecting the policy and legal framework and improving the efficiency of mineral resource management

After the National Assembly promulgated the Mineral Law in 2010, the Central Government issued Resolution No. 02-NQ/TW of the Politburo dated 25/4/2011 on the strategic orientation of the minerals and mining industry until 2020, vision to 2030. The National Assembly has issued 1 additional Law related to the mineral sector, and 1 Resolution on prior granting mineral exploitation rights; The 12th National Assembly Standing Committee also issued 1 Resolution on the results of monitoring and promoting the implementation of legal policies on mineral management and exploitation associated with environmental protection; 6 Resolution on resource tariff, natural resource tax rate and environmental protection tax. After 10 years, relevant Ministries and agencies have developed and submitted to the Government and the Prime Minister for promulgation and promulgated according to their authority 10 decrees, 7 decisions, and nearly 60 circulars guiding the creation of a complete legal document system on mineral, serving as a legal corridor for developing the mining industry.

Awareness of organizations, individuals, businesses operating in minerals, and people in mineral areas has been raised, focusing on innovation in science and technology, equipment, and effective exploitation of natural resources and attention to environmental protection; strengthen supervision of the community and people in areas where mineral projects are located.

Localities with minerals have focused on quality instead of a simple growth target. The number of local mineral licenses has decreased, and they have resolutely stopped and revoked licenses and investment certificates for mineral exploitation and processing that are ineffective and cause environmental pollution.

The legal system and policies on minerals and environmental protection have been fundamentally amended and supplemented by reality and relevant laws. The value of mineral resources has been quantified and brought significantly to the national budget through the collection fees of data use and mineral exploitation rights.

The role of state management from central to local levels has been strengthened, improving accountability. Inspection, testing and supervision are focused and carried out regularly. Licensing mineral activities through the auction of mineral exploitation rights ensures openness, transparency, and selection of qualified investors with technology, and minimizes negativity.

Administrative procedures for business investment, licensing of mineral activities, and export of minerals are continuously improved. However, the licensing time for some mineral exploitation projects is still long, affecting business opportunities in the face of market fluctuations.

▲ *Minister of Industry and Trade Nguyễn Hồng Diên delivered a speech at the Conference announcing national plans for the energy and minerals sector for the period 2021-2030, with vision to 2050*

Although the growth target of the mining industry has not been achieved as expected according to Resolution No. 02/TW of the Politburo of the Communist Party of Vietnam, the industry has paid more attention to growth quality and sustainable development goals. The increase in the proportion of the processing and manufacturing industry and the reduction in the proportion of the mining industry in the past period is consistent with the orientation of industrial restructuring.

Environmental protection in mineral exploitation and processing has been taken into consideration, businesses are more aware of minimizing environmental pollution. Many concentrated mineral processing zones have been formed and controlled dust, noise, exhaust gas, and wastewater into the environment.

Attract investment to develop the mineral sector

As of December 2019, the total number of valid mineral exploration/mining licenses was 4,062, of which 582 licenses (61 exploration licenses, 522 mining licenses) were issued by the Ministry of Natural Resources and Environment (MONRE); 3,480 licenses (250 exploration licenses, 3,230 exploitation licenses) were issued by the Provincial People's Committee according to its authority. Thus, there are currently 3,752 valid mineral exploitation licenses issued by the MONRE and the Provincial People's Committee to about 3,300 organizations and individuals, which has significantly reduced the number of mineral mining projects approved before 2010. In general, organizations and individuals exploiting minerals have paid more attention to investing in mining and processing technology to increase the value of minerals to meet domestic and export needs. Environmental protection in mineral activities has been taken into account and implemented in line with regulations, however, due to fluctuations in the world mineral market, mining activities for some minerals such as iron ore, titanium, paving stones... have significantly decreased in output.

Many mineral deep processing projects have been implemented, including several large-scale investments that have gone into production, processed products have high added value, creating many jobs for local workers. Significant contributions to the state and local budget such as the Nui Phao tungsten-polymetallic mining and processing project, Sin Quyen copper mine project (Lao Cai), and Lao Cai copper smelting project with a total capacity of 30,000 tons of metallic copper/year; Lam Dong bauxite - aluminium complex project and Nhan Co Alumina Factory project invested by Vinacomin Coal Import Export Joint Stock Company (TKV), have gone into commercial production with a design capacity of 650,000 tons of alumina/year, the iron factory complexes Lao Cai Steel, Cao Bang Iron, and Steel, Hoa Phat Hai Duong Steel, Hoa Phat Dung Quat Iron and Steel Complex...

Mining projects according to central planning licensed by the MONRE are large enough in scale, focus more on technology, environmental protection, and avoid fragmentation, and basically mining projects have been associated with processing to provide raw materials for processing projects.

Applying scientific and technological solutions, innovation, and modernization in the mineral sector

In the period of 2010 - 2020, in addition to implementing scientific and technological tasks at the ministerial and central levels in the field of mineral exploitation and processing, the Ministry of Industry and Trade (MOIT) has been assigned by the Prime Minis-

ter to preside over the implementation of the project on innovation and modernization of technology in the mining industry until 2015, vision to 2025. Up to date, there have been 88 scientific and technological tasks implemented with a total amount of 1,225 billion VND, of which national capital is 392 billion VND, mobilized from other sources is 833 billion VND.

Many technological solutions are the results of scientific and technological research that have been successfully applied to the production and business sectors of the industry, contributing to meeting the needs of mining and processing enterprises, applying, innovating, and modernizing technology, increasing the localization rate in equipment manufacturing, reduce the trade deficit, improve productivity, reduce costs, increase product competitiveness, bring economic efficiency for the industry.

Mineral processing: Currently, some types of metallic minerals have been processed into final mineral products such as copper, lead - zinc, tin, and gold... using traditional technology (hydrometallurgy). Some types of metals such as manganese, chromite, and titanium... have only produced intermediate products, which are ferro products. The remaining non-metallic products such as white limestone, kaolin, feldspar, serpentin, etc. have been mastered by the technology and made final products to supply other industries. Some minerals such as bauxite, iron, copper, tungsten, and apatite meet world-class advanced equipment technology.

Forecasting in planning plays a guiding role in promoting the development of the mining industry and mineral resource management

In the context of increasingly difficult conditions for exploiting mineral resources, promoting the development of science and technology and applying technical advances to production plays an important role in the sustainable economic growth and development of Vietnam's mineral exploitation industry. Besides, it is necessary for Vietnamese scientists and technologists to research in the field of exploration, exploitation, processing and use of minerals sustainably, responding to climate change and the 4.0 Industrial Revolution.

Currently in the world, advanced mineral exploitation and processing technologies that meet the requirements of sustainable development are focusing on smart technology for exploration and reserving volume assessment, including geomechanical assessment; technology allowing the implementation of continuous mining systems to become a viable option in ore mining and rock removal; clean technology and environmentally friendly waste utilization and reuse; Mineral beneficiation technology allowing to further improve mineral recovery rates; The technology allowing mining in complex geological and mining conditions, while ensuring environmental friendliness.

The application of scientific and technical advances will contribute to improving the efficiency of exploration, exploitation, processing, and use of minerals and minimizing the negative impacts of mineral exploration, exploitation, processing, and use of minerals in the future. Scientific and technological advancements in the exploration, exploitation, processing, and use of mineral resources contribute to the effective and economical exploitation, processing, and use of mineral resources towards the goal of sustainable development in the mineral industry.

Create positive changes, raise awareness about planning and development of the mining industry and mineral resource management

In recent years, along with socio-economic development, propaganda, dissemination, and legal education in the mineral sector have created positive changes in the awareness of officials, civil servants, public employees, workers in the mineral industry in particular, and the people of the country in general. The basic contents and great value of the mineral and mining industry strategy for the country‘s socio-economic development have been fully and fundamentally recognized, increasingly deeply, gradually in creating strong and profound changes in the awareness of voluntarily obeying the Law, rational and economical use of resources, and joining hands to protect mineral resources.

The licensing process has been proactive in selecting mineral exploitation and processing investment projects with advanced, environmentally friendly technology, poor ore mining and processing projects, and thoroughly using and saving minerals. Therefore, it has limited the situation of fragmented, small, and ineffective investment and mineral exploitation.

In addition, through inspection and examination, violations were discovered such as exploitation without a license; buying, selling, transporting, consuming, and storing minerals of illegal origin; Mining minerals over the allowed mining capacity... and has made records to sanction administrative violations in many cases, contributing to increasing the efficiency of usage and saving mineral resources across the country.

Although the management of mineral planning has achieved the above positive results, the implementation of mineral planning still has certain limitations and problems. These are, the work of building,

organizing, and implementing the planning has not been synchronized for the planning for exploration, exploitation, and processing of minerals with the licensing of mining as well as other planning, especially with local development planning. The impact assessment of the exploration, exploitation, processing, and use of minerals on socio-economic development, national defence, security, and the environment has not been given due attention. Accordingly, mineral exploration, exploitation, and processing have negative impacts on the tourism and agriculture-forestry industries because the mining and processing process takes up a large amount of land and affects the environment. Implementation capacity, including management and technical aspects, at the Central and local levels is not strong enough, and the quality of human resources does not meet the requirements.

Planning for exploration, exploitation, processing and use of minerals in the period 2021 - 2030, vision to 2050, toward sustainable development

Mineral management in our country in the current context has to face advantages and difficulties. The advantage is that a system of legal documents has been gradually completed, detailed, and specific, creating a legal basis and favourable conditions for the national management of minerals. Fundings for the public management of minerals and environmental protection in mineral activities are gradually invested and used more rationally. Party committees, authorities, unions from Central to local levels, and people throughout the country have been aware and have gradually stepped into synchronization; Organizations and individuals engaged in mineral activities strictly implement mineral laws, contributing to ensuring social security, order, and safety. To date, Viet Nam has negotiated, signed and implemented 19 Free Trade Agreements (FTAs), creating linkages between Vietnam and the world in sharing benefits, including the goal of managing mineral resources, especially efforts to resolve general environmental issues; has been taking advantage of advanced management methods, capital, science and technology from the world to serve mineral resource management. The difficulty is that awareness of mineral management is incomplete, especially awareness of governmental management of minerals in an integrated manner; mineral management institutions are not synchronized; environmental issues in global mineral management as well as risks of environmental incidents in the mineral sector.

In the above context, on July 18th 2023, the Prime Minister issued Decision No. 866/QD-TTg approving the Planning for exploration, exploitation, processing and use of minerals from 2021 to 2030, vision to 2050 (hereinafter referred to as the Planning 866) with the general goal of: "Mineral resources are strictly managed, exploited, processed, and used economically and effectively, associated with the needs of economic development, environmental protection, adaptation to climate change and the goal of achieving carbon neutrality. Promote investment and form a synchronous and effective mining and processing industry with advanced technology and modern equipment in line with world trends. For minerals with large, strategic, and important reserves (bauxite, titanium, rare earth, chromite, nickel, copper, gold), mining-licensed enterprises must have sufficient capacity and must invest in appropriate processing projects using advanced technology, modern equipment, and sustainable environmental protection. Limit and eventually end the exploitation of small, scattered, low-reserve mines, and concentrate mineral resources from small - scale mines/mining sites into mine clusters that are large enough for synchronous investment from exploration, exploitation, and processing together with applying advanced technology and modern equipment". The objectives of the Planning 866 show that mineral planning management has been given comprehensive attention: from exploration, exploitation, processing, and use of minerals.

To realize the goals in the mineral sector, the Planning 866 stipulates land use orientations for the development of the mining industry, infrastructure, environmental protection, and science and technology:

Firstly, land use layout orientation: Land demand for mineral exploitation development is about 190,000 hectares in the period of 2021 - 2030 and about 305,000 hectares in the period of 2031 - 2050, basically in accordance with land distribution targets in Resolution No. 39/2021/QH15, to ensure the implementation of economic development goals.

Secondly, infrastructure development orientation:

(1) For investors: mineral exploitation and processing projects must be based on the needs of the project to plan and build a system of collector roads connecting with highways and national routes in certain locations. The connection location must be approved by competent Government agencies before deployment. At the same time, the investor must base on the needs of the project to register for use with governmental management agencies and must be approved before implementing the project.

(2) State management: synchronous investment in transport infrastructure and general seaports to serve the development of mineral exploitation and processing appropriate to each stage of development. Continue to upgrade and invest in new traffic routes and national power grids for remote areas and concentrated industrial parks to serve the development of mineral projects and the socio-economic development of the region.

Thirdly, orientation for environmental protection:

With the goal of green growth, circular economic development, and a strong shift from brown to green strategy, the orientation on environmental protection needs to address the following issues:

(1) Promote the application of advanced technology, green technology, economical use, and take advantage of resources; recycling technology using effectively waste ores, tailings, and poor ores; collect and thoroughly treat all types of waste generated in production; recycle and reuse as much as possible for production and supply to the needs of other economic sectors, gradually forming a circular economy.

(2) Prevent, minimize, and fix incidents and environmental risks in mineral exploitation and processing projects.

(3) Renovate and restore the environment of mineral mines immediately after completion in the direction of integrating environmental regeneration and restoration combined with the development of green projects for socio-economic development (high-tech agricultural zones, eco-tourism services, residential areas...) and environmentally friendly economic sectors.

(4) Thoroughly overcome the problem of dust generation in production affecting the environment and population during the mineral exploitation and processing process. Improving the environmental landscape of mineral production areas to ensure green - clean - beautiful contributes to protecting the general environment.

(5) Proactively adapt to climate change, ensure landfill safety, minimize drifting soil and rocks, and prevent flood risks; reduce greenhouse gas emissions, and limit the impact of climate change.

Fourthly, science and technology orientation:

Continue to effectively implement phase 2 of the Project on technological innovation and modernization in the mining industry until 2025 approved by the Prime Minister in Decision No. 259/QD-TTg dated 22/2/2017.

Promote research, transfer, acquisition, and application of advanced scientific and technology, technology and equipment conversion of stages: exploration, exploitation, mineral processing, and environmental protection for each group/type of minerals towards a green production model.

For Highlands bauxite minerals, titanium, rare earth, Thanh Hoa chromite, Lao Cai apatite, Binh Thuan titanium, Son La nickel, copper-gold, other large-scale mines/mining clusters such as Thach Khe iron mines, Lao Cai Province copper mine... must form a mining complex associated with processing, applying advanced technology and modern equipment.

In addition, the Planning 866 also offers 9 groups of solutions and main resources to achieve the following goals and directions.

Firstly, legal and policy solutions: Continue to review, amend, supplement, and perfect the governmental mechanisms, policies, and laws on minerals, creating favourable conditions for businesses to invest in mining and processing of minerals projects. Strengthen coordination between the MONRE, the MOIT, and the Provincial People's Committee in licensing mineral activities, providing information on the situation of exploitation and processing after licensing. For some large-scale and strategic minerals and mineral mines such as bauxite, titanium, rare earth, nickel, copper, gold, and chromite, before licensing mineral exploration and exploitation, the licensing agencies get opinions from governmental management agencies on planning, exploitation, and processing on the compatibility with planning and supply and demand situation.

Secondly, financial and investment solutions: Review and promptly adjust reasonable taxes, fees, and charges, ensuring harmony of interests between the government, businesses, and local people where minerals are located. Encourage qualified domestic enterprises to play a key role in the exploration, exploitation, and processing of strategic minerals with large volume reserves. Diversify investment capital sources through investment capital contributions, shares, joint ventures, and other credit capital sources.

Thirdly, scientific, technological, and environmental solutions: Applying specific mineral exploration techniques in the best possible technological and technical direction in Vietnam, ensuring compatibility with local realities. With mineral processing and use activities: focus on applying advanced science and technology in the operation process towards a circular economy, green economy, and low carbon.

Fourthly, propaganda and awareness-raising solutions: Promote propaganda and dissemination of guidelines, policies, and laws on minerals, and publicize mineral planning. Raise awareness about the role and laws on minerals; Strengthen community supervision of mineral activities in the area; publi-

cize and transparent revenues and use of revenue sources of mineral enterprises. Media agencies coordinate with Ministries, agencies, and People's Committees of provinces with mineral activities, especially sensitive minerals such as bauxite, iron...

Fifthly, solutions for training and capacity building: Focus on investing in innovation and modernization of training and research equipment for educational institutions, specialized research institutions, and key laboratories. Enhance the leading role of research institutes and universities to promote scientific and technological research and environmental protection.

Sixthly, solutions for international cooperation: Promoting scientific and technical cooperation, technology transfer in exploration, exploitation, processing and use, environmental protection, labour safety, and the applications of information technology in management. Cooperate in investing in mineral exploitation and processing projects that require high technology; Restrict cooperation, joint venture, association, and purchase of shares to foreign investors for mining and mineral projects.

Seventhly, capital mobilization solutions: Investment capital for projects on exploration, exploitation, and processing of minerals, in addition to part of the capital from the Government budget, is mainly guaranteed by enterprises themselves with their own capital, commercial loans (mainly) on the financial market, capital mobilized from other sources such as the stock market, domestic and foreign organizations, individuals, and businesses.

Eighthly, human resource solutions: Develop plans to recruit and train human resources in accordance with industry requirements and development progress of mineral exploitation and processing projects. Focus on recruiting and training onsite workers, especially in mountainous areas with difficult and especially difficult socio-economic conditions. Presenting policies to attract high-quality human resources and preferential treatment for mining workers, especially underground mining workers. Open links with domestic and international training establishments, have recruitment policies for skills improvement training, transfer training, or send abroad for training with high-quality, career-attached labour resources. For officials and workers in minerals and metallurgy, it is necessary to recruit and arrange personnel with expertise and practical experience; Support and update legal knowledge on natural resources and environment and related laws for the mineral and metallurgical officials and workers who need to be recruited.

Ninthly, solutions for organizing and supervising the implementation of the planning: Identify tasks and responsibilities for managing and implementing the planning of relevant organizations, units, and agencies, including the MOIT, and MONRE,… improving the effectiveness of coordination and supervision of planning implementation.

Thus, with the results achieved in the Planning for exploration, exploitation, processing, and use of minerals for the period to 2020 and the determination of goals, orientations, solutions and resources to implement the Planning for the period of 2021 to 2030, vision to 2050, Planning for exploration, exploitation, processing and use of minerals plays an important role in mineral management. Currently, the MOIT is presiding and coordinating with ministries, agencies, and localities to complete and report to the Prime Minister for approval of the Planning to implement the Planning for exploration, exploitation, processing, and use of various types of minerals in the period of 2021 - 2030, vision to 2050. Therefore, the close coordination between Ministries, agencies, and localities in organizing and implementing the Plan is highly important ▪

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The vital role of the voluntary carbon markets and impact of the Inflation Reduction Act on these markets in the US

The development of transparent, sound and efficient voluntary carbon markets (VCMs) is of vital importance to the growing number of companies using carbon credits to help meet their emissions reduction and net zero goals.

The article provides an overview of the VCMs and the impact of the Inflation Reduction Act on these markets in the US.

The importance of VCMs

Carbon markets exist as mandatory (compliance) schemes and voluntary programs. Mandatory carbon markets (which are also referred to as emissions trading systems (ETSs)) represent a market-based approach to reducing carbon emissions.

VCMs are trading systems in which carbon credits are sold and bought. The VCMs function alongside compliance schemes and enable companies, governments, non-profit organizations, universities, municipalities and individuals to purchase carbon credits (offsets) on a voluntary basis. Market demand from entities and individuals purchasing carbon credits that are created through investments in nature-based or technology-based projects have fueled growth of the sector. Companies or individuals can use carbon markets to compensate for their greenhouse gas (GHG) emissions by purchasing carbon credits from entities that remove or reduce GHG emissions. One tradable carbon credit equals one ton of carbon dioxide, or the equivalent amount of a different GHG reduced, sequestered or avoided. When a credit is used to reduce, sequester, or avoid emissions, it becomes an offset and is no longer tradable.

Unlike the regulatory compliance market - a result of policy or regulatory requirements - the VCM incentivizes project developers (Governments, industries, and individuals) to reach net zero through reduction (changing land management practices), avoidance (switching to renewable energy) or removal (revegetating an area to sequester carbon) of GHGs; it encourages achievement of Sustainable Development Goals (SDGs). While compliance markets make use of independently operated registries, a central regulator establishes or approves all standards used by these independent entities. The independent registries then typically have discretion in how to implement the regulatory standards in a manner most appropriate to the markets they oversee. In contrast to the highly regulated mandatory carbon market, VCMs do not currently involve any direct government or regulatory oversight.

The importance of VCMs is growing, because VCMs help major polluters offset GHG emissions and create innovative ways to solve the climate crisis.

Inflation Reduction Act marked a historic moment for the advancement of clean energy technologies and decarbonization

The US is entering a new era of climate action. In August 2022, the US's Inflation Reduction Act (IRA) was approved, which represented the outcome of the significantly more ambitious "Build Back Better" Bill. It marked a historic moment for the advancement of clean energy technologies and decarbonization of the US electric grid. This far-reaching Law includes provisions to "finance green power, lower costs through tax credits, reduce emissions, and advance environmental justice". The IRA is intended to reduce US carbon emissions by roughly 40% by 2030 and to reach a net-zero economy by 2050. In support of these goals, the IRA makes "the single largest investment in climate and energy in American history", in the amount of US$ 369 billion to advance clean energy technologies, reduce GHG emissions, and support environmental justice issues. The Law expands existing tax incentives and introduces incentives for developing technologies, including clean hydrogen, standalone storage, nuclear, sustainable aviation, and transportation electrification provisions.

The IRA has the potential to rapidly transform the US energy grid and spur clean energy innovation that will create more projects and financing opportunities for many energy customers. While the Law does not directly impact the voluntary market, the climate portions of the IRA represent the biggest investment in clean energy sources in US history and are approximately four times larger than the incentives included in the American Recovery and Reinvestment Act of 2009.

The IRA provisions aim to strengthen innovation with investments in new clean energy technologies, expand domestic clean energy production and manufacturing, and lower energy prices for customers. This legislation promises significant progress towards meaningful emissions reductions through the development of clean energy technologies, which will help to make progress toward the US. climate commitment.

The incentives in the IRA pave a path for corporate buyers to step up action and advance climate-related commitments.

The IRA also opens new pathways to transfer private capital into renewable projects. For example, the IRA includes updates to a tax credit located in Section 45Q of the Internal Revenue Code. This credit incentivizes the use of carbon capture, utilization and storage (CCUS) technology. The updates increase the credit values for qualifying technologies, thus increasing the incentive to use these technologies. Further, the updates allow 45Q credit recipients to transfer all or any portion of the credit value to any third-party tax-paying entity in exchange for a cash payment during the credit window. Beyond monetization of 45Q credits, these updates also have the potential to advance the VCMs. Projects utilizing CCUS technology may have the opportunity to sell carbon credits into the market representing their carbon abatement. Thus, if more businesses adopt CCUS technology due to the favorable tax treatment under 45Q, this may also lead to an increased supply of carbon credits, and therefore increase trading, in the VCMs.

The IRA introduces new tax credits and clean energy financing for a range of clean energy technologies, including clean hydrogen, nuclear, storage, carbon capture and sequestration, and electric vehicles. These incentives not only drive investment into the development and deployment of new, emerging technologies needed to drive grid decarbonization, but also provide voluntary buyers with more options to meet their own climate and sustainability goals.

As the voluntary markets are expected to serve a growing role in fulfilling carbon emissions commitments, it is likely that regulation in this space will also increase. Boards of directors and executives, as well as other participants in these markets should keep a close eye on legal and regulatory developments as they consider their use of carbon credits and offsets as part of overall emissions reductions targets and strategy ▪

NHẬT MINH

(Source: Cleary Gottlieb)

The global carbon markets need to be more strictly regulated

Governments around the globe have made commitments to limit global warming and reach net zero carbon emissions by 2050 in order to deliver against the targets of the Paris Agreement. Carbon markets have a significant role to play in helping to achieve these commitments by enabling governments and organizations to more effectively manage emissions and emissions reductions limits.

Financial sector regulation of carbon emissions, trading and disclosure will develop given the fundamental need to reduce gross carbon emissions to manage the financial risks of climate change. In the short to medium term, carbon markets will become more highly regulated, in order to introduce greater consistency, reinforce the integrity of sustainability disclosures, and respond to stakeholders' expectations that sustainability information should be transparent and comparable.

Mandatory and voluntary markets

Carbon markets exist as mandatory (compliance) schemes or voluntary programs. Emissions trading schemes (ETS) usually fall into the first category, with participants identified by governments based on carbon intensity, sector or size. The EU ETS is the world's largest cap and trade scheme, covering just over a third of the EU's GHG emissions.

Under these schemes, a limit (cap) is set on the total amount of certain GHGs that can be emitted by the companies covered by the scheme. The cap is reduced over time so that the total permitted emissions fall. Within the cap, companies buy or receive emissions permits (or allowances) which they can trade with one another as needed. At the end of each year, companies must surrender enough allowances to fully cover their emissions or incur heavy fines.

Conversely, baseline-and-credit mechanisms (also known as carbon credit schemes) are largely voluntary and have typically grown organically to meet the demand from organizations which seek to manage their carbon footprint. These schemes allow the purchase or sale of "carbon credits", which represent a standardized unit of carbon (1 ton CO_{2e}) being either removed from the atmosphere or not produced. While ETSs cap the amount of carbon that can be emitted by an organization, carbon credit markets allow companies to manage the impact of their emissions more proactively.

Voluntary markets function independently of compliance markets, and the credits traded cannot be used to meet the legal and regulatory obligations placed on organizations by compliance markets.

Increasing the legal and regulatory for carbon markets

The global landscape for carbon markets has developed rapidly leading to a patchwork of regulations and standards. Standards are heavily influenced by organizations operating in the voluntary markets. Mandatory frameworks are also being reviewed. Therefore, Carbon Border Adjustment Mechanism ➡

(CBAM) would address the risks of so-called "carbon leakage", where firms take advantage of less stringent and more favorable carbon credit rules to move emissions outside the domestic market, potentially undermining climate efforts. The CBAM would equalize the price of carbon between domestic and imported products.

Under its July 2021 Fit for 55 initiatives, the EU put forward a comprehensive set of changes to the EU ETS which aim to drive a reduction of 61% in overall emissions from certain sectors by 2030. This would be achieved by strengthening the current provisions (including aligning the EU ETS cap with net zero) and extending the scope of the scheme, for example to the maritime transport sector. The package also introduced an EU CBAM which is more advanced in its development than the UK CBAM, having been approved by the EU Commission in March 2022 for phasing-in from 2023 with charges applied from 2026.

Activity from financial regulators is also picking up. ESMA delivered its final report on the EU carbon markets in March 2022, in response to a request by the European Commission for an analysis of European emission allowances (EUAs) and derivatives on EUAs. ESMA's policy recommendations include measures to provide more information to market participants, regulators and the public such as: Extending position management controls to EUA derivatives; Amending EUA position reporting; Tracking the chain of transactions in the Markets in Financial Instruments Regulation (MiFIR) regulatory reports; Providing ESMA with access to primary market transactions.

More broadly, the International Organization of Securities Commissions is undertaking a review of the weaknesses of voluntary carbon trading schemes and is developing an assurance framework for sustainability-related information.

Regulators take a greater role in supervising carbon trading frameworks

Increasing requirements to make corporate sustainability disclosures and demonstrate progress towards net zero commitments, including through transition plans, may influence organizations' participation in carbon credit markets. The International Sustainability Standards Board's (ISSB) first two draft standards propose that net zero transition plans be published by all firms, although the pace and scale of adoption is as yet unclear. In March 2022, the Taskforce for Nature-related Financial Disclosures (TNFD) published the prototype framework that encourage firms to understand and disclose the dependencies of their risks and opportunities on nature, including the sequestration (capture and storage) and release of carbon into the atmosphere.

However, carbon credit markets should only form one part of a wider strategy towards decarburization and transition. The not-for-profit association Carbon Market Watch notes that carbon markets are about national limits and not about the decarburization of individual firms, and it has called for a better approach to accelerate the transition, rather than simply passing emissions allowances around the system through offsets.

Guidance has been issued on where corporates should and should not be using voluntary credits. For example, the Science Based Targets Initiative (SBTI) makes it clear that carbon credits should not count as a reduction in carbon emissions against science-based carbon targets, but that they could be used to neutralize the impact of residual emissions once those targets have been achieved, or to finance the reduction of GHG emissions outside of the organization's own value.

Within the patchwork of frameworks and national regulations, the cost of a unit of carbon emissions can vary significantly. Some of the highest prices are seen in Europe, while developing nations tend to charge less. The introduction of CBAMs represents a significant step towards leveling up carbon prices. However, as regulators take a greater role in supervising carbon trading frameworks, it will be important that they set suitably ambitious prices to encourage the transition away from carbon-intense operations.

There is not yet an accepted, consistent methodology to define and calculate carbon assets and liabilities. The work of the ISSB may help to define these concepts, driving comparability between trading schemes and paving the way for assurance over carbon metrics.

Voluntary carbon trading frameworks raise another important issue - how to be certain of the existence of carbon units being traded, for example, how to confirm that a carbon offsetting project in a remote part of the world actually exists and isn't being double counted. Assurance of this information is complex, and without it, a firm engaging in carbon trading could suffer reputational damage or become liable for carbon taxes which it believed it had already offset. Formal adoption of voluntary frameworks into national rules could help delineate responsibilities and reduce the opportunities for inaccuracies and fraud.

The scope of formal regulation looks set to increase. The EU ETS remains the largest carbon market in the world and as such could drive standards. Whichever jurisdiction is first to issue rules may set the ton of regulation globally, with other frameworks either aligning with or building on what has come before. Where firms are already participating, or plan to participate in carbon markets, it will be important for them to engage proactively as regulation evolves ▪

GIA LINH

(Source: KPMG International)

Assessment of climate action for 51 countries and the EU between 2010 - 2020

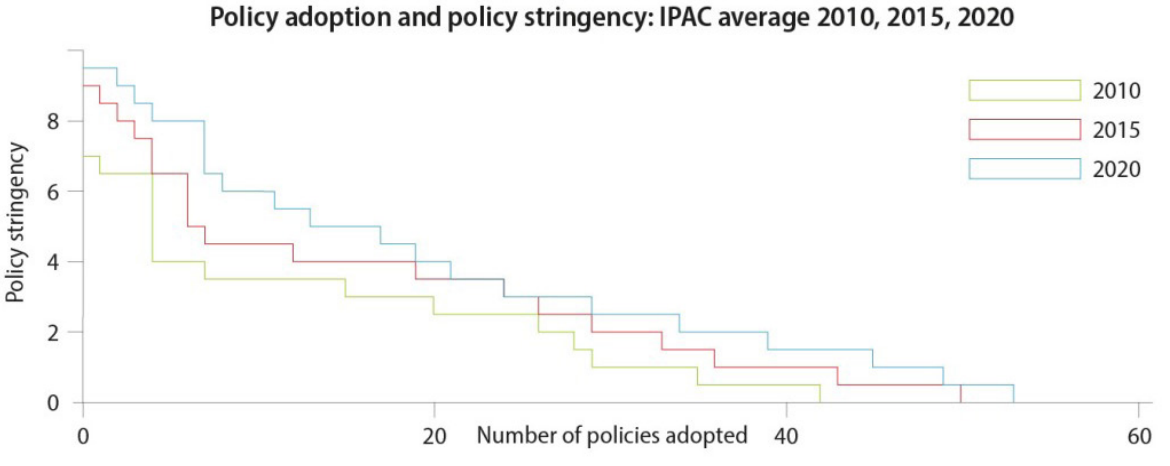
In the period 2010 - 2020, many countries in the world have made efforts to strengthen their climate action, but many countries have not adopted the full range of policies available or used setting of the necessary stringency. So, more work needs to be done by countries to explore which policy mixes work best under which circumstances to reach countries' Nationally Determined Contributions (NDCs) and the goals of the Paris Agreement.

Providing crucial insights into the progress of countries toward their net-zero goals

We have seen a growing number of countries strengthen their emission reduction pledges by updating their NDCs or by pledging carbon neutrality targets towards mid-century. But with the increasing urgency of the climate crisis, what are countries doing to implement these targets and how has the climate policy landscape evolved over the last decade or so? At the 26th United Nations Climate Change Conference of the Parties (COP26), most countries updated their NDCs. The United Nations Framework Convention on Climate Change (UNFCCC) compiled the principal measures reported by countries in their NDCs in 2022. To support the UNFCCC reporting process, the Organization for Economic Cooperation and Development (OECD) International Program for Action on Climate (IPAC) has carried out a detailed assessment of climate action for 51 countries and the EU through the Climate Actions and Policies Measurement Framework (CAPMF). The CAPMF draws on the UNFCCC effort to identify countries' declared climate policies but goes further by tracking which policies and policy instruments have been adopted and with what level of stringency. The CAPMF is a structured and harmonized climate mitigation policy database with 128 policy variables grouped into 56 policy instruments and other climate actions, covering 51 countries and the EU (OECD, G20 and OECD accession candidate countries) and the EU from 2000 to 2020. This Framework provides information to develop indicators to support the country's progress towards net-zero GHG emissions. It covers both climate policies with explicit intent to advance mitigation as well as non - climate policies that are expected to have a positive effect on mitigation. These include sectoral, cross-sectoral and international policies of which market-based instruments (carbon taxes, subsidies for zero-carbon technologies), non - market - based instruments (standards, bans) and other climate actions (short - term and long - term emissions targets, climate governance).

The CAPMF indicates that countries, on average, strengthened their climate action between 2010 - 2020 (Figure 1) - increasing not only the number of policies adopted, but also the stringency of already existing policies. The increase in policy adoption was particularly driven by support for renewable electricity, carbon pricing as well as bans and phase out of fossil fuel infrastructure such as coal power plants.

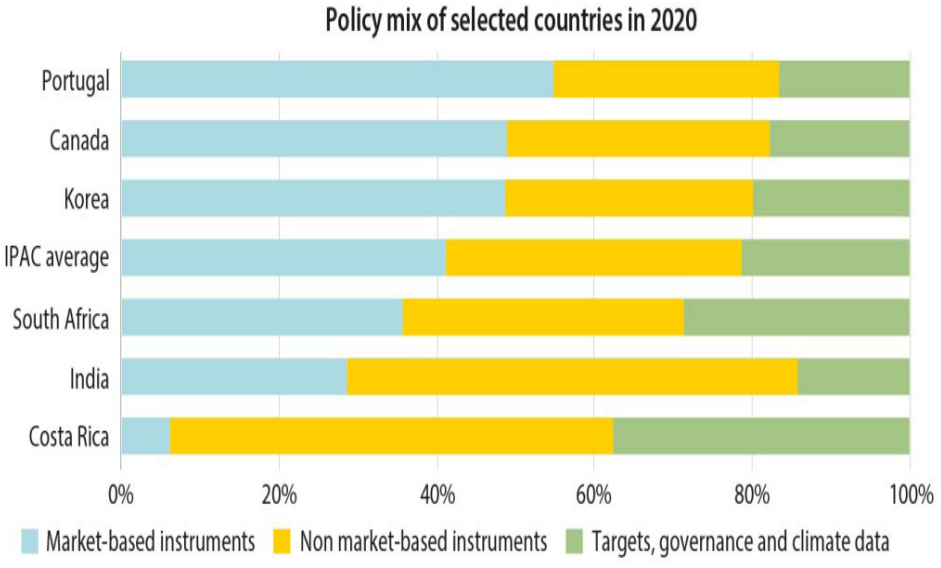
This increase in the overall average, however, masks important differences in policy development across countries. While most countries increased the number of adopted policies between 2015 and 2020, not all adopted the same amount. For example, Canada implemented 10 of the total 56 additional policies covered in the analysis be-



▲ *Figure 1. Countries strengthened climate action between 2010 and 2020*

tween 2015 and 2020 (representing almost 18% of new policies). Some countries did not adopt any and others even backtracked on climate policies.

Countries have made efforts to strengthen their climate action, but many countries have not adopted the full range of policies available or used setting of the necessary stringency. More can and should be done to achieve the ambitious Paris Agreement targets.



▲ *Figure 2. Climate policy mixes differ substantially across countries*

Pursuing efforts to fight climate change

Over the last 10 years, countries have changed the types and mix of policies they use. Market-based policy instruments such as carbon pricing or financial support for renewable energy have increasingly been adopted by countries. The rise in carbon pricing was particularly driven by the implementation of the European Union Emissions Trading Scheme in 2005, after which countries increasingly used carbon pricing schemes. However, global carbon price levels and emissions coverage are still too low to be in line with the goals of the Paris Agreement.

Countries use very diverse policy mixes to reduce emissions (Figure 2). While some countries such as Portugal primarily rely on market-based policies, others like Costa Rica emphasize non-market-based instruments, such as minimum energy performance standards and bans or phase outs of fossil fuel infrastructure. These differences reflect the complex interactions of multiple factors, including legal traditions, political constraints, and social preferences.

The 2015 Paris Agreement marked a pivotal moment in our global efforts to combat climate change. The parties to the Agreement have already taken substantial action. Yet, there is an urgent need to set more ambitious targets to accelerate implementation.

While countries by and large strengthened their climate action in the last decade, emissions are not on track to meet countries' NDCs and are not compatible with reaching net-zero GHG emissions by mid-century according to the IPAC Climate Action Monitor 2022. In fact, after COVID-19 pademic dented global GHG emissions in 2020 and 2021, emissions strongly rebounded in 2022, reaching the largest annual level ever recorded. The analysis based on the CAPMF suggests that there are still opportunities for countries to strengthen their climate action to accelerate further emissions reductions. In fact, no country has adopted all policies covered in the database. Policy makers could use the CAPMF to identify areas where new policies could be adopted, or existing ones strengthened.

Descriptive results of the CAPMF suggest that countries with stronger climate action are associated with steeper emissions reductions. In fact, countries with an above-average number of adopted policies and above-average policy stringency were most successful in reducing their emissions. However, more work needs to be done to explore which policy mixes work best under which circumstances to reach countries' NDCs and the goals of the Paris Agreement. In addition, achieving the necessary transformation, more effective and strategic international cooperation in technology development and transfer, and innovation is essential for rapid system transformations aligned with the goals of the Paris Agreement.

By providing essential data, addressing challenges, and fostering collaboration, IPAC plays a crucial role in shaping effective climate policies and ensuring a resilient transition to a sustainable and low-carbon future. As the world grapples with the urgent need for climate action, the insights and initiatives derived from IPAC offer a pathway toward a more sustainable and climate-resilient global community ▪

ĐỨC ANH

(Source: OECD Environment)

Governments need to prioritize building climate and economic resilience

With current levels of global warming, scientists warn that some catastrophic climate systems "tipping points" are already dangerously close to being triggered. Governments and society must act fast to reduce emissions and adapt to already "baked in" climate impacts. Climate policies need to go beyond the sole aim to reduce emissions, and must also aim to be cost-effective, fair and equitable, politically tenable, compatible with health, social and fiscal policy and aligned with foreign policy concerns.

Climate-related challenges

The COVID-19 pandemic has demonstrated the climate-related opportunities a crisis can bring, such as immense economic recovery spending and capacity for dramatic societal transformations within short time periods as witnessed during COVID-19 lockdowns and through energy-saving behavior during the recent energy crisis. They also bring climate-related challenges to light - misaligned recovery spending, locked-in fossil fuel use, and the disruptive effects of geopolitical tensions. The immense scale and speed of the transformation necessary to reach net zero will have profound implications on public revenues, economic structures and labor markets. If left unaddressed, these aspects could undermine and even derail climate policy ambition. In addition, potential future disruptions, such as the rapidly increasing use and capabilities of artificial intelligence, must be considered in the development of climate policies.

Building climate and economic resilience

The OECD's flagship initiative "Building Climate and Economic Resilience: Net Zero+" outlines a series of recommendations for a resilient transition to net-zero emissions while building resilience to the impacts of climate change itself. The initiative collates climate-relevant findings from across the OECD's multidisciplinary expertise - for example on environment, economic and tax policy, financial and fiscal affairs, development, science and technology, and employment and social affairs - to provide cohesive recommendations for making the transition to net zero emissions resilient, and as well as building resilience to the impacts of climate change.

Drawing on a wide range of policy expertise across the OECD, in its first phase, the Net Zero+ initiative collated insights to develop concrete actions for governments to build climate and economic resilience:

Focus policy making on a systems level rather than individual components or outcomes. Systemic resilience implies anticipating future shocks, building buffers to absorb initial impacts, and ensuring that resources are available to invest in recovery efforts.

Do everything possible to limit global warming to 1.5°C with no overshoot. Faster reductions are essential and the shape of the pathway matters.

Ensure that crisis relief and economic stimulus spending are aligned with climate goals and sufficiently targeted. The massive amounts spent on crisis relief and economic recovery over the past few years was an opportunity to accelerate climate action, but more could have been done. We must do better to seize the climate-related opportunities that may come with future disruptions.

Get climate policy basics right, tailoring a mix of price-based and other instruments to regional, national and local circumstances, and greening of public governance. Resilient climate policies must be effective and appropriate to their context.

Mainstream climate change adaptation throughout national policy processes. Exploit synergies between mitigation and adaptation policy objectives while minimizing trade-offs. It's time to get serious about mainstreaming adaptation into core policy thinking. Climate mitigation and adaptation actions should be leveraged in ways that simultaneously support both sets of policy objectives, for example through nature-based solutions.

Use strategic foresight and anticipating transition bottlenecks. Some obstacles are already clear - such as the cost of capital, critical materials supply, and re- and up-skilling needed for the transition. Foresight processes can tease out other bottlenecks and possible future disruptions and develop forward-looking strategies to deal with them.

The OECD's modeling of the public finance implications of the net-zero transition shows widely heterogeneous effects across countries and time periods. Address the public finance implications of the net-zero transition through careful fiscal planning, assessing direct and indirect effects of policies, and climate-aligned tax instruments. Existing taxes on fossil fuels generate significant governments revenues. Reaching net zero means these and others will be lost as economic structures shift.

Innovation is essential to bring down the costs of emissions reductions and to reach hard-to-abate sectors. Accelerate innovation through a mission-oriented, outcome-based approach. Target support measures for early-stage innovation and research and development.

To ensure that the net-zero transition is publicly supported, governments must clearly communicate not only why policies are needed, but how they will be implemented and what impacts they may have on households. Carefully assess direct and indirect distributional impacts of climate policy. Communicate clear, accurate and easily accessible information to the public about how policies work. Managing the economic effects of climate policies on people is essential.

Better align financial system policies with climate mitigation and adaptation goals, including improved market practices, alignment of core investment policies, use of responsible business conduct tools, and harnessing the double role of the insurance sector as investor and insurance provider. Reaching net zero will require vast amounts of investment. There will be numerous economic opportunities, but financial markets and the private sector cannot rely on public spending to unlock these.

Their needs and perspectives must be given equal consideration. Recognize the interlink ages between climate and development transitions, drawing on all levels of development co-operation to converge on a global approach that aligns development and climate objectives. Developing countries are both the source of most future emissions and the most exposed to future impacts of climate change.

The net-zero transition will cause some jobs to be lost, but new jobs will emerge. Ensure reasonable labor market flexibility and mobility while promoting job quality and protecting workers. Identify skills needs and bottlenecks and prioritize up- or re-skilling. Helping workers shift between sectors, and ensuring they have the skills needed, is integral to an effective, fair and equitable transition.

However, recent global crises, and those to come, are an opportunity for governments to prioritize building climate and economic resilience - one that should not be missed ▪

CHÂU LONG

(Source: OECD Environment)

Climate change impacts the rights to life, health, food, water, culture and to a clean, healthy and sustainable environment of present and future generations. Marginalized communities and Indigenous peoples are bearing the brunt of climate harm today, and this will only worsen with an increase in greenhouse gas emissions from the burning of more fossil fuels.

So, the time has come to reach a Climate Deal that will only be accessible to companies that decarbonize. Those that fail to decarbonize will not meet the standards required by the Climate Deal and the energy sector of the future. From oil to hydrogen, gas to biofuels, coal to nuclear, solar to wind, and buildings to transport, only companies that make clear commitments to decarburization should benefit from regulatory incentives, financing, fiscal support for innovation, and beyond. This issue needs to be discussed and decided at the 28th UN Climate Change Conference (COP 28) in Dubai (UAE) from 30th November until 12th December 2023.

The world will continue relying on oil and gas production for decades to come

The International Energy Agency (IEA) recently reported that by 2025, renewables will fuel 35% of global electricity generation, dethroning coal as the world's largest power source. In the US, solar power alone will account for over half of the new capacity in 2023. According to a major study published last year by the University of Exeter's Global Systems Institute, the world may have already passed a "global solar tipping point", where "solar energy gradually comes to dominate global electricity markets, even without additional climate policies".

At current exponential growth rates, solar, wind and batteries will supply over 80% of global electricity by the 2060s. Though impressive, the Intergovernmental Panel on Climate Change (IPCC) says this is not fast enough.

According to US Climate Envoy John Kerry, in 2018, the IPCC found that to keep global warming within the 1.5 degrees Celsius safe limit agreed upon by world governments in Paris eight years ago, we need to not only eliminate carbon emissions but start removing 5 billion tons a year of carbon dioxide from the atmosphere by 2050. So, while we need to accelerate the build-out of renewables faster than the current rate, with fossil fuels supplying about 78% of the world's energy needs and we'll continue relying on oil and gas production for decades to come. Therefore, it's imperative that fossil fuel industries adapt to the demands of decarbonization.

But for COP28 to deliver a new Global Climate Deal that incentivizes and compels the fossil fuel industry to decarbonize will require three things:

Adapting to decarbonization demands will be key

Firstly, we need to accelerate the build-out of global renewable energy infrastructure as fast as possible. The dominance of the new clean electricity ecosystem based on solar, wind, storage and some other clean energy solutions is inevitable, but we have to boost it dramatically. This requires prioritizing climate financing to help decarbonize emerging countries with the greatest need to industrialize.

Secondly, given that we will still rely on fossil fuels during the energy transition, we need to ramp up the economic and technological viability of carbon capture and storage (CCS) technologies to decarbonize them as much as possible. By partnering with renewable energy to power CCS, fossil fuel companies can bring the economic and energy costs down dramatically, and scale it up faster.

Thirdly, we need to accelerate both carbon withdrawal technologies and nature-based solutions that can draw down billions of tons of carbon from the atmosphere every year. Any technology that contributes to the net-zero deserves to be studied.

Energy and transport companies need to accelerate their "just transition" journey

The President-Designate of COP28, the UAE's Minister for Industry and Advanced Technology and Special Envoy for Climate. Al Jaber proposes several ambitious goals, something that should be particularly considered. If COP28 fails to ratify even these proposals, we will have missed yet another unprecedented opportunity to create a firm foundation for even faster action to avoid climate change. That is why COP28 should launch an International Commission of High-Level Experts possessing knowledge in the scientific, economic, legal, technological and social fields to lead, supervise, and ensure the fulfillment of a new Global Climate Deal on these terms.

Energy companies need to accelerate their "just transition" journey or face disruption. Environmental, social and governance (ESG) criteria will soon be insufficient, and the companies incorporating them will not be pioneers, but merely compliant. Companies that ignore them will be left out of the market. Either industries move rapidly into net-zero, or they'll face deterioration of assets and profits.

Finally, it is important to note that energy is now not only a market for goods but also for services. For this reason, the leading companies will be those with the greatest capacity for innovation. And the message to the energy and transport companies is clear: "Decarbonization will happen, and there is no way out. If you choose to be part of it, you'll not only be saving your industry, but saving our planet too" ▪

AN BÌNH

(Source: Euronews)

▲ *Wind turbines turn behind a solar farm in Rapshagen (Germany)*

Sharing urban water solutions among cities

The World Water Cities Forum (WWCF) was first held as part of the 7th World Water Forum in 2015 and has continued annually in conjunction with the Korea International Water Week (KIWW) since 2016. The WWCF 2023 takes place from December 7th to 8th, 2023 in Daegu, Korea, with the participation of 11 cities around the world including: Catalonia (Spain); Mikkei (Finland); Daegu (Republic of Korea); Batam (Indonesia); Ho Chi Minh City (Vietnam); Vientiane (Lao PDR); Bandung (Indonesia); Lahore (Pakistan); Almaty (Kazakhstan); Manila (Philippines); Taipei (Taiwan).

Cooperation and Innovation between Water Cities Participants Government Officials, Water Specialists and Academics The Forum has been recognized as the prime venue for sharing urban water solutions among cities with key objectives: To help developing cities and countries who are suffering from water challenges by providing real solutions; Provide policy and technical suggestions for tackling a wide range of urban water challenges, including water supply, wastewater treatment, rainwater management, and water reuse and recycling, in response to climate change; Explore a variety of policy and technical options reflecting the nexus between water, food, energy, health, and education; Enhance awareness and share up-to-date information on the three cross-cutting issues of urban water management - Innovation, Finance, and Governance; Consider practical solutions for urban areas in developing countries which are under heavy pressure of the complexity of water challenges.

Building on the success of the WWCF 2022, delegates from different countries discussed water-related issues and solutions for each city, with some main themes, included "Water in Cities: Safeguarding Clean Water and Adequate Sanitation Services for Cities with Good Governance", "Digital Water Management: Unlocking Innovative and Advanced Solutions to Urban Water Management Systems through the Interface between Science and Technology", and "Securing Water Resources: Enhancing Urban Water and Ecosystems in the Era of Climate Change", the WWCF 2023 serves as the place for leading global urban water discourses based on professional insights and experiences of different strategic city partners and urban water experts. To address different emerging challenges related to urban water management in the world, the WWCF 2023 focuses on three themes as follows:

"City to City Learning: Experience and Knowledge Sharing to Improve Water Environment" facilitates the transfer of successful strategies, innovative technologies, and adaptive policies from one urban centre to another through: Creating a collaborative platform as

▲ *World Water Cities Forum 2023*

a space for sharing best practices, success stories, and challenges, fostering a collaborative environment among cities; Developing knowledge-sharing protocols for the systematic sharing of water-related knowledge and experiences between cities; Supporting and investing in capacity-building programs that ensure the empowerment of city officials, managers in the water sector, and stakeholders of urban water management within effective water governance; Promoting inclusive decision-making governance, fostering a sense of ownership, increasing the effectiveness of policies, and promoting sustainable urban water management practices.

"Smart Water Management: Application of AI for Creating Sustainable, Resilient Water Ecosystems" supports leveraging cutting-edge technologies and data-driven approaches as transformative solutions to address the complexities of water management through: Enhancing integrated water governance framework encompassing smart technologies, data analytics, and traditional water management practices, facilitating coloration among various stakeholders that ensures a holistic and adaptive approach; Data sharing and interoperability that simplifies the exchange of information between various stakeholders and

▲ *Delegates took a souvenir photo at the WWCF 2023*

technologies across different smart water management systems; Predictive analytics for ecosystem risk assessment, assessing and mitigating risks to water ecosystems; Regulatory framework for water quality monitoring, which facilitates encompassing key parameters in standardizing processes, effective report exchanges and protocol implementation.

"Response to the Climate Crisis: Urban Water Disaster Mitigation, Risk Reduction and IWRM" fosters comprehensive solutions to the multifaceted urban water challenges presented by changing climate through: Developing climate-resilient green infrastructure that facilitates reduction of the impact of urban flooding and adaptive to drought conditions; Implementing enhanced early warning systems with investment and deployment of real-time monitoring technologies providing timely alerts to enable cities to deal with potential water-related disasters; Incorporating nature-based solutions that reduce the vulnerability of urban areas to water-related disasters and contribute to long-term resilience and sustainability with enhanced ecosystem services; Implementing principles of Integrated Water Resources Management (IWRM) about optimizing the urban water allocation, use, and management of water that will give cities a sustainable approach to water management, tackling climate change impact.

At the WWCF 2023, Prof. Dr. Nguyễn Văn Phước, Chairman of Ho Chi Minh City Association for Clean Water and Environment presented a speech with the topic "Smart Water Management: Smart water management", applying AI to create a sustainable water ecosystem, capable of recovery.

The WWCF 2023 is one of the important main events of KIWW. The WWCF 2023 plays a key role in expanding knowledge about the importance of water and providing new solutions to world water problems and response to climate change.

Since 2015, the WWCF has been serving as an exclusive platform for city leaders and water experts to discuss water-related issues and solutions for each city and share best practices and policies related to water management. The Forum for discussing the way to utilize water management and water technology/water industry development as a tool for creating attractive, livable, resilient, and prosperous cities. All participants have gained new insights into the successful implementation of water policies, how to engage stakeholders and how to collaborate with participating cities ▪

CHÂU LOAN

Nam Cau Kien Industrial Park: Development orientation towards the circular economy model

Industry is one of the important sectors of the economy with growing demand. In Vietnam, the Industrial Park (IP) Management Board has regulations on increasingly high environmental protection standards. Therefore, businesses have been innovating technology to minimize environmental pollution and increase production value towards sustainable development. On the occasion of Vietnamese Entrepreneurs' Day (13th October 2023), Environment Magazine had an interview with Dr. Phạm Hồng Điệp - Chairman of Shinec Joint Stock Company (Investor of Nam Cau Kien IP) about extended producer responsibility (EPR), implementation of circular economy and roadmap to reduce greenhouse gas emissions, helping businesses develop sustainably and create a more customer-friendly image.

▲ *Dr. Phạm Hồng Điệp - Chairman of Shinec Joint Stock Company (Investor of Nam Cau Kien IP)*

The Law on Environmental Protection (LEP) 2020 and the Decree guiding its implementation stipulate the waste recycling responsibility of producing and importing organizations and individuals. As a business investing in IPs, how do you evaluate the role and responsibility of businesses in implementing EPR regulations?

Dr. Phạm Hồng Điệp: EPR is defined as an "approach to environmental protection policy whereby the producer responsibility for a product extends to the disposal stage of the product's life cycle" (guidelines for implementing the United Nations Basel Convention 2019). In the EPR mechanism, for product packaging, the responsibility of relevant businesses is not only limited to ensuring health and safety after the product is sold, but also needs to ensure product packaging reused or recycled, that does not pollute the air, soil, rivers and oceans.

By exercising corporate responsibility, post-production packaging increases recovery and recycling rates, contributing to reducing the amount of non-recyclable packaging released into the environment, while increasing the attraction of waste recycling and treatment businesses in Vietnam.

In 2020, the LEP No. 72/2020/QH14 was approved by the National Assembly on 17th November 2020 (effective from 1st January 2022), which stipulates in more detail, and synchronizes the system to promote EPR in Viet Nam. Article 54: Responsibility for waste recycling of producing and importing organizations and individuals; Article 55: Responsibility for waste collecting and treating of producing and importing organizations and individuals; Article 54: Responsibility for waste recycling of producing and importing organizations and individuals: Organizations and individuals producing and importing products and packaging with recycling value must carry out recycling according to mandatory recycling ratio and specifications, except for products and packaging that are exported, or temporarily imported, re-exported, or produced, imported for research, study, or testing purposes; Article 55: Responsibility for waste collecting and treating of producing and importing organizations and individuals: Organizations and individuals producing, importing products, packaging containing toxic substances that are difficult to recycle or that cause difficulties in collection and treatment must make financial contributions to support activities specified in Clause 3 of this Article, except for products exported or temporarily imported for re-export or produced, imported for research, study or testing purposes.

At Nam Cau Kien IP, there are industrial sectors related to waste recycling and treatment. Businesses demonstrate their responsibility through the formation of industrial symbiotic chains. Businesses are responsible for collecting and transferring waste to waste treatment facilities right in the IP, not only demonstrating their responsibility to handle the post-production phase of the product, but also contributing to minimizing pollution thanks to the cycle within the IP, reducing logistics costs, and treated waste is collected more quickly.

The responsibility of business is carried out within the business, recycling, extending the product life cycle or cooperating with the outside through capable businesses to form symbiotic chains inside and outside the IP. The role of circular economy in businesses in EPR is essential, jointly implementing responsibility with product manufacturing businesses.

IP investor plays an important role in indirectly forming awareness and implementing actions to fulfil the responsibility of each business. Through a community of sharing and cooperation between businesses, symbiotic chains are gradually formed. One business's waste will become another business's raw material, creating more useful and environmentally friendly products, bringing higher value compared to disposal or treatment at a longer range without industrial symbiosis in the IP.

With the goal of regenerating energy, saving resources, and implementing circular economy, how has the Company currently implemented these activities?

Dr. Phạm Hồng Điệp: At Nam Cau Kien IP, we build and develop with the orientation of an ecological IP following a circular economy model. Up to now, Nam Cau Kien IP has fully met the criteria of ecological IPs and circular economy with the formation of industrial symbiotic chains, industrial symbiosis between businesses and the IP, and investment in service infrastructure, meeting prescribed criteria.

One of the lines of industrial symbiosis that is formed and developed is renewable energy, optimally exploiting clean, green energy sources and recirculating wastewater treatment to help save natural resources. With the solar power system, we have piloted installation at the Company Office since 2020. Up to now, the results have not only reduced electricity consumption but also reduced costs by 90%; it also contributes to reducing electricity used from fossil fuels, thereby indirectly cutting the amount of CO_2 generated in the IP.

Our goal is to be carbon neutral by 2030. One of the proposed plans is to green rooftop solar power over the entire factory roof area across the IP with an expected capacity of up to 40 MW. This is a big goal in implementing the commitment on life and CO_2 emissions of the IP, contributing to Việt Nam's commitment to net zero emissions. However, currently we are stuck with a number of policies related to supporting businesses in project implementation as well as regulations and procedures related to standards for applying regulations on fire prevention, fire fighting, related costs, investment subjects, ownership, grid connection, battery storage... Although the National Power Development Plan VIII was launched to encourage renewable energy projects, actual implementation is still very difficult.

Regarding the water resources saving project, with the characteristics of IPs having businesses that use a large amount of water in a day, recently we have taken advantage of that water source to water plants and wash roads. However, to be more effective in extending the life cycle of that water source as well as meeting the needs of businesses, it is necessary to add clean water sources for production while still meeting regulatory standards and at a more reasonable cost. We have researched and implemented a wastewater recirculation project with the goal of supplying clean water for production to investors.

By reusing and circulating over 70% of the water generated, we can satisfy the needs of very large consuming businesses, reduce water costs for those businesses by up to 15% and still ensure product quality as well as production line. However, we are also facing issues related to state regulations on the water recirculation sector, applicable standards, and related tax policy regulations. Although businesses are very supportive and confident in encouraging the IP to develop water circulation for production. However, to bring multifaceted benefits to all parties, the State needs to have clear regulations on circulating water quality so that businesses can "remove" the fear of using circulating water sources without specific instructions as currently.

It is known that according to the roadmap, the domestic carbon credit exchange will operate on a pilot basis from 2025 and officially operate in 2028. This is in accordance with the general emission reduction roadmap and regulations that businesses are required to develop emission reduction plans from 2026 onwards. So how is Shinec Joint Stock Company prepared, especially issues related to greenhouse gas inventory, calculation of emission reduction and energy savings...?

Dr. Phạm Hồng Điệp: For Shinec Company, there are no production activities that emit greenhouse gases in terms of industrial production. Currently, it is not yet time to deploy it into transactions, so preparing the

readiness of businesses is extremely important. We deploy a series of activities such as research, training, and communication, cooperation with units in assessing the emission levels of businesses, participating in consulting activities to support technology from domestic and international partners on CO_2 reduction.

Therefore, with the goal of carbon neutrality, cooperation with businesses as well as proactive investment in infrastructure is essential. The carbon credit exchange is still new to businesses. Raising awareness and understanding is important, in addition, the IP and businesses have proactively researched to reassess the businesses' carbon emission sources in every stage of production and disposal. With guidance from State agencies and partners, we are conducting an assessment and building a roadmap to improve the system and buy and sell credits based on allowed quota.

For IPs, investment in infrastructure is emphasized such as building ecological works by increasing the proportion of multi-layered trees, restoring biodiversity, and cooperating in investing in carbon emission reduction works like solar energy. Connect the business community to contribute to common works or proactively invest in own businesses. Thanks to that, the proportion of ecological and environmentally friendly works increase.

**** To deploy technologically innovative businesses that meet "green" standards, what suggestions and recommendations do you have for the authorities?***

Dr. Phạm Hồng Điệp: The digital technology age is extremely important, especially green digital technology to reach quickly and on a wide scale is extremely essential in the rapid and sustainable development of ecological IPs and circular economy, and combating climate change.

Therefore, state management agencies need to quickly promulgate regulations and policies related to green sector development such as the development of circular economy ecological industry. Based on that, businesses have the basis to build sets of ecological standards applicable to businesses, through more effective synchronization of technology applications. In addition, there is also a need for financial credit packages to support small and medium-sized enterprises in accessing digital technology.

To successfully deploy digital technology, first of all, the business itself needs to be structurally re-modelled in a unified way in terms of processes, methods, and scope of implementing sustainable development in applying an advanced technology to become a tool to support each business's implementation. It is necessary to clearly see the benefits from seamless, interconnected information, anytime, anywhere, and to evaluate the effectiveness of the implementation not only of the business itself but also the management and governance of the entire IP to have a clear view, consulting to support the business community for sustainable development.

**** Thank you very much!***

NAM HƯNG

The voluntary carbon market (VCM) - a tool help mobilize public sector finance towards nature - based solutions (NbS)

Scientists said if global average temperatures surpass pre - industrial levels by more than 1.5°C, it would lead to far more serious impacts on people, wildlife and ecosystems. However, avoiding this scenario is not achievable without sustained and rapid industrial decarbonization. So, we need NbS, which can provide up to 30% of the mitigation required by 2030 in order to keep the 1.5°C target in reach.

The powerful tool at our disposal can mobilize private sector finance and channel it toward NbS in the Global South, where it is most needed, which is the VCM, where companies or individuals can buy carbon credits as part of their own plan to meet their climate goals. The VCM can help mobilize public sector finance towards NbS, particularly in the Global South where it is most urgently needed. When we outlined five reasons why forest carbon credits are critical to climate action, we found that the fact is that we won't achieve our global climate targets without nature, and we won't protect and restore nature at the scale required without carbon markets.

The VCM is currently the most effective way for them to address these emissions by mobilizing billions of dollars in private sector finance every year and also helps make up the US$ 4.1 trillion financing gap in nature by 2050. Such finance is additional to that pledged by governments. The value of the global VCM topped US$ 1 billion for the first time in 2021 and could be worth between US$ 5 - 30 billion per year by 2030, with perhaps two thirds of this channelled into NbS, filling existing gaps in climate finance for nature. However, in the last three years, only 1.2% of the annual cost effective potential of NbS has been unlocked by the VCM.

Investing in nature-based solutions through the voluntary carbon market

Market initiatives to solve both nature loss and climate change

One of the barriers is that far too often the use of carbon credits and NbS carbon credits in particular have been framed as an proposition. This implies companies think they can either invest in them or fund the decarbonization of their operations. Adopting a single approach is not enough to solve the twin crises of nature loss and climate change. This is why climate science is now demanding a "both/and" approach, that is, simultaneously investing in internal reductions and NbS credits. What is encouraging is that leading companies understand this "both/and" approach, and are publicly committed to it. In addition, recent research has further shown that companies that purchase a material amount of carbon credits on average reduced their emissions faster than those who have not.

In recent years, a number of market initiatives have emerged from both the private and public sectors seeking to improve the integrity and functionality of VCMs. These range from the creation of trade infrastructure to new forms of project certification. While VCMs and compliance markets remain distinct, there is an increasing level of overlap between the two. Multiple initiates have created a hybrid model for voluntary markets in which the Government plays a more active role in defining and regulating companies' voluntary trade of carbon credits.

High-quality carbon credits - A way to support a range of critical mitigation efforts

As the world intensifies its efforts to combat climate change, discerning organizations are seeking not just any carbon credits, but those with exceptional quality that generates genuine environmental impact. The good news is that initiatives like the Integrity Council for the VCM which are aiming to forge a clear path forward towards higher integrity, greater transparency and overall more consistency in the marketplace.

Recent recommendations issued by civil society, such as the Tropical Forest Credit Integrity guide and the NCS Alliance's Buyer's Guide, offer clear guidance that companies can turn to in the interim. Purchasing carbon credits through the VCM is not an alternative to rapid decarbonization within value chains.

▲ *The VCM can help mobilize public sector finance towards NbS*

High-quality carbon credits are a way for companies to support a range of critical mitigation efforts outside of their value chains, including the potential to channel billions of dollars into NbS that would not receive funding otherwise. In the future, NbS carbon credits must improve in line with this new science and guidance, updated methodologies and evolving technology.

The VCM has seen rapid growth in recent years, driven in part by the growing chorus of net-zero commitments made by companies around the world. When investments are made with due diligence, high-quality NbS credits will ensure that emissions reductions or removals happen, that nature is being protected or restored, and that communities are not only receiving benefits, but are also active participants.

Failure of the market now would slow humanity's path to net-zero emissions and derail financial innovation in other ecosystem services. Climate change and nature loss are crises and inaction is not an option. The VCM is critical for climate action and major progress has been made to improve outcomes - with many more improvements already under way.

Now is exactly the time to invest in NbS through the VCM, alongside other immediately deployable climate solutions, so we can ensure a better future for the planet. If implemented correctly, carbon markets could both accelerate action to combat climate change, and also deliver much-needed co-benefits for nature and people ▪

HỒNG CẨM

(Source: Ecosystem Marketplace)

Composting is a simple yet powerful way to combat climate change

Composting is actually one of the climate solutions that can immediately make a significant impact, reducing greenhouse gas (GHG) emissions. Composting with Anaerobic Digestion (AD) is as an innovative, scalable environmental solution that recycles organic waste, contributing to climate change mitigation and advancing sustainability efforts.

Compost benefits the climate in a few different ways, including by reducing GHG emissions at landfills, by promoting uptake of carbon dioxide by vegetation, and by making our projects and gardens more resilient to the effects of climate change.

Composting is an eco-friendly method of recycling organic waste by breaking it down into nutrient-rich material, often used as a natural fertiliser for plants. This simple yet powerful practice helps reduce the amount of waste sent to landfills and mitigates climate change by cutting down on methane emissions. When organic waste decomposes in landfills, it generates methane, a potent GHG that contributes significantly to global warming. This eco-friendly method has been embraced worldwide for its efficiency in recycling organic waste and promoting soil health, which can capture and store atmospheric carbon dioxide, thereby reducing GHG concentrations. Composting can be done on a small scale, such as in backyard compost bins, or on a larger scale in commercial composting facilities. Besides, composting repurposes food scraps and other organic waste, decreasing the volume of waste sent to landfills and incinerators.

Composting can be accomplished in two distinct ways: Anaerobically and aerobically. Anaerobic composting generates biogas which can be harnessed and used as a valuable energy source, while aerobic composting enhances soil fertility and waste reduction. In particular, the method achieves high efficiency for environmental protection and combating climate change is AD. Through this natural process, organic materials are broken down by microorganisms, resulting in nutrient-rich compost that enriches the soil and benefits the environment, while also generating a source of clean, renewable energy. While based on ancient processes, AD - coupled with cutting-edge technology - stands as an innovative, scalable environmental solution that recycles organic waste, contributing to climate change mitigation and advancing sustainability efforts.

By redirecting organic waste from landfills and decomposing it in an oxygen-free environment, AD sequesters the release of methane, a potent GHG with a considerable impact on global warming. The biogas generated during the process, comprised of methane and carbon dioxide, can be captured and utilized as a sustainable energy source. Advanced technologies enable the purification of biogas, making it suitable for replacing natural gas to heat homes, power vehicles and generate electricity.

AD takes the benefits of composting to a more advanced and impactful level because of its scalability for commercial uses. This technology serves as a sustainable recycling solution, converting organic waste such as food processing waste to two valuable products: Clean, renewable energy and reusable digestate, which provides a nutrient-rich boost for soils. The AD process occurs within sealed containers called digesters, where controlled conditions foster the efficient decomposition of organic matter.

Additionally, AD promotes a circular economy by transforming waste into valuable resources by diverting that very waste from landfills, where its inevitable decomposition releases methane, one of the most prevalent and harmful GHGs. With widespread adoption and support, AD stands as a proven solution in the fight against climate change, providing a greener and more sustainable future for generations to come. Composting also presents a smart alternative by breaking down these organic materials in an oxygen-rich environment, which significantly reduces methane emissions.

The adoption of composting and AD offers multifaceted environmental benefits that extend beyond climate change mitigation. In addition to significantly reducing GHG emissions, particularly from landfills, it also supports biodiversity by creating a healthy soil ecosystem that fosters beneficial microorganisms and reduces the need for harmful pesticides.

Composting and AD are gaining traction, as they begin to take center stage as effective and immediate solutions in the battle against climate change. These sustainable solutions stand out as simple and powerful techniques that turn organic waste into nutrient-rich compost and renewable energy - while utilizing readily available materials that would otherwise contribute further damage to the environment ▪

NAM VIỆT

(Source: Eponline.com)

The bitter truth about chemical recycling

In today's industrialized world, plastic is everywhere. At supermarkets, food and household items are usually packaged in plastic bottles, tubs and packaging. When you order something online, your product may arrive shrink-wrapped in plastic. Not only that, but plastic is often part or all of the product itself, be it kids' toys, holiday decorations or one of our ubiquitous electronic devices.

Is chemical recycling the way to deal with plastic waste?

The world is desperately in need of effective plastic solutions. According to the United Nations Environment Program, about 430 million metric tons of plastic are produced per year. Most of this plastic is used only briefly and then discarded, often improperly. An estimated 2,000 garbage trucks full of plastic are dumped into the world's oceans, lakes and rivers every day. The problem is set to get far worse. If the plastics industry is permitted to continue growing without significant regulation, plastic production may nearly triple in the next 40 years, from about 460 million metric tons in 2019 to 1.23 billion metric tons by 2060.

The planet has already become so inundated with pollution from plastics and other synthetic chemicals that scientists say we've breached a critical "boundary". This assertion is based on the planetary boundaries theory, which argues that Earth has nine key operating systems that enable life to thrive. However, each of these systems has a boundary threshold - or thresholds - that, if crossed, can destabilize Earth's "safe operating space". Plastic pollution is considered part of the "novel entities" boundary, and scientists say that this one, along with five other boundaries, including climate change and biosphere integrity, has been crossed.

Plastic producers and fossil fuel companies argue that chemical recycling presents a solution to the world's plastic problem since it is intended to process plastics that can't traditionally be recycled, keeping them out of the environment. Many plastic products are marked with seemingly helpful recycling symbols, leading consumers to believe that most, if not all, plastic can be recycled. But that's not the case. Traditional recycling - the process of breaking down, melting and remolding plastic to form new products - is expensive, time - consuming and limited to certain plastic types. In the US, for example, only types 1 and 2 are easily recyclable, while 3 through 7 aren't. Recycling rates are also historically low; in the US, it's estimated that only 5 - 6% of plastic is recycled.

There's another way to deal with plastic waste, it is called "chemical recycling", or "advanced recycling" an industrial process that the industry claims could recycle more types of plastics and help humanity transition to a circular economy. However, according to a recent report released by Swedish nonprofit International Pollutants Elimination Network (IPEN) and US - based NGO Beyond Plastics, most chemical recycling claims have yet to be proven, while existing chemical recycling facilities are exacerbating the pollution problem.

The IPEN and Beyond Plastics report suggests that chemical recycling is not really recycling at all. Instead, it's an umbrella term for a range of technologies that use heat or chemicals (or both) to break down the polymer chains in plastic waste to create "output". Two main chemical recycling processes are in use today: Pyrolysis, which heats waste without oxygen at very high temperatures; and gasification, the heating of waste in a low - oxygen environment. In most cases, the output is fuel, although chemical recycling can also generate feedstock for new plastic products, according to the petrochemical industry.

However, the report shows that most chemical recycling facilities in operation today produce very little usable plastic feedstock despite creating no shortage of hazardous waste that damages the environment and threatens human health and safety. The petrochemical industry says that "chemical recycling" processes can recycle more types of plastics and help humanity transition to a circular economy. However, Mr. Lee Bell, the report's lead author and IPEN's policy advisor for persistent organic pollutants (POPs) disputed these claims: "We're seeing this technology hyped by the plastics industry as a solution to the plastic crisis, and it's no such thing. Simultaneously, chemical recycling is a "risky" business".

According to research that authors reference, chemical recycling processes create large amounts of toxic waste and toxic emissions that can cause significant human health problems, while the facilities themselves have been prone to fires and explosions. Additionally, they say that the greenhouse gas emissions from chemical recycling processes contributes to the acceleration of climate change. Far from offering a solution, these processes can "create as much as 100 times more damaging environmental and climate impacts than virgin plastic production", which seriously calls into question the efficiency and environmental benefit of chemical recycling.

But Mr. Ross Eisenberg, the President of America's Plastic Makers, an arm of the American Chemistry Council (ACC), a plastic industry association based in Washington, D.C, takes a different view. He argues that chemical recycling activities are strictly monitored and provide a way to "build a more sustainable and lower carbon future". Mr. Ross Eisenberg also referenced a study conducted by the Argonne National Laboratory, a US Government-funded research and development center in Illinois, that found that chemical recycling engaged in pyrolysis oil production generated an 18% to 23% decrease in greenhouse gas emissions and also decreased fossil energy use, water use and solid waste.

However, as Mr. Lee Bell explained that, this particular study relies on industry data and doesn't "address or characterize the toxicity of solid waste, atmospheric emissions or other hazardous releases from the pyrolysis process". He said the Argonne study also doesn't note that pyrolysis oil is usually loaded with contaminants, making it "unsuitable" for plastic production and refineries, and that it requires dilution with virgin petrochemicals, which makes the pyrolysis process "neither sustainable nor circular".

A closer look at chemical recycling facilities' databases in the world

While investors have already spent billions of dollars to develop chemical recycling, the industry is not yet fully fledged. For example, the chemical industry trade group American Chemistry Council (ACC) is advocating for the establishment of more than 150 new plants across the US, but at present, there are only 11 constructed facilities in the country. Among them, four operate at a pilot or demonstration scale, and four others are partially operational. IPEN and Beyond Plastics analyzed company records, news sources and other information to provide details about these US's facilities in their report. At least seven of the facilities were found not to be operating at capacity or delivering what they had promised, with aims and goals still unmet and unproven.

In addition, the report notes that a Brightmark Energy facility in Ashley, Indiana, predicted in June 2020 that it would "reach a yearly plastic waste recycling capacity of 100,000 tons by early 2021", and the operation received US$ 4 million in US Federal subsidies to help make this happen. However, to date, the plant has only processed about 2,000 tons of plastic waste, while it has been impacted by fires, oil spills and worker health and safety complaints. For the remaining four facilities, there is a paucity of publicly available information about their capacities and output.

Among them, Chevron intends to build a chemical recycling facility to turn waste plastic via pyrolysis into oil that can be refined into jet fuel. However, the US Environmental Protection Agency found that the project had a public risk factor of 1 in 4 - a level 250,000 times greater than what is typically permitted. "This means that 25% of the local population would likely develop cancer in their lifetime as a result of exposure to the facility's emissions", the report's authors write. Other potential plastics - to - fuel products connected to this proposed plant had even greater risks associated with them.

Chemical recycling plants aren't only popping up in the United States. There are already plants in the U.K. and several other countries in Europe, including Denmark, Netherlands, Germany, France, Belgium, Spain and Poland.

The concerns regarding air pollution and contamination from these facilities are essentially the same for chemical recycling plants on both continents.

The challenge with plastics is huge. So we know we need lots of different solutions here. It's clear that chemical recycling is one of the issues that we are going to have to deal with plastic pollution. Chemical recycling - or what the industry likes to call "advanced recycling" - is increasingly touted as a solution to the plastic waste problem, but a landmark new report from Beyond Plastics and IPEN shows this technology hasn't worked for decades, it's still failing, and it threatens the environment, the climate, human health, and environmental justice. This report clearly shows that chemical recycling's lack of viability, and its harms so that others, especially lawmakers and regulators, can see this pseudo-solution for what it is.

Mr. Lee Bell said he believes one reason chemical recycling has been able to progress without strong opposition and close scrutiny is because companies are not releasing adequate data, especially in relation to their toxic emissions and hazardous waste streams. This lack of data and transparency can pose a problem for environmental regulators, policymakers and even investors who are enabling the rise of this industry, he said. At the same time, Mr. Lee Bell believes policymakers are now becoming more aware of the risks associated with chemical recycling. He noted that the petrochemical industry "could not demonstrate that it's environmentally sound as a technique for managing plastic waste. And it was not agreed to include it in the global plastic waste treatment guidelines. It remains to be seen whether chemical recycling will be included in the global plastics treaty" ▪

GIA LINH

(Source: Mongabay.com)

The World Economic Forum's 5 major priorities for climate action at COP28

The 28th session of the Conference of the Parties (COP28) which will be held in the UAE from 30th November - 12th December 2023, with four cross-cutting themes aimed at tackling the causes of climate change and managing the impacts of a warming planet: Technology and Innovation; Inclusion; Frontline Communities and Finance.

At COP28, the World Economic Forum (WEF) will focus on key priorities of climate actions for high-level delegates to discuss and find effective solutions.

1. THE FIRST GLOBAL STOCKTAKE ON CLIMATE ACTION PROGRESS

The majority of agreed international climate targets are embedded within the Paris Agreement on climate change and the 17 UN Sustainable Development Goals. At the halfway point for meeting climate goals by the target date of 2030, COP28 will host a "global stocktake" to measure progress in detail, identify areas of failure and reinvigorate commitment to ensure climate pledges are turned into action.

2. SPEEDING THE ENERGY TRANSITION

Reducing carbon emissions from fossil fuels will be critical to keeping the 1.5°C target alive. According to a study published in the journal Earth System Science Data, greenhouse gas emissions are now at an all-time high. The same study says the rate of emissions is slowing but the target set in the Paris Agreement is in immediate jeopardy. This is a critical decade: human-induced global warming rates are at their highest historical level, and 1.5°C global warming might be expected to be reached or exceeded within the next 10 years.

Accelerating the energy transition inclusively and sustainably will sit high on the agenda at COP28. Discussions will focus on the rapid scaling up of renewable energy, how innovations like hydrogen fuels and carbon capture technologies can help reduce emissions. At the same time, delegates will look for pathways to ensure the energy transition benefits developing nations and minority communities in equal measure, to deliver a just transition that leaves nobody behind.

3. PUTTING PEOPLE AT THE HEART OF CLIMATE ACTION

Climate change is already impacting human health across the world. Air pollution blights lives in cities and millions in developing countries live with water shortages or supplies that are a danger to health.

At COP28, delegates will discuss on initiatives that be designed to "protect lives and livelihoods and support community resilience and stability" in the face of the advancing effects of climate change. High-level discussions will take place around health, relief, recovery and peace. There will also be a focus on regions of the world consumed by conflict and beset by a range of issues that make climate mitigation and adaptation extremely difficult.

4. CLIMATE FINANCE AND THE IMPACT OF GLOBAL TRADE

Global trade has been a major contributor to greenhouse gas emissions - with production and distribution responsible for around 25% of global emissions. Trade Day at COP28 will explore the potential for trade to reduce emissions across the value chain and grow markets for climate-friendly products such as electric vehicles and non-plastic packaging.

Providing equitable financing for climate action and adaptation will be critical in keeping 1.5°C alive. Many developing countries are disproportionately impacted by the climate crisis and are struggling to access the adaptation and mitigation funding they need. COP28 will dedicate a day to climate finance in an attempt to ensure affordable sustainable development finance is available to all stakeholders. In addition to the financial aspects of food and agriculture, and the nature ecosystems pillars, the Forum is also working with the COP28 Presidency to explore potential outcomes for financing the net zero transition.

The WEF's Centre for Nature and Climate is a multistakeholder platform that seeks to safeguard our global commons and drive systems transformation. It is accelerating action on climate change towards a net-zero, nature-positive future:

Scaling up green technologies: Through a partnership with the US Special Presidential Envoy for Climate John Kerry, and over 65 global businesses, the First Movers Coalition has committed US$ 12 billion in purchase commitments for green technologies to decarbonize the cement and concrete industry.

1 trillion trees: Over 90 global companies have committed to conserve, restore and grow more than 8 billion trees in 65 countries through the 1t.org initiative - which aims to achieve 1 trillion trees by 2030.

Sustainable food production: The WEF's Food Action Alliance is engaging 40 partners who are working on 29 flagship initiatives to provide healthy, nutritious, and safe foods in ways that safeguard our planet. In Vietnam, it supported the upskilling of 2.2 million farmers and aims to provide 20 million farmers with the skills to learn and adapt to new agricultural standards.

Eliminating plastic pollution: The WEF's Global Plastic Action Partnership is bringing together governments, businesses and civil society to shape a more sustainable world through the eradication of plastic pollution. In Ghana, more than 2,000 waste pickers are making an impact cleaning up beaches, drains and other sites.

Protecting the ocean: The WEF's 2030 Water Resources Group has facilitated almost US$ 1 billion to finance water-related programs, growing into a network of more than 1,000 partners and operating in 14 countries/states.

Circular economy: The WEF's SCALE 360 initiative is reducing the environmental impacts of value chains within the fashion, food, plastics and electronics industries, positively impacting over 100,000 people in 60 circular economy interventions globally.

5. BROADER LEADERSHIP ON CLIMATE CHANGE

COP28 will also look to engage a broader range of leaders to convert climate pledges into action. The COP28 Local Climate Action Summit will bring together hundreds of mayors, governors and leaders from business and NGOs who play a critical role in implementing climate policy at city and regional levels in their home countries.

Recognizing the impact these sub - national leaders can deliver, United Nations Secretary - General António Guterres said: "Cities are where the climate battle will largely be won or lost. We all need to push further and faster; keep collaborating, innovating and raising ambition. Mobilizing and equipping local governments with the capacity and financing to accelerate climate action is necessary if we are to bend the emissions curve".

COP28 President - designate Sultan Ahmed Al Jaber added: "By bringing hundreds of local leaders to COP28, we will foster new, multi-level partnerships to help fast - track the energy transition, fix climate finance, focus on people, lives and livelihoods, and make sure local voices are heard at the international climate table".

Looking ahead to the next 10 years, climate and environmental risks dominate global risk perception, with failure to mitigate climate change the most pressing, according to the WEF's Global Risk Report 2023 ■

MAI HƯƠNG

(Source: World Economic Forum)

As the impacts of climate change continue to increase, concerns over climate risks are compelling companies and organizations to invest in carbon offsetting. Voluntary initiatives serve as a strategic approach employed by corporations to enhance their environmental performance and foster innovation for climate solutions.

Barriers to the development of voluntary carbon offsetting

Almost a fifth of global emissions are now covered by some kind of carbon market, and the cumulative value of all of those was an estimated US$ 850 billion (€ 768.1 billion) in 2021. But we still need to do more if we are to reach net zero emissions by 2050. More companies than ever are aware of the severity of the challenge we face, and they are searching for ways to be part of the global solution to the climate crisis.

To address climate risks, a carbon offset broadly refers to a reduction in greenhouse gas emissions - or an increase in carbon storage (through land restoration or the planting of trees) - that is used to compensate for emissions that occur elsewhere. Although, voluntary carbon offsetting has picked up steam in recent years, these offsets are definitely not perfect. For instance, there is no internationally defined standard for what constitutes a valid offset, meaning schemes can be marketed to businesses with little oversight. Companies with good intentions have to navigate an oversupply of low-quality offsets that do little to actually remove carbon dioxide from the atmosphere in a permanent way. Companies can easily offset today's emissions against new forest growth that may not begin to store significant amounts of carbon for another 70 years and which might not grow successfully at all.

Carbon offset generates reductions in greenhouse gases

Nor do "avoided emissions credits" solve the problem. Avoided emissions credits let one party emit the amount someone else claims they would have emitted but didn't. These offsets are hard to verify, and they risk creating complacency from participating companies without contributing to the critical challenge of rapid emissions reduction. If we are to achieve our net zero goals as a society, carbon capture has to be part of the solution.

The Intergovernmental Panel on Climate Change (IPCC) has said that to limit global warming to 1.5 degrees Celsius, between five and 15 billion tons of CO_2 will have to be removed from the air and stored permanently every year. So, how do we bring more certainty to world of offsets while at the same time scaling up the amount of carbon removed in the first place?

Need to ramp up carbon removal technology

The answer could lie in an emerging ecosystem of so-called carbon removal credits (CRCs). CRCs follow strict quality criteria involving permanence, additionally and verifiability. However, there are obstacles to overcome before carbon removal credits are truly mainstream.

Many carbon removal initiatives are still in the early stages, permanent storage facilities are just being developed, and the carbon markets are only starting to understand the differences in credit quality. And, the price per ton removed is high, for now. We believe that despite these challenges, CRCs should sit at the center of companies' emissions policies.

▲ *Filao trees form a curtain that protects the beginning of the Great Green Wall, planted to slow coastal erosion along the Atlantic Ocean in Senegal*

Organizations are beginning to build the infrastructure we need to ramp up carbon removal technology. Remove is one example of a newly launched European accelerator for early-stage carbon removal startups designed to support the emerging carbon removal ecosystem. And some of the biggest and most influential private and public companies see the benefits of an innovation-led approach. Stripe, Alphabet, Shopify, Meta, and McKinsey founded the Frontier Fund, which is an "advance market commitment" to select and invest in the most promising climate technologies and teams.

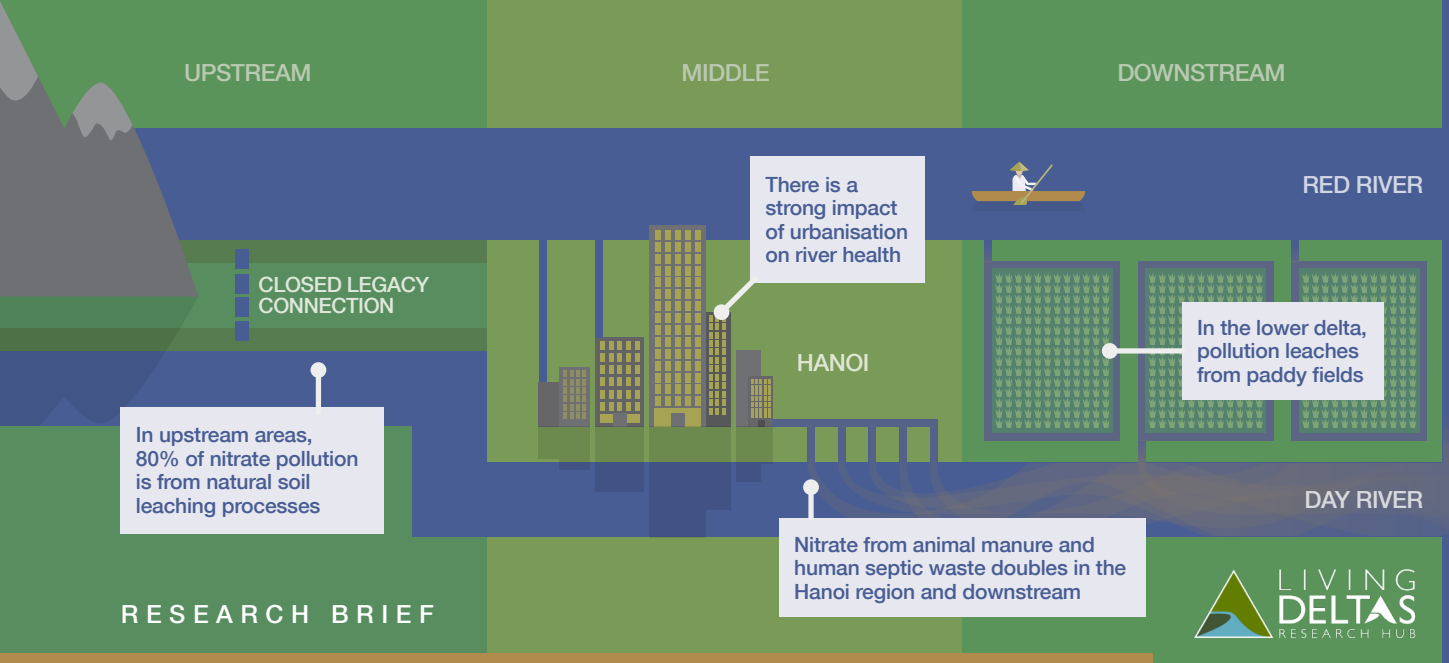
Albeit at a smaller scale, Ledgy has decided to invest its climate budget along similar principles. After a rigorous evaluation process, Ledgy has decided to buy carbon removal credits from $SeaO_2$ as a first investment. Why? It's simple: 24% of all global carbon emissions are bound up in our seas and oceans. Additionally, the concentration of carbon in the ocean is more than 150 times higher than in the air, making oceanic carbon capture technology a potent weapon in the fight against climate change.

$SeaO_2$'s carbon capture technology could offer a new route to oceanic carbon capture at scale. $SeaO_2$'s first prototype, which has the capacity to extract one ton of carbon dioxide per year, launches in the North Sea this month. The prototype is just a stepping stone: the next "pilot plant" - which will be able to extract 250 tons of carbon per year - is on track to launch by the end of 2023.

In recent decades, disruptive startups have turned many industries upside down by reinventing established ways of working. We are confident in the potential of oceanic carbon capture and CRCs, more generally, in helping the push towards net zero. Companies thinking about funding and financing new climate innovations should look at CMC Company and the startups building carbon removal technology as part of a balanced and effective emissions reduction strategy. The world needs more startups thinking differently about commercializing technologies, and in turn, they need forward-thinking early customers ■

PHẠM ĐÌNH

(Source: Euronews)



RESEARCH BRIEF

LIVING DELTAS RESEARCH HUB

livingdeltas.org

Nitrate Pollution in the Red River Delta

Project supported by:

Newton Fund

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BGS British Geological Survey

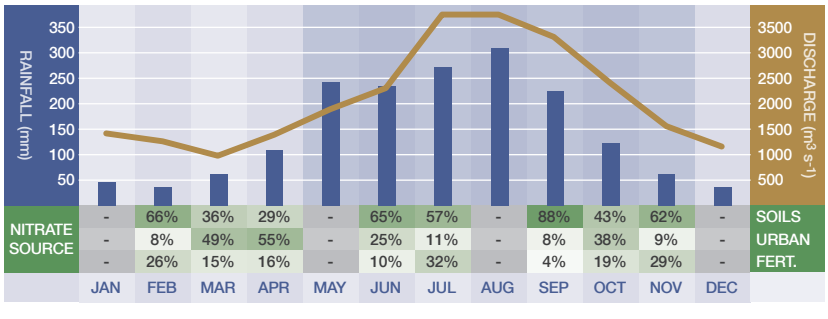
University of Nottingham UK | CHINA | MALAYSIA

The Red River Delta is home to the capital of Vietnam, Hanoi. The large population relies on the catchment for the provision of primary water resources for its industry and agriculture. This critical reserve is rapidly becoming impacted by anthropogenic activities and we demonstrate how nitrate pollution, in particular, is influencing the health of the Red River Delta.

Dominant sources of nitrate in the Red River Delta

1. **Natural soils** originating in upstream regions of the river
2. **Manure** and **septic waste** from animals and humans
3. **Chemical fertiliser** in regions where **rice paddy fields** dominate

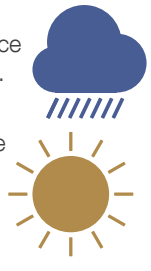
Seasonal changes linked to monsoon season



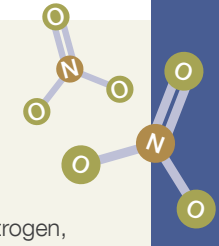
NITRATE SOURCE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SOILS	-	66%	36%	29%	-	65%	57%	-	88%	43%	62%	-
URBAN	-	8%	49%	55%	-	25%	11%	-	8%	38%	9%	-
FERT.	-	26%	15%	16%	-	10%	32%	-	4%	19%	29%	-

As well as a spatial trend in the source of nitrate pollution in the delta (both Red and Day rivers) we also see a seasonal change in the source and amount of pollution, linked to the monsoon season (May to Nov).

During the dry season, manure and septic waste contributes 50% of nitrate contamination in the middle and lower reaches of the delta, due to poor waste management. We therefore see a strong impact of urbanisation on these river systems, which is reducing the health of the rivers via decreasing oxygen concentrations.



What is nitrate and where does it come from?



Nitrate, is a compund of nitrogen, that is essential for plant growth. Via the addition of chemical fertilisers and poor waste water treatment, more nitrate has been entering water courses. This has been increasing with population growth, impacting the global nitrogen cycle.

What are its impacts?

The addition of nitrogen to the environment leads to a process called euthrophication. Eutrophication is the addition of nutrients to water courses and the excessive biological production that it stimulates. This can be detrimental to water quality.

Recommendations

Authors: Virginia Panizzo, Do Thu Nga & Trinh Anh Duc with: Andrew Smith, Melanie Leng, Suzanne McGowan, Thi Thu Trang Ngo, Thi Nguyet Minh Luu, Ioannis Matiatos, Thi Thao Ta
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Pumping in dry season

The Day River system is most vulnerable to nitrate pollution in the dry season, due to the lower water levels. We recommend the pumping of less-polluted water from the Red River system to the upstream sections of the Day River in dry periods to dilute pollution in this stream.

Re-establish natural links

The redistribution of water to the Day River system will also provide greater water resources for paddy field irrigation of the spring crop. This will re-establish the natural linkages between the two main streams of the Red River Delta.