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Assessment of Stocks and Extraction/ Production potentials of Sustainable Alternative sources to River Sand

Working togther toward sustainable sand mining and management.

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IKI INTERNATIONAL CLIMATE INITIATIVE

Activity

Assessment of Stocks and Extraction & Production Potentials of Sustainable Alternative Sources to River Sand

Project

Drifting sands: Mitigating the impacts of climate change in the Mekong Delta through public and private sector engagement in the sand industry

WWF-Viet Nam

Consultant
VIET NAM INSTITUTE OF BUILDING MATERIALS

Ausgust 2023

The report **Assessment of Stocks and Extraction & Production Potentials of Sustainable Alternative Sources to River Sand** is conducted by the Viet Nam Intitute of Building Materials (VIBM). It reflects the outcomes of activities carried out within the Project *Drifting Sands: Mitigating the impacts of climate change in the Mekong Delta through public and private sector engagement in the sand industry* (IKI SMP), as well as the expertise of VIBM.

The IKI SMP project is overseen by the Viet Nam Dyke and Disaster Management Authority, Ministry of Agriculture & Rural Development (VNDDMA) and the World Wide Fund for Nature in Viet Nam (WWF-Viet Nam), funded by the German Government's International Climate Initiative (IKI). While the report presents research findings, it does not necessarily represent the official stance of VNDDMA, IKI, or WWF-Viet Nam.

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Index

Index

Abbreviations

Abbreviations	
VIBM	Vietnam Institute of Building Materials
VMD	Vietnam Mekong Delta
HCMC	Ho Chi Minh City
BFS	Blast furnace slag
SCBA	Sugarcane Bagasse Ash
WWF-Việt Nam	The World Wide Fund for Nature in Vietnam
EPR	Extended Producer Responsibility
IBST	Institute of Building Science & Technology

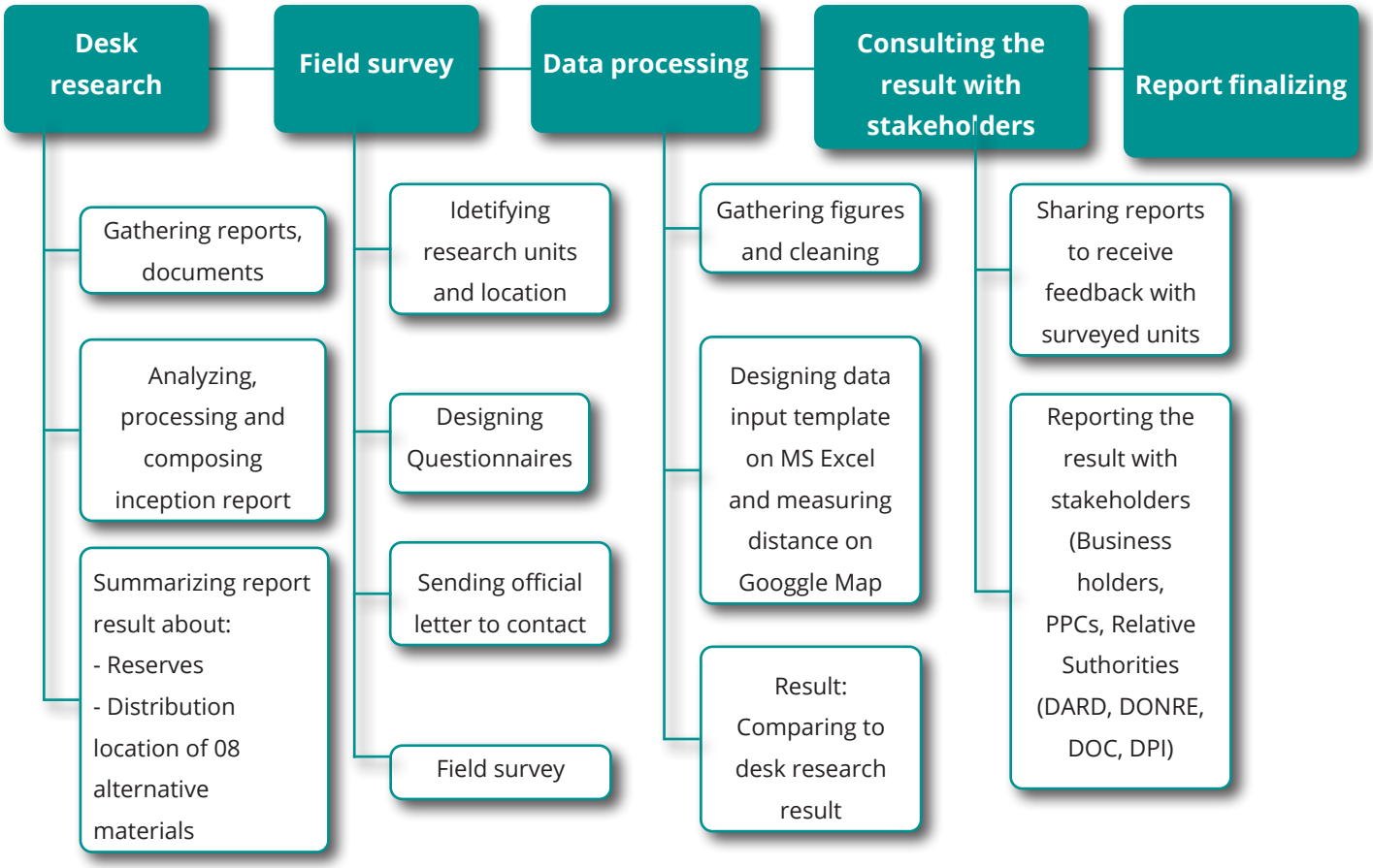
Figure Index

Table Index

SUMMARY

This report is the result of the study "Consultancy service involving an assessment of stocks and extraction/production potentials of sustainable alternative sources to river sand (Lot 1B)" by the Vietnam Institute of Building Materials (VIBM), contracted by WWF-Vietnam. Faced with the current situation of demand for river sand for construction in the Mekong Delta province in general, and Ho Chi Minh City (HCMC) in particular, with strong tendency to increase in the next decade, and the supply of sand rivers are increasingly scarce and depend entirely on the upstream countries of the Mekong River Basin. At the same time, river sand exploitation is limited for many reasons which includes the serious impact to the living environment of residents in the Mekong Delta. Therefore, finding alternatives that can reliably replace river sand is a very necessary and urgent requirement. Results of the previous research on identifying more solid replacement materials for river sand in the South (Lot 1A) have shown 18 types of alternatives, including 08 types that have the potential theoretically, including: M-sand, rice husk ash, sugarcane bagasse ash, recycled concrete, waste glass, blast furnace ash, waste rubber (waste tires) and coal thermal power bottom ash. This is the principle and basis for conducting this study.

Although each type of the above-mentioned alternative has its own distinction, the methodology to evaluate yield/production ability, location, and potential for exploitation for replacing river sand in construction can be briefly summarised in the diagram below. Accordingly, the research team from VIBM conducted a secondary assessment through data collected from reliable documents and reports. Results from this step will help identify the current status of alternative materials development, theoretical reserves/supply capacity, locations to focus on, and main producers/collectors, ... This information will help the consultant team develop a semi-structured questionnaire and develop a survey plan. Next, the group met at the production facility to interview and collect information from the most important actors for each type of alternatives to river sand in the entire South of Viet Nam. At the end of the survey, the results were cleaned and input to Excel, and the distance from the production facility to the consumption place was estimated through Google Maps application. After completing data processing and developing a preliminary report, key findings were presented at consultation events organised by WWF. The figures are sent to manufacturing facilities to confirm data accuracy before finalising the final report. The methodology diagram is as follows:



The consultant team conducted surveys at a number of facilities exploiting and processing crushed stone and M-sand such as: Phuoc Hoa Fico Joint Stock Company, Hung Vuong Construction Company Limited - Binh Phuoc and Dong Nai Branches, Company BMT Production and Trading of Construction Materials (Construction Materials), An Giang Stone Exploitation and Processing Company Limited and Kien Giang Construction Materials Production Joint Stock Company. In general, M-sand products only account for about 10-15% compared to other construction stone products but can completely be possible to increase its production output and flexibly convert between products, implying that M-sand has great potential to replace river sand with large reserves in the medium term. According to desk research, total M-sand production in the southern region is about 2.38 million m^3/year, however, research data at 9 large-scale factories from this study in 5 southern provinces shows that the supply capacity of M-sand is about 5.4 million m^3/year and has not reached the design capacity. The unit price at the mine of M-sand is quite competitive at about 150,000 VND/ton (depending on the quality of the original rock as well as the size of M-sand particles), compared to good quality river sand with satisfactory particle size that can be used for concrete production (250,000 VND/ m^3). However, the biggest limitation is the transportation of M-sand from production facilities to the Mekong Delta provinces, so breakthrough solutions are needed to reduce the time and distance of transporting M-sand from the Southeast to the Mekong Delta provinces. With current traffic conditions, the consultant team recommends that M-sand produced in Ba Ria - Vung Tau, Dong Nai and Binh Phuoc should be

transported to Ho Chi Minh City where the demand for construction materials is highest in the region. M-sand from An Giang and Kien Giang should be considered to transport to serve the needs of the Mekong Delta provinces.

Ho Chi Minh City Urban Environment Company Limited (Citenco) is the largest state-owned company collecting and recycling construction waste in Ho Chi Minh City today. However, after the Covid 19 pandemic and the slowdown of the real estate market, the volume of waste concrete in the city has increased. Barely at Citenco in particular, output has decreased from 1,300 tons/day to 170 tons/day and is almost completely used as backfill material.

Regarding the remains of alternative materials, through desk assessment and field surveys, it was found that the remaining emissions and reserves are not large enough to replace river sand sources, despite the distance from the facilities to the Mekong Delta centre being short (below 100 km) or medium (around 150 km). Besides, most of these materials are being utilised quite thoroughly and bring certain economic value, specifically as follows:

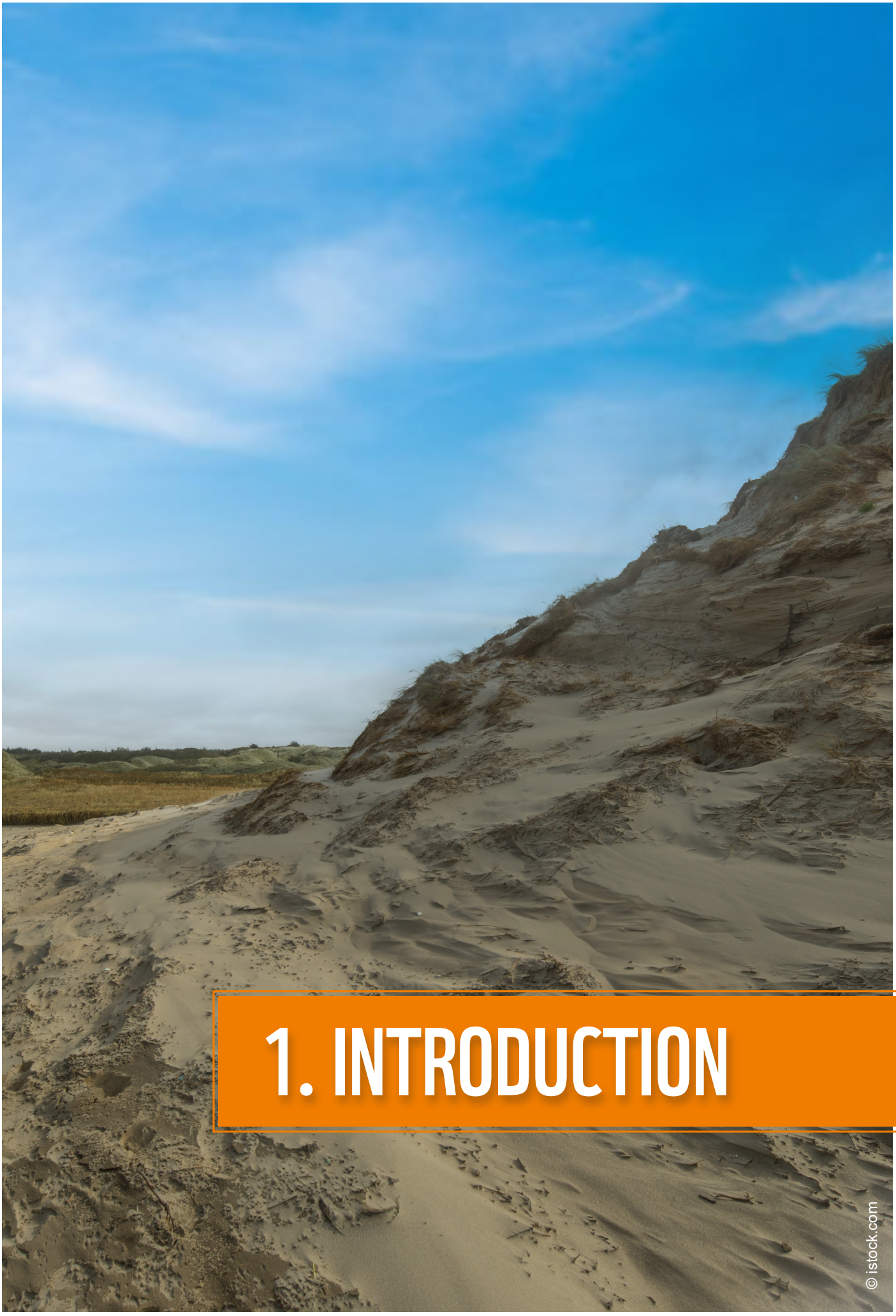
- Rice processing factories generate rice husk ash with a total output of about 14 tons/day but almost all of it is used to produce compost.
- The sugar factory generates sugarcane bagasse ash with a lower yield than theoretical calculations and also uses it all to produce compost. The reason the actual sugarcane bagasse ash reserve is lower than the theoretical estimate is explained by the factory due to difficulties in maintaining the raw material area.
- Waste glass is distributed in small quantities, mainly in Ho Chi Minh and Binh Duong cities. However, only transparent waste glass is purchased by collection units for sale to recycling into recycled glass in China and some neighbouring countries. Although coloured glass is not utilised, according to world research, it can be used in the construction field to produce cement and concrete...
- Blast furnace slag tends to be ground into finely ground blast furnace slag and serves construction materials factories. Currently, blast furnace slag sources are concentrated in Ba Ria-Vung Tau with output as of October 2023 of about 630,000 tons/year, lower than the design capacity of 1 million tons/year. However, this amount of slag has also been completely recycled.
- Waste rubber in the South is only used to produce FO and DO fuels at a price 10-15% lower than traditional fuels. Waste rubber reserves are currently not enough to supply oil production needs.
- Bottom slag at Lee & Man Vietnam Paper Co., Ltd. and Duyen Hai Thermal Power Company meets the quality according to current TCVN standards, however, the remaining reserves are insignificant (about 5%) and mainly used to make internal roads of the factory.

Thus, it can be seen that the most potential material today is M-sand, which was put into use around the world about 50 years ago. Its production technology is available

and with the large reserves, its capacity can be increased to meet current and medium-term sand demand for the South. Meanwhile, the rest of potential alternatives may theoretically be potential but their reserves are small or almost utilised. This result was reported by the consultant team at the RGSPlan Reporting Workshop on December 13, 2023 in Can Tho city which received high consensus from the attending delegates. At the same time, the delegates also proposed further research on the solution of using M-sand as an alternative to river sand in terms of economic, social, environmental aspects... It can be seen that, although the actual results are preliminary, its initial survey result is truly meaningful in finding solutions/alternatives for river sand in the Mekong Delta within construction activities in the VMD and HCMC.

Based on the research results, conclusions about alternative to river sand, recommendations from production facility owners, feedbacks from conference participants and experts, consultant team has a number of proposals to promote study and development of alternative materials in the South in particular, and Vietnam in general, as follows:

- Towards M-sand:
  - Research and edit the current Vietnam standards (TCVN) for M-sand which is no longer appropriate;
  - Research and promulgate economic and technical norms for using M-sand to replace river sand in construction projects, especially projects using state capital investment;
  - Propaganda to change awareness about M-sand so that it can be applied more widely;
  - Analyse cost effectiveness of M-sand production;
  - Issue more sustainable production standards for M-sand in Vietnam;
  - Research appropriate and cost-effective methods of transporting M-sand to the Mekong Delta.
- Waste concrete is a material that is assessed to be potential in the future when high-rise buildings enter the demolition phase.
  - Continue to research the classification and application of construction waste from construction projects, including waste concrete as construction materials.
  - Research and complete technical standards and economic norms for recycling debris for concrete and mortar.
  - Issue a mandatory recycling rate requirement for new projects built with state capital to save natural resources.
- For the rest of materials: Research and compare the technical, economic and environmental aspects of potential alternatives to river sand in the direction of utilising the current and using it as a construction material.



1. INTRODUCTION

1.1 Background

Vietnam's Mekong Delta has an area of about 40,548 km2 including 13 provinces, is home to about 17.804 million people and accounts for about 18% of the country's GDP. With an extremely low average altitude of about 0.8 m above sea level, the Mekong Delta is also one of the most vulnerable places to sea level rise due to climate change. The construction of hydroelectric dams and sand mining to supply booming construction activity have reduced the average annual total sediment load of the Mekong River at Kratie (Cambodia) by about 77%. Regarding sand mining in the Mekong Delta, the demand for sand as construction materials in the Mekong Delta is increasing to develop the infrastructure network for the Mekong Delta. According to data from the Ministry of Natural Resources in 2023, in the 2021-2025 period alone, about 47.81 million m^3 is needed in the Mekong Delta region while river sand resources have been licensed for exploitation (64 licences) with a total reserve of about 47.81 million m^3. 80 million m^3, exploitation capacity of about 17 million m^3/year (of which 14 million m^3 of sand is levelled). However, the current levelling sand reserve is only about 37 million m^3, meeting about 70% of demand. This leads to key expressway projects facing delays due to lack of filling sand. On the other hand, in the coming time, highway projects will be deployed simultaneously, plus 16 important projects just approved by the government in 2023, causing a huge demand for sand materials in the next decade.

However, the development of river sand mineral resources in Vietnam is in the early stages. In fact, M-sand has been used since the late 90s of the twentieth century, in some northern mountainous provinces, to make mortar, plaster, low-grade concrete and unburnt brick production, but in low volume. In recent years, according to VIBM's survey study, the production and consumption of M-sand across the country has increased but only reached about 50% of the total designed capacity (8.6 million m^3/year) [1]. In which, the main users of M-sand are concrete structure factories and commercial concrete mixing plants, while civil and state-funded projects do not use commonly M-sand yet, although Vietnam has issued standards on M-sand for concrete and mortar (TCVN 9205:2012: M-sand for concrete and mortar); At the same time, there are also technical guidance documents for the production and use of M-sand such as TCVN 9382:2012 (technical instructions for selecting concrete ingredients using M-sand)... The reason is said to be the lack of material norms for concrete and mortar using M-sand, thus, organisations and businesses do not have a basis to establish and manage construction investment costs. In addition, there are many concerns about the quality of M-sand due to uncontrolled technology used in producing M-sand.

Rice husk ash is a byproduct from rice production/processing factories. And since the early 2000s, rice husk ash has begun to be collected and sold to ornamental and vegetable farmers in Hanoi. To date, in the southern provinces, this material is still only used as fertiliser, with the output calculated according to statistical data at about 1.9 - 2.7 million tons [2], [3], [4], [5]. Although there has been a standard issued (TCVN 8827:2011 "Highly active mineral admixture for concrete and mortar -

Silica Fume and finely ground rice husk ash") related to this material, its application as a material Construction is only stopping at research. Similarly, there have been many studies and tests of waste concrete as construction materials and related standards have been issued such as: TCVN 11969:2018 - Large recycled aggregate for concrete; or TCVN 13694: 2023 – Recycled aggregate from construction solid waste for urban road foundation - Technical requirements and test methods. This type of waste arises from construction projects; Survey activities, renovation, demolition, repair, construction... and construction waste accounts for about 10 - 12% of the total amount of urban solid waste [6]. The main application of this material is still as a sub-surface layer for levelling materials because the classification at source is not good so construction waste is mixed with concrete, bricks, mortar, etc.; leading to low quality of recycled aggregate. In addition, we do not have price subsidies (inputs) large enough to enable the price of recycled aggregate to be attractive compared to river sand. The concept of waste concrete first appeared in TCVN 6705:2009, and since then there have been many studies on its use as a construction material. However, in the South, Ho Chi Minh City has the highest construction and demolition density rate, and is lacking levelling materials, this type of waste seems to be obviously used for this purpose but does not even meet the demand. Therefore, up to now, waste concrete is still only used as filling material.

Meanwhile, blast furnace slag (BFS) is created from the process of producing cast iron, finely ground blast furnace slag is a product of blast furnace slag grinding. According to VIBM's survey results, by 2020, there were 8 iron and steel factories with blast furnaces in operation, including a BFS processing factory in Ba Ria-Vung Tau. Bottom slag is waste from factories that burn coal, and there are large-capacity factories such as Duyen Hai Thermal Power Plant and Lee & Man Paper Factory in the South that came into operation from 2015 & 2018, respectively. Although these materials have a short history, up to now there has been a lot of research and practical application in the production of construction materials, as well as relevant TCVNs being issued.

In contrast, up to now, Vietnam has had almost no or very little research on sugarcane bagasse ash, waste glass and waste rubber used as construction materials, and there are no relevant standards announced. Sugar mills were established during the French colonial period, but when the country was unified, a number of modern sugar mills began to be built in the South and sugarcane bagasse ash (SCBA) was considered the final waste in the sugarcane production line. Until now, this waste has always been used as fertiliser. The market and glass production/consumption output in the South is considered to be the largest in the country, thus, it is expected that the amount of waste glass will be large in this area, especially in Ho Chi Minh City and Binh Duong- home to the largest float glass industry in Vietnam (established in 2001). However, according to collection units, the output of this type is not large as they are almost always collected and exported to China and neighbouring countries for the purpose of recycling into recycled glass products. Regarding waste rubber, one of the first studies and applications was by Dr. Ngo Quang Minh [7] who researched

and built a facility to process waste rubber into simple tiles around 2004. In the South, in 2008, Dr. Mai Ngoc Tam (VIBM) succeeded in researching the technology of pyrolysis of waste rubber into DO industrial oil [8]. Then, since the 2010s, the technology of pyrolysis of tires and other waste derived from old rubber into FO & DO has arrived [66]. In recent years, in Southern Vietnam, old tires are mainly used in FO & DO production.

To support finding alternatives to river sand in the Mekong Delta, in 2022, WWF-Vietnam collaborated with THP Engineering SRL to conduct an assessment to find more sustainable materials to replace river sand in the South. Research results show that there are about 18 types of materials that feasibly replace river sand in a more sustainable way for different uses (concrete, mortar, brick production, sidewalk paving, levelling, etc.) ...) in the construction industry with replacement rates ranging from 5-100% depending on the type of replacement material. In particular, among these 18 types of alternatives, slag from rice husk ash, sugarcane bagasse slag, and M-sand are available sources in the Mekong Delta as described in Table 1.

#	Application	Alternative materials and replacement rate (%) to river sand	Potential alternative in Mekong Delta
1	Production of traditional concrete	Rice husk ash slag (30%), Foundry sand (20-30%), Sugar cane bagasse ash (20-30%), Copper slag (50%), Blast furnace slag granules (40-60%), Furnace bottom slag (30 -50%), Fly Ash (50%), Geopolymer Fly Ash Sand (100%), Stone Powder (50%), Granite Powder (30%), Marble Set (10%), Scrap Glass (10-20%), Foundry Slag (25%), Waste	Rice husk ash, sugarcane bagasse slag, kiln bottom slag, and fly ash are alternative materials with significant potential in the Mekong Delta.
2	Production of brick	Rice husk ash (30%), Fly ash and Furnace bottom slag (30%), stone powder (100%)	Slag from milled rice husks and ash and slag from operating thermal power plants can replace river sand in brick production.

#	Application	Alternative materials and replacement rate (%) to river sand	Potential alternative in Mekong Delta
3	Production of self-compacting concrete	Foundry sand (30%-48mPA), Sugarcane bagasse ash (20%), Scrap glass (5-15%), Foundry slag (25%), Rice husk ash (25%),	Sugarcane bagasse ash and rice husk ash
4	Production of high strength concrete	Copper slag (40%), Stone set (20%), Scrap rubber (30%)	Scrap rubber can be used in saltwater environments and seaport projects
5	Paving the sidewalk	Furnace bottom slag (100%), fly ash (30%), stone powder (30%), scrap glass (70%), scrap rubber (12.5%),	Scrap rubber: Sidewalks, concrete highway floors and highways, tunnels and spillways with 25% NaOh
6	Mortar production	Fly ash (60-70%), Marble set (20%), Scrap glass (20%)	Fly ash from operating thermal power plants can be used to produce mortar
7	Making mulch for waste landfills	Rice husk ash (50-60%), Scrap glass (100%), Scrap bricks (50-100%), Fly ash (50-80%), Construction scrap (50-100%),	These materials can be used from local sources in the Mekong Delta.
8	Making road base	EAF Slag (100%), Blast Furnace Slag (100%), Construction Scrap (100%), Artificial Sand (100%), Foundry Sand (50-100%)	

Table 1. List of potential alternatives to river sand in construction in Mekong Delta

1.2 Study objectives

The objective of this study is to evaluate the potential of sustainable alternatives to river sand to meet the growing demand for construction and filling materials in the Mekong Delta, Dong Nai basin and Ho Chi Minh City.

A previous study identified 18 agricultural, industrial, construction and other wastes suitable as alternatives to river sand in Southern Vietnam. The objective

here is to analyze the reserves or available volumes of the following alternative sources and materials:

- M-sand,
- Rice husk ash slag,
- Sugarcane bagasse ash,
- Recycled concrete,
- Waste glass,
- Blast furnace slag,
- Waste rubber (waste tires),
- Furnace Bottom slag

The results and recommendations from this study will be used to provide evidence to call for change in sourcing practices within the construction sector and in related policies.

1.3 Scope of study

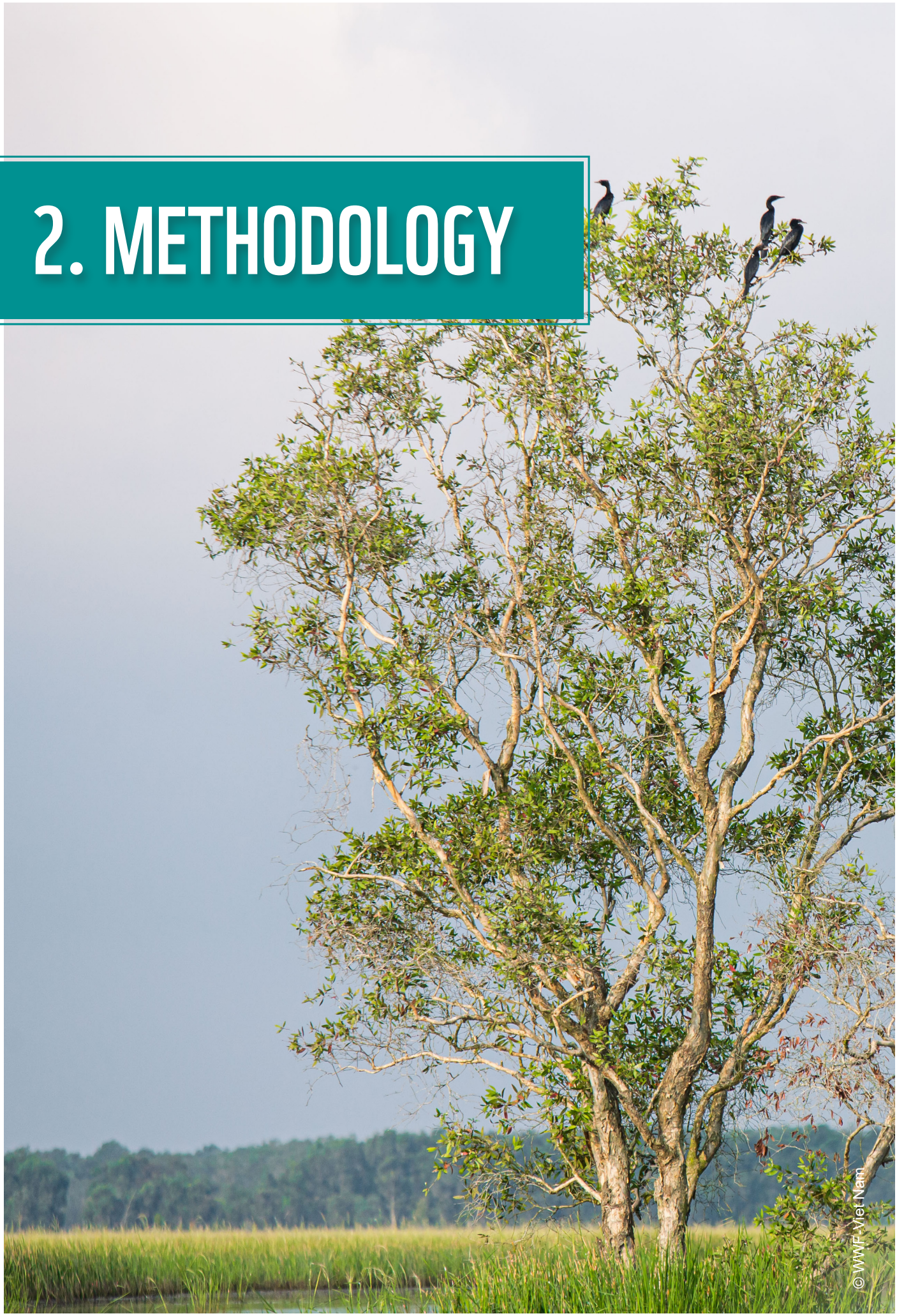
Regarding the scope of the study, the survey and assessment will be carried out on 08 alternatives to river sand including M-sand, rice husk ash, sugarcane bagasse ash, recycled concrete, glass waste, blast furnace slag, waste rubber (waste tires) and coal thermal power bottom ash. The study conducted an assessment of the reserves, distribution locations, and replacement potential of these alternatives in the South of Vietnam to replace river sand in construction and levelling in the Mekong Delta and HCMC.

1.4 Structure of the report

Based on the objectives, general methods and scope of study just mentioned, the expected structure of the report "Consultancy service involving an assessment of stocks and extraction/production potentials of sustainable alternative sources to river sand (Lot 1B)" includes the following main parts:

- Overview/introduction. This section briefly introduces and states the reason for the creation of the study.Methodology. This section will cover a general method for evaluating alternative materials both indirectly and directly.
- Analyse data, results and discuss. This section will analyse the results collected from the survey process.
- Recommendations from basements. This section addresses the recommendations of manufacturers regarding alternative material sources for river sand.
- Conclusion and suggestions.
- References.
- Appendix.

2. METHODOLOGY



2.1 General methodology

The purpose of this study is to evaluate the ability to replace river sand in construction and levelling in the Mekong Delta and Ho Chi Minh City with 08 types of alternative materials that are more sustainable in terms of reserves or available quantity. location, accessibility, quality (if feasible) and exploitation potential. The methodology is described generally according to Figure 1 below:

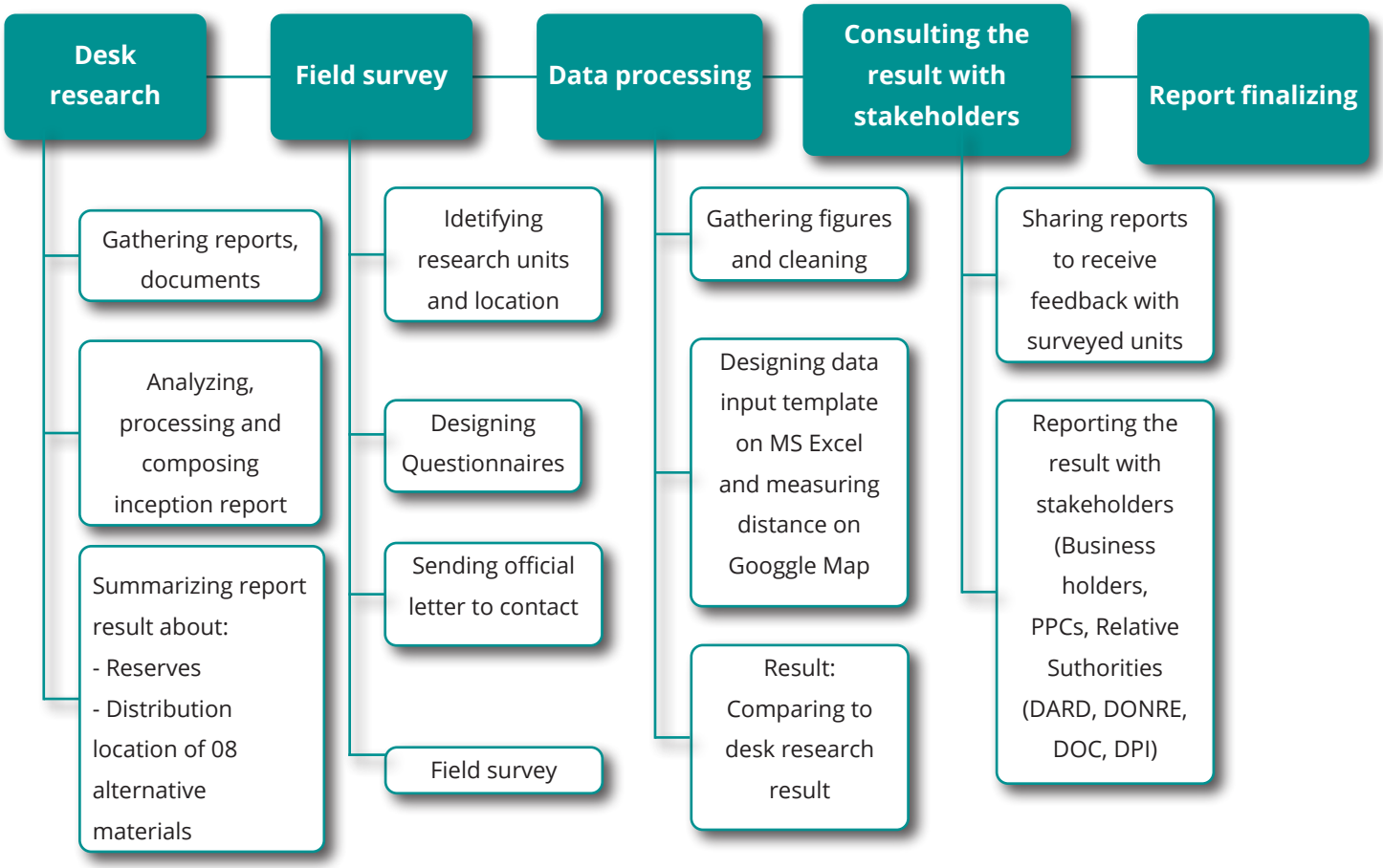


Figure 1. Diagram depicting the methodology for performing the evaluation of alternative materials

aspects depends much on the characteristics of each type of material, for example, it is possible to evaluate the reserves of rubber or glass waste directly, but to evaluate the reserves of rice husk ash and sugarcane bagasse ash, we must use conversion factors and go through data on rice/rice production, sugarcane production in the South, etc. In general, to evaluate the replaceability of any alternative material in the list of 8 types above, we need to follow these steps:

- **Step 1. Desk research assessment.** Through this step, the consultant team collects and synthesises relevant documents, reports, etc. Next, we analyse and process data to provide initial results on reserves, distribution locations and utilisation directions of these 8 types of materials in Vietnam up to the present time. The results from step 1 provide crucial direction for the field survey in the next step. Details of the initial survey results for 08 alternative materials have been mentioned in detail in the inception report.
- **Step 2. Field survey.** The research team identifies this to be the main task of this study. To conduct a field survey, the initial results in the desk

assessment step are considered input data and quite important. The team will identify the location to survey replacement materials based on the results of assessing reserves, distribution locations... in step 1, and will consider surveying replacement materials with sufficiently large and concentrated reserves in some typical provinces and cities in Southern Vietnam. Next, we proceed to design semi-structured questionnaires to serve the survey process (semi-structured questionnaire file attached to this report), noting that the questionnaire had been commented on by WWF-Vietnam. After that, the consulting team sends an official letter and discusses with production and processing facilities about the intention and purposes of the survey. Once approved, a survey would be conducted based on questionnaires to synthesise and process data later.

- **Step 3: Process survey data.** Within the scope of this study, the authors believe that the input data (reserves, distribution locations...) are small and unfocused, thus, data processing will not be able to use specialised software, but to look into qualitative data analysis through the use of Excel software with some simple calculation functions (designed file for calculating field survey data attached to the report). On the other hand, to identify the distance from the distribution location of alternative material sources to the consumption place, which is the centre of the Mekong Delta provinces and Ho Chi Minh City, the team uses Google maps application to measure the distance relatively and accurately as input to the matrix table. This allows the policy makers to consider and decide the feasibility of transporting the alternatives to consumption sites. However, world experience recommends that carbon emissions and mitigation solutions should be considered when the transportation distance from the source to the consumer is greater than 100 km.

During field surveys of M-sand at processing plants, the calculation of remaining mine reserves is quite important, related to assessing the potential for future exploitation of M-sand materials. The formula design to calculate potential M-sand output as follows:

Data of	Licence period for exploitation, years	Years of exploitation, years	Mining capacity, tons/year	Remaining mine reserves, tons	Density of crushed M-sand, %	Output of M-sand that can be exploited in the future, tons
Clarification	Included in the company's "Mineral Exploitation License"	Calculated from the year the exploitation licence was granted	Calculated relative to design capacity		Ratio of M-sand compared to other products	Comparatively, because most have the flexibility to change product ratios
Formula	(1)	(2)	(3)	(4) = [(1)- (2)] x (3)	(5)	(6) = (5) x (4)
Eg. Phuoc Hoa Fico Joint Stock Company	Licensed to exploit for 28.5 years (from 2019 to 2047)	4.5	1.4 million m3/ year (equivalent to 3.7 million tons/year)	= (28.5-4.5) x 3.7 = 88.8 million tons	10%	88.8 million tons

- **Step 4: Consult research results with relevant parties. T**o increase the reliability of collected data, research results, and participation of relevant parties, survey results are sent to the facilities that conducted the survey to confirm the data and information. In addition, to complete the final report, the team will present implementation results at seminars, workshops, and bilateral meetings organised by WWF-Vietnam, with the aim of receiving feedback and contributions from experts from Universities, Research Institutes, Officials from relevant Departments (Department of Construction, Department of Natural Resources and Environment, Department of Agriculture and Rural Development), Ministries such as the Ministry of Natural Resources and Environment, Construction, ...
- **Step 5: Finalise the final report based on feedback from WWF and other stakeholders.**

Details of the methodology for each material will be presented in the following sections.

2.2 Alternatives to the river sand

2.2.1 M-SAND

The assessment of M-sand on replacement ability was as follows:

Desk research assessment:

The consultant team collected relative data towards the construction stone mines and factories which produce M-sand located within the Southern area, including stone types, exploitation, processing status, and calculation of remaining stones that

can be used to produce M-sand. Some main documents used in this study includes:

- Construction material planning has been implemented by the Southern Institute of Building Materials;
- Scientific articles have been published in domestic and foreign magazines related to M-sand in the southern region;
- Theoretical calculation information from stone reserves in the provinces;
- Information from the Department of Construction of the Southern provinces;
- Quickly assess the locations of potential mines to main consumer markets in the Mekong Delta and Ho Chi Minh City.

Field survey:

Once the list of stone mines and M-sand manufacturers were identified, a list of questionnaires was prepared to serve collecting needed information site, includes questions with main content as follows: Information of the surveyed units (Name, Address, ...); information regarding M-sand producing (producing technology, volume and quality of M-sand, remaining reserve, ...); market (key buyers, unit price, purchasing method, ...); some recommendations from M-sand manufacturers. Then, we consulted with WWF to finalise the questionnaire and survey plan on site.

From data collected by survey, the team input and processed via Excel to process the assessment regarding quality, reserves, market serving feasibility of M-sand types, as well as the summary of proposals from stone mine and M-sand facilities. Finally, the team presented and sent the result to the stakeholders to finalise the study.

2.2.2 RICE HUSK ASH

Similar to M-sand, there was a desk assessment and field survey to research the alternative of rice husk ash, detailed as follows:

- Available reserve or producing potential of Rice husk ash (RHA), as well as its quality, location and approaching feasibility was considered via data from Vietnam Food Association, scientific reports, sources of news, etc. Via these tools, the team was allowed to define the target location to focus on survey
- Designed the questionnaire and build the survey plan
- Used the questionnaire and directly interview the business leaders and factory managers in large-scale rice processing manufactures, regarding capacity, reserve, quality, current status of use and distribution of rice husk ash source
- The assessment of RHS reserve was conducted based on the converted ratios from rice plant, rice, rice husk. In particular, about 20% of rice husks is obtained compared to the total amount of rice processed (milled form rice), and about 18-25% RHA is obtained after burning rice husks [9], [3], [4], [5]

- Contacted the large-scale rice mills for survey plan with the goals to collect data about the surveyed units ((Name, Address, ...); information regarding milling rice (milling technology, input capacity, rice husk and rice husk ash yield, utilisation direction, ...); some recommendations from manufacturers.

2.2.3 SUGAR BAGASSE ASH

The assessment of sugarcane bagasse ash was similar to rice husk ash, detailed as follows:

- Contacted for work and data collection from Sugarcane Association, DARD, published reports, ...
- The assessment of sugarcane bagasse ash reserve was via the conversion from sugarcane and bagasse output following common conversion coefficient in domestic and foreign studies. On average, each ton of sugarcane produces 20% bagasse [10]. This bagasse is often used right at the sugarcane mills as fuel source to generate steam and energy. Final product obtained after burning bagasse is raw sugarcane bagasse ash after burning, one ton of bagasse is estimated to yield 140 – 280 kg of ash [11], [12].
- Contacted the large-scale sugarcane mills for a survey plan with the goals to collect data about the surveyed units (Name, Address, ...); information regarding sugar producing (producing technology, input capacity, sugarcane bagasse and ash yield, utilisation direction, ...); some recommendations from manufacturers.

2.2.4 RECYCLE CONCRETE

- Via satellite images of the Southern, it is shown that only HCMC, Di An and Bien Hoa cities are areas of high construction density. However, Di An and Bien Hoa don't have many high-rise buildings but are mainly expanding construction in width. High-rise buildings (if any) have been newly put into use recently, thus, construction emission from demolition is currently insignificant. Specifically, cities and residential clusters in the Mekong Delta, mostly the geography was formed through sea and river sedimentation, thus, small construction after demolition will be used as levelling and reinforcing materials for on-site foundation strengthening. Therefore, currently only HCMC generates large recycled concrete to be considered for the field survey step.
- Besides, to identify the goals and scale of the survey, the consultant team also used the figures from DONRE's reports, study thesis about the construction waste in HCMC, ...
- Via conducting the above steps, a list of leading companies and units in construction waste collections and processing was identified. Next, the team

developed the questionnaire and contacted them for an interview plan directly with their business leaders.

- Met and discussed with the companies in private and public sectors in HCMC which are running in construction waste demolishing, collecting, transporting and processing to collect data regarding the emission volume, recycling feasibility, price, and recycling goals.

2.2.5 WASTE GLASS

- The source of waste glass, large emission facilities, and waste glass market in the South was identified via study reports and information from different sources. Then, the consultant team identified the emission and collection facilities needed to be surveyed. Finally, we developed the questionnaires and field survey plan.
- The team interviewed scrap glass collectors and considered meeting with the Glass Packaging Institute if possible. The survey content focused on information: recycling output, current utilisation direction of this type of waste and recommendations from facilities.

2.2.6 BLAST FURNACE SLAG

- Accessed sources of investigation reports and research projects on blast furnace slag (BFS) conducted by the Institute of Building Materials and other organisations to collect information on sources of blast furnace slag emissions in Vietnam.
- Quick assessment of BFS emissions from emission sources, infrastructure and transport capacity of BFS sources to the Mekong Delta region.
- Based on the results from the desk assessment, the team determined the blast furnace slag survey point at the blast furnace slag grinding facility in southern Vietnam. The survey content revolved around some information such as production technology; blast furnace slag output; current recycling status, main output products, transportation methods, ...

2.2.7 WASTE RUBBER

- Secondary research results show that there are actually a number of factories that burn coal and generate bottom slag in the South. Thereby, a number of factories that generate large quantities of waste can be selected.
- Next, the team conducted a theoretical estimate of the amount of bottom slag emitted based on data on coal burning technology, quality of coal used, and number of operating hours/year. Depending on the burning technology, the ratio of fly ash/bottom slag will be different. On average, the proportion of fly

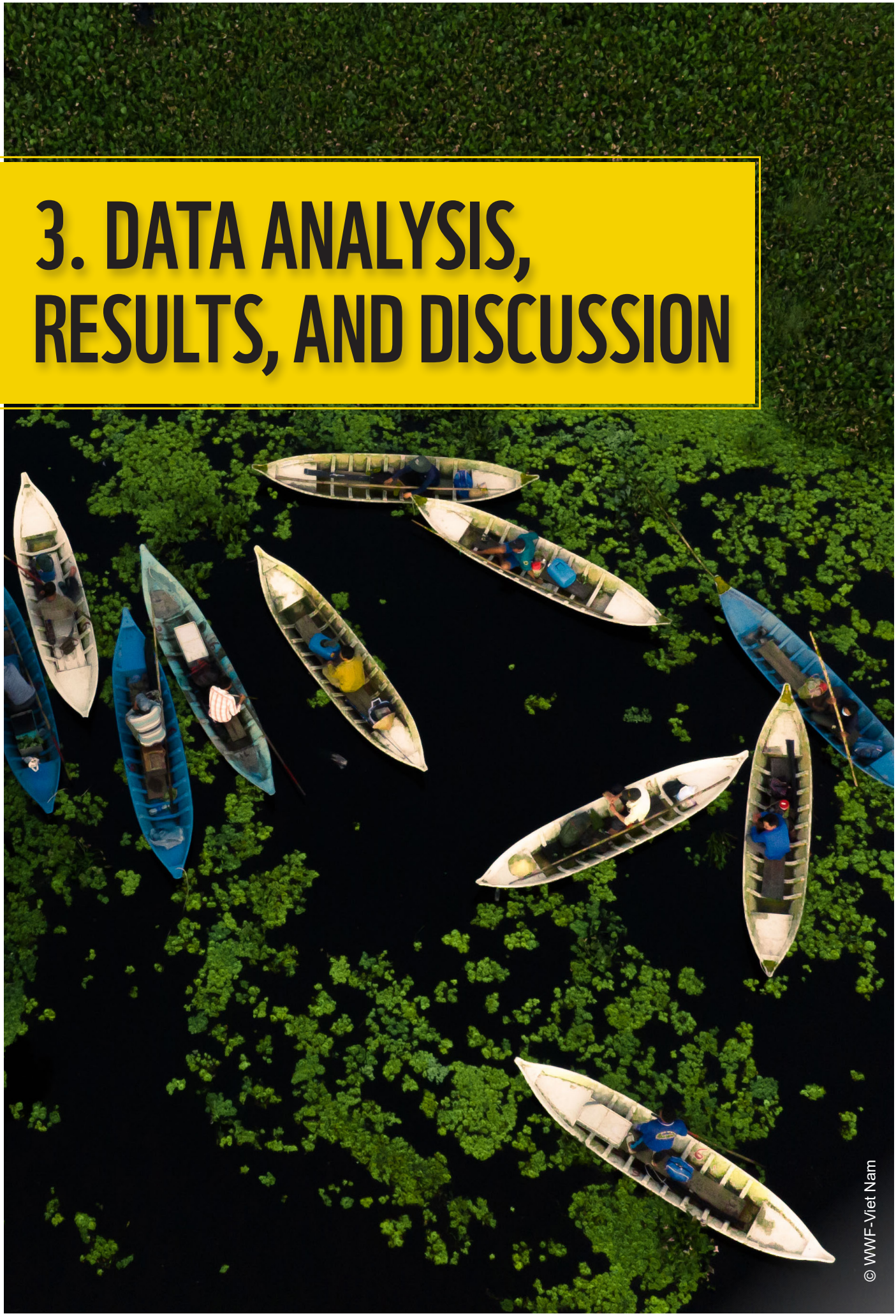
ash accounts for 80 ÷ 90%, bottom slag accounts for 10 ÷ 20%. To calculate the annual amount of bottom slag generated, this study is based on the list of coal-fired thermal power plants operating in Southern Vietnam as of 2023 and the following assumptions:

- The average number of operating hours per year for factories is 6,000 hours.
- Domestic coal has an average ash level of 30%, coal consumption rate is 0.55 kg/kWh. (according to data collected from Duyen Hai thermal power plant in Tra Vinh).
- Imported coal has an average ash level of 8%, coal consumption rate of 0.5 kg/kWh (according to data collected from Duyen Hai Thermal Power).
- The rate of fly ash/bottom slag generation is 90/10% for spray coal combustion technology and 80/20 %

– After researching and collecting information related to bottom slag sources in the southern region of Vietnam such as: number of factories in operation, factory location, design capacity, type of coal burning technology used... the team selected survey locations at a number of thermal power plants and paper factories with coal burning activities. The questionnaire focused on a number of issues: information about the survey unit; main product; amount of coal used; amount of bottom slag generated; Current status of bottom slag; form of transfer/consumption of bottom slag; Method of transporting bottom slag.

– From the survey information, the implementation team calculated and compared with the indirect assessment results, thereby making assessments on the quality, reserves, and ability to supply bottom slag products to the market.

3. DATA ANALYSIS, RESULTS, AND DISCUSSION



3.1 M-sand

According to survey results in the previous research of the Institute of Building Materials, as of December 2019, M-sand production nationwide reached more than 4.1 million m^3/year, reaching about 50% of design capacity [1]. Among them, the Southern provinces have great potential for producing M-sand and are close to the largest consumption markets, including Ba Ria - Vung Tau (1.5 million m^3/year), Dong Nai (0.58 million m^3/year). year), Binh Duong (0.2 million m^3/year), An Giang (0.1 million m^3/year), Kien Giang (0.1 million m^3/year) [1]. These provinces all have large reserves of construction stone resources, capable of expanding the scale of M-sand production capacity to supply provinces, cities in the Mekong Delta and HCMC.

Results of actual surveys on reserves, supply capacity, distribution locations, M-sand quality, and prices within the framework of this study as of the end of 2023 at large factories and mines in Southern Vietnam Nam is described in detail in the appendix and summarised in Table 2 below:

#	Surveyed units	Producing capacity (million tons/year)	Sales output, (tons/ month)	Remaining mine reserves (estimated)	Quality of M-sand	Price of M-sand, VND/ton (excluding VAT)
I	**Ba Ria- Vung Tau**					
1	Phuoc Hoa Fico Joint Stock Company	1.44*	30,000	88.8 million tons	- Complies with TCVN 9205 standard - Complies with QCVN 16/BXD regulations	160.000
2	Hoa An 1 Stone Company	0.65**	10,000	720,000 m^3 stone in block	- Complies with TCVN 9205 standard - Complies with QCVN 16/BXD regulations	140.000 - 158.000
3	Thanh Tam Joint Stock Company	0.75**	5,000	9.4 million m^3 stone in block	Not yet achieved TCVN 9205	140.000 đ

#	Surveyed units	Producing capacity (million tons/year)	Sales output, (tons/ month)	Remaining mine reserves (estimated)	Quality of M-sand	Price of M-sand, VND/ton (excluding VAT)
II	**Binh Phuoc**					
4	Hung Vuong Construction Company Limited - Binh Phuoc branch	7.2**	25,000-30,000	58.8 million m^3 stone in block	- Complies with TCVN 9205; TCVN 8859 standards - Complies with QCVN 16/BXD regulations	160.000
III	**Dong Nai**					
5	Hoang Hai Company Limited	No*	No	10 million m^3 stone in block	Low quality stone, does not meet the quality when producing M- sand	
6	Branch of Hung Vuong Construction Company Limited	1.8**	60,000 tấn/ tháng	-	Complies with TCVN 9205 standard - Complies with QCVN 16/BXD regulations	165.000
7	BMT Construction Materials Production and Trading Joint Stock Company	1.5**	100,000	174.4 million m^3 stone in block	Complies with TCVN 9205 standard - Complies with QCVN 16/BXD regulations	150.000

#	Surveyed units	Producing capacity (million tons/year)	Sales output, (tons/ month)	Remaining mine reserves (estimated)	Quality of M-sand	Price of M-sand, VND/ton (excluding VAT)
IV	**An Giang**					
8	An Giang Stone Exploitation and Processing Company Limited	60,000 m^3/ năm	5000 tấn/ tháng	485,492 m^3	- Complies with QCVN 16:2019/ BXD regulations	180.000 – 200.000/m^3
V	**Kien Giang**					
9	Kien Giang Construction Materials Production Joint Stock Company	500.000 m^3/năm	40.000 tấn/ tháng	Mine 1: 6,000,000 m^3. Mine 2: 2,341,093 m^3	- Meets quality standards according to ISO 9001:2015. - Kien Giang Department of Construction announced the certificate of conformity.	150.000 – 300.000 đ/ m^3

Table 2. Main information of surveying at M-sand manufacturers in the Southern Vietnam

Notes: * Estimated according to the factory's reported data is 120,000 tons/month

** Estimated production time is 10 hours/day and 1 production year is 300 days.

During the field survey at the M-sand manufacturers, the consultant team was provided with data and reserves of the remaining mines. In fact, this is an estimated number based on calculation of the mine's remaining mining time and allowable design capacity (these figures are all mentioned in the Company's Mineral Mining License). However, some factories do not agree to provide relevant information.

From the results of desk assessments and field surveys at M-sand production facilities/mines, the consultant team has the following comments:

- Most M-sand products only account for about 10-15% compared to other construction stone products such as crushed stone, stone for roads, stone for concrete production and precast concrete structures. However, all surveyed factories said they have the ability to increase M-sand output and flexibly convert between products, fully capable of meeting the market for sand materials. It was also found that whether desk assessment or a field survey all led to this important conclusion.

- According to statistical data collected by the Institute of Building Materials based on the report on Construction Materials Development Planning in the Southern provinces to 2020, with a vision towards 2030 implemented in 2019, the total production of M-sand in the southern region is about 2.38 million m^3/year. However, based on data at the surveyed factories, the output of M-sand capable of supplying to the market is 13.88 million tons/year. If converted to a unit of m^3 with the density of M-sand being about 2.7 tons equivalent to 1 m^3 (depending on the quality of the original rock), the ability to supply M-sand is about 5.4 million m^3/year, more than 2 times the reserves according to previous statistical reports.
- Branches of Hung Vuong Construction Company Limited in Dong Nai and Binh Phuoc are the leading unit in M-sand production in the South.
- Most factories have modern M-sand production equipment systems, using vertical VSI crushers (Vertical shaft impacts) technology. Some units also invest in a second sand washing system using British cyclone technology (such as Hung Vuong Construction Company Limited - Binh Phuoc and Dong Nai Branches), ensuring the quality of M-sand meets the requirements when used in concrete products, concrete structures...
- 100% of the surveyed production facilities have systems to treat and recirculate wash water. Dust, mud, and clay after washing the sand are filtered, pressed into slabs, and packed into cakes to be used as levelling material.
- The unit price of M-sand at the mine is about 150,000 VND/ton, depending on the quality of the original rock as well as the modulus of M-sand.
- Transportation of M-sand within a range of less than 100 km is mainly by road, longer distances are transported through intra-provincial ports and to other provinces by barge.
- The main consumers of M-sand are concrete mixing plants (for example, mixing plants in Binh Phuoc, Bau Bang (Binh Duong)), precast concrete structure factories (for example, Cong Phuoc's factory). Viet Han Concrete Company, factory of Mekong No. 1 Construction Investment Joint Stock Company...), or self-production and self-consumption in concrete factories (for example, Hung Vuong Construction Construction Company Limited -Binh Phuoc Branch).

According to the comments just mentioned, M-sand has been utilised in concrete production and is capable of meeting the river sand market in terms of output, or in other words, this is a very potential river sand alternative. Therefore, the implementation team conducted a further assessment of the relative distance from M-sand production facilities to the centres of provinces and cities in the Mekong Delta and Ho Chi Minh City. Detailed as in Table 3 below:

TT	Southern provinces	HCMC	Long An	Tien Giang	Can Tho	Ben Tre	Vinh Long	Tra Vinh	Dong Thap	Soc Trang	An Giang	Kien Giang	Hau Giang	Bac Lieu	Ca Mau	Average distance, km
	M-sand production facilitíe/ mines	District 1	Tan An city	My Tho city	Can Tho city	Ben Tre city	Vinh Long city	Tra Vinh city	Cao Lanh city	Soc Trang city	Long Xuyen city	Rach Gia city	Vi Thanh city	Bac Lieu city	Ca Mau city	
I	Ba Ria- Vung Tau															
1	Phuoc Hoa Fico Joint Stock Company	60	103	127	222	143	185	182	205	275	244	294	263	323	362	200
2	Hoa An 1 Stone Company	85	161	179	232	195	195	211	214	286	253	306	273	332	371	220
3	Thanh Tam Joint Stock Company	75	120	128	269	145	185	202	205	276	244	294	264	323	363	207
II	Binh Phuoc															
4	Hung Vuong Construction Company Limited - Binh Phuoc Branch	120	175	193	288	209	251	248	243	341	282	331	329	361	411	253
III	Dong Nai															
6	Branch of Hung Vuong Construction Company Limited	47	95	113	208	129	170	168	190	261	229	279	249	304	348	187
7	BMT Construction Materials Production and Trading Joint Stock Company	48	96	114	209	130	172	169	191	262	230	281	250	305	349	188
IV	An Giang															
8	An Giang Stone Exploitation and Processing Company Limited	243	200	191	115	207	133	198	101	177	58	60	117	192	239	150
V	Kien Giang															
9	Kien Giang Construction Materials Production Joint Stock Company	266	253	216	146	260	167	219	126	187	83	30	98	237	154	167

Table 3. Estimate the distance from the M-sand production facility to the Mekong Delta and Ho Chi Minh City

Notes: The relative distance is determined based on the Google maps software/ application, the unit is km, and is the distance from the production facilities to the centre of the provinces/cities in the Mekong Delta and HCMC.

Through estimating the distance just mentioned, it is found that:

- Transporting M-sand from production facilities in Ba Ria - Vung Tau, Dong Nai or Binh Phuoc to Ho Chi Minh City is quite close, generally less than 100 km (except Binh Phuoc). This is the market with the largest demand for river sand in the South.
- On the contrary, the distance to bring M-sand from the Southeast provinces to Ca Mau is the furthest which is over 300 km, and to Can Tho (nearly 200 km).
- Besides, if M-sand from An Giang and Kien Giang is brought to neighbouring provinces (less than 50 km) or the centre of the Mekong Delta with only a distance of less than 150 km.
- On average, the distance transporting M-sand from the above survey facilities to the Mekong Delta is approximately 200 km.

Thus, M-sand in the southern region is completely capable of replacing river sand in terms of reserves. However, it is necessary to consider the plan of transporting M-sand at production facilities to the Mekong Delta provinces and HCMC appropriately as a big question that needs to be resolved.

3.2 Rice husk ash

According to the results of the desk assessment, large-scale rice processing facilities in the Mekong Delta are concentrated in provinces such as Long An, An Giang & Dong Thap. Among them, there are many large-scale rice processing factories belonging to Loc Troi Group.

According to another survey, the amount of rice husk waste in the Mekong Delta is about more than 3 million tons/year, but only about 10% of it is used. Rice husk ash is often not used up and it must be burned or dumped into the river for destruction [13].

The consultant team has conducted field surveys at rice milling and processing factories in Long An, Dong Thap, and An Giang. The detail is as described in the below Table 4:

#	Survey content	Vinh Hung Food Company Limited	Tan Hong Food Company Limited	Vinh Binh Food Company Limited
1	Location	Long An	Dong Thap	An Giang
2	Raw material source in use	Buy more from outside 5-10%	Buy more fresh rice from farmers 70-80%	Buy more from farmers 30-40%
3	Input rice capacity	Drying capacity is about 100-1200 tons of fresh rice/ day, milling about 400 tons of dry rice/ day	Drying about 1000 tons of fresh rice/day; milling about 450 tons of dry rice/day.	About 17 thousand tons of dry rice/year (average about 1400 tons/month)
4	Rice yield	Approximately 320 tons/day	Approximately 360 tons/day	Approximately 1120 tons/month
5	Converted to initial rice husk yield	80 tons/day	90 tons/day	252 tons/month
6	Rice husk status	Burning (50%), the remaining part is sold to outside	80% of rice husk is sold to outside, the remain of it is used in company's dryer	30% used in rice dryer (about 76 tons/month), the remaining part is sold to outside
7	Output of rice husks sold	Approximately 40 tons/day	Approximately 72 tons/day	176 tons/month
8	Rice husk ash yield	Approximately 8 tons/day.	Approximately 3,2 tons/day.	45-50 tons/month
9	Rice husk ash status	60-70% sold to make compost	All is sold to make compost	All is sold to make compost
10	Distance to Can Tho city	206 km	144 km	111 km

Table 4. The survey result at rice mill and processing factories

Actual survey result shows that the three factories have very large capacity compared to the remaining factories in the area. The average rice milling capacity is 400-450 tons/day, of which the total amount of rice husk accounts for 18-20% of the total amount of rice milled (average 80-90 tons/day). About 20-50% of the generated rice husks are reused on site by factories for drying fresh rice, the rest is sold to other

units to use for purposes such as making boiler fuel, dryers, brick kilns, animal feed production, etc. The percentage of rice husk ash obtained after factories burn rice husks in rice dryer is 18-20%, most of that is black ash with low quality. Currently, all of this rice husk ash is sold by factories to make compost and for crop fertilizer which is no longer stored at the factory.

The following are the results of comparing indirectly calculated data and direct investigation data at three rice processing factories in the Mekong Delta, as in Table 5 below:

#	Rice processing facilities	Milling capacity	Amount of rice husk reobtained (tons/day)	Amount of rice husk ash generated (tons/day)		
				According to theoretical calculations	According to direct surveys from this study	Relative ratio
1	Vinh Hung Food Company Limited	400	80	16.0	8.0	0.5
2	Tan Hong Food Company Limited	450	90	18.0	3.2	0.2
3	Vinh Binh Food Company Limited	400	72	14.2	2.8	0.2

Table 5. Comparing indirectly calculated data and direct investigation data on rice husk

**Notes:* The amount of rice husk ash according to theoretical calculations is the amount calculated according to the actual rice input data and the conversion rate to rice husk ash as just mentioned, while the amount of rice husk ash according to the survey is the actual number provided by the factory.

The data table above (Table 5) shows that the average rice husk ash generation rate of large rice processing factories in the Mekong Delta region is 0.3. Thus, it can be calculated that the annual reserve of rice husk ash in the Southern region is about 21,720 tons/year, of which in Long An province is 12,000 tons; Dong Thap province is 5,400 tons; An Giang province is 4,320 tons. But according to actual surveys, all the amount of rice husk ash generated every month has been sold to offtake units and fertiliser production facilities for farming, and there is not even enough rice husk ash to serve the needs of farmers for use as fertiliser in the area. Therefore, the possibility of using rice husk ash to replace river sand in the Mekong Delta region is very low, although the estimated distance from these rice processing factories to the centre of the Mekong Delta is acceptable.

3.3 Sugarcane bagasse ash

According to the desk assessment results stated in the inception report, by 2017, Vietnam had 39 sugar factories with a total capacity of 155,000 TCD [14], [15]. However, due to many recent factors such as the entry into force of the ASEAN Trade in Goods Agreement (ATIGA) and the impact of the COVID-19 pandemic, the number of sugar factories has decreased significantly from 38 to 29 in the 2019/2020 crop year and finally reduced to 25 in 2020/2021, of these 5 factories are in the Mekong Delta [14]. Sugarcane bagasse ash is collected from boilers and treated by landfilling or used as fertiliser [16].

In this study, the research team conducted a direct survey at the Soc Trang sugar factory. At the time of the survey, the factory was in the maintenance phase after the sugarcane pressing season. The research team collected some key information as follows:

#	Survey content	Survey information
1	Location	Soc Trang province
2	Input source	Sugarcanes are planted in clusters mainly in Long Phu district and nearby
3	Main product	Molasses sugar, electricity
4	Input sugarcane capacity	Design capacity 2,500 tons/day. In 2022, production will reach 100,000 tons of sugarcane
5	Sugar yield	In 2022, it will reach 10,000 tons of sugar
6	Sugarcane bagasse amount	About 28,000 - 29,000 tons (equivalent to 28 -29% of the input amount of sugarcane). 100% bagasse is burned
7	Sugarcane bagasse ash amount	1,000 tons of ash (equivalent to 1% of the input amount of sugarcane)
8	Sugarcane bagasse ash status	All purchased by private units as raw materials for fertiliser processing
9	Means of transport	Sugarcane bagasse ash is mixed with water to pump to the dumping area. The organic fertiliser processing facility is located in the landfill area, so there is no need to transport ash far from the factory area
10	Distance to Can Tho city	69 km

Table 6. Main survey information at Soc Trang Sugar Joint Stock Company

Although according to calculations, the annual amount of sugarcane bagasse ash by 2030 can reach a maximum of nearly 30,000 tons/year in the Mekong Delta region and 14,000 tons/year in the Southeast region if factories operate at full capacity, and the total capacity achieved according to the expected data of the sugarcane development proposal. However, due to difficulties in raw sugarcane areas and markets, the operations of sugar factories cannot implement the approved proposal. Especially in the Mekong Delta region, the number of factories has decreased from 10 factories to 2 factories and operates only 30-40% of design capacity. Therefore, the actual amount of sugarcane bagasse ash measured is much smaller than the theoretical number.

In the Southeast region, there is currently no assessment information on the operating situation of sugar factories in this area, however the geographical distance to the centre of the Mekong Delta region is quite far, from 230-270 km. In addition, the amount of ash after burning is often mixed with water by factories to pump it to the landfill, sugarcane bagasse ash often has high moisture content, fluctuating between 20-40%; thus, transporting sugarcane bagasse ash to the Mekong Delta as alternatives to river sand is considered low feasibility.

In the Mekong Delta region, actual survey shows that the source of sugarcane bagasse ash from sugar factories has off-take units who purchase the output for making compost and microbiological fertilisers, not dumped into landfill as stated in previous reports during desk assessment. This activity is also how the factories process waste in compliance with environmental treatment plan as a compulsory requirement towards the generated sugarcane bagasse ash after burning sugarcane bagasse during the sugar production. In addition, actual data on the amount of newly produced sugarcane bagasse ash during the production process of factories in the 2022/2023 crop year only reaches 1200-1600 tons (about 4-5% compared to the theoretical number). Besides, due to geological and topographical characteristics in the Mekong Delta region, sugarcane growing areas here occur the phenomenon of alum or saltwater intrusion. Therefore, it is necessary to carefully analyse the chemical composition of sugarcane bagasse ash here to be consistent with studies on the purpose of using it to replace river sand.

Khu vực	Total amount of sugarcane produced\ (Tons/ day		Maximum annual total amount of sugarcane bagasse ash (tons)		Ratio ash/ sugarcane (%)		Distance to the Mekong Delta region (km)
	Indirect data	Survey data	Indirect data	Survey data	Indirect data	Survey data	
Southeast region	19,800	-	14,000	-	0,62	1	230-270
Mekong Delta region	27,000	1,650 – 2,250	30,000	1,200-1,600			-

Thus, comparing the numbers between theoretical calculations and the current status of sugar production in the Mekong Delta region, the amount of sugarcane bagasse ash generated annually in this area is very low. Although there are no specific reports regarding the amount of sugarcane bagasse ash generated in the Southeast region, with the situation of the sugar industry and the production activities of sugarcane enterprises here, the actual amount of ash generated is lower than the theoretical number. With the average transportation distance from factories in the Southeast region to the Mekong Delta region being very far, along with the fact that sugar factories have off-take units to purchase all the amount of sugarcane bagasse ash to serve their needs and ensuring mandatory regulations on environmental management in production, thus, the potential for sugarcane bagasse ash reserves in the above two areas to be used to replace river sand in the Mekong Delta region will not be high feasibility.

3.4 Recycled concrete

Several preliminary assessment results are as follows:

- Based on the State's regulations on the useful life of works, reports from the Department of Construction on old and damaged works in the area: Currently Ho Chi Minh City has nearly 500 old apartment buildings in danger that need to be renovated or eliminated with nearly 27 thousand apartments and 2 million m2 of construction floor space [17].
- Construction waste in Ho Chi Minh City is used by people to level new projects. Many projects have to buy more construction waste at spontaneous dumps for use at a unit price of about 100,000 VND/1m^3 [18].
- Constructions such as old apartment buildings need to be demolished and renovated according to statistics from HCMC Department of Construction, of

which have from 2 to 13 floors, and on average 4 floors [17]. Therefore, this supply is not too large at the present time or in the medium term.

Some survey results on construction waste in Ho Chi Minh City:

Survey results at public and private companies related to demolition activities, collection, transportation, treatment and recycling of construction waste in Ho Chi Minh City are as follows:

#	Survey content	Survey information		
1	Names of survey units	Ho Chi Minh City Urban Environment Company Limited (Citenco)	District 1 Public Service Company Limited	Tin Duc Construction Services Trading Company Limited
2	Main business	Collect, transport and process all types of waste in Ho Chi Minh City, including construction waste. Citenco is also providing demolition services for construction projects.	Providing environmental sanitation and urban landscape services, including demolition, collection and transportation of construction waste	Demolition, collection and transportation of construction materials
3	Material characteristics	Already sorted at source. However, they will be resorted at Citenco	Already sorted at source	Dismantled and sorted at source, then transported by specialised vehicles: vehicles that only transport debris and vehicles that transport other materials.
4	Capacity to receive construction waste	At Le Dai Hanh station: 700 tons/day; Vo Thi Sau station: 600 tons/day. Since the pandemic has declined, in 2022 there will only be a total of 170 tons/day, Reason: Waste reduced; Volume control is not good (illegal); Costly when dumping debris waste.	About debris: 100 m^3/month. However, the company only provides dismantling, collection, and transportation services	About a few houses/ month, equivalent to about 500-600 m^3 of debris/month. Previously it was more, now the workload has been reduced by 60-70%.

#	Survey content	Survey information		
5	Cost of collection and transportation of construction waste	Depending on vehicle type and transportation distance, ranges from 100,000 to 420,000/ton	Costs for dismantling and transporting construction materials according to state unit prices. Price is about 800,000 VND/car of 3 m^3 and 15 km	The main cost of demolition, including dismantling, collection and transportation, is 120,000 to 150,000 VND/ m^3 of debris.
6	Raw material gathering yard	Construction materials are collected and transported by people, construction units or companies to 2 transfer stations for classification, reuse and recycling of material load.	There is no gathering yard	There is no gathering yard
7	Treatment	(1) All types of soil, rocks, broken bricks... are classified and reused as filling materials. (2) iron, steel, plastic, paper... are transferred to authorised units for appropriate treatment. (3) The company is conducting research on recycling incinerator ash and slag to make construction materials	The company's cleaning team is in charge of household waste, which is treated by landfill. (2) Debris will be transported to a transfer station (possibly Citenco) or to a levelling place (usually a residential house).	Debris is transported to the levelling site (included in the initial demolition fee), or the storage yards according to regulations (yards in District 4, District 8, District 12 and Hocmon). However, if transported to Citenco's storage yard or transfer station, there will be an additional fee.

Table 7. Survey information at companies related to construction waste in Ho Chi Minh City

Results of field surveys at companies with activities related to waste concrete show that:

- Before being collected and transported, construction waste is sorted right t the source.
- Ho Chi Minh City currently has the two largest transfer stations managed and operated by Citenco, but there has been a very sudden decrease in construction material waste from at least 1,300 tons/day to just over 170 tons/day after the covid epidemic.

- Up to now, construction waste in the HCMC is used as levelling material, there is no surplus for recycling to apply for other purposes. This result is similar to the team's previous desk assessment.
- Small projects (residential houses) will often contact private companies to carry out contracts from demolition, collection, and transportation to construction waste treatment sites. While large projects will often hire professional units to carry out the work. However, if this waste is taken to transfer stations, additional fees will be charged.

Thus, the output of waste concrete in the city. There is no surplus left in Ho Chi Minh City because it has been fully utilised for the city's levelling activities. Therefore, it is not a potential alternative for river sand at the present or in the short term.

3.5 Waste glass

Through initial assessment, it is found that the waste glass market in the South is the largest in the country and concentrated in Ho Chi Minh City where there are many construction projects, with the neighbouring Binh Duong province hosting Vietnam's largest Viglacera float glass factory. However, there are no specific statistics on this waste output.

Regarding the field survey, the team found that this material source is distributed in small quantities, and field assessment is not really necessary. In fact, the team also contacted and sent official letters to a number of units but did not receive approval to conduct the survey. As a result, they only ended up talking by phone and processing information. Some results collected are as shown in Table 8:

#	Company	Activities related to waste glass
1	Viglacera Float Glass Company (Binh Duong)	There is waste glass generated during the production process. However, the factory reuses it for the glass melting process and does not dispose of this waste into the environment.
2	Thien Loc Company Limited (HCMC)	Specialising in purchasing transparent scrap glass and recycling it into glass/recycled glass products right at the facility
3	Khanh Huy scrap purchasing (Binh Duong)	Specialising in purchasing transparent scrap glass and recycling it into glass/recycled glass products right at the facility
4	Ngoc Minh Phat Glass Trading Service Company Limited (Binh Duong)	Purchasing scrap glass, with an input capacity of about 20 tons/month, but only collecting colourless glass, mainly in Ho Chi Minh City and Binh Duong areas, or purchasing at the factory site. The container will then be packed and exported to China for glass recycling facilities to "reblow" into new recycled glass.

Table 8. Some information from glass factories and waste glass purchasing units

Thus, through desk assessments and direct calls to manufacturers with activities related to waste glass, we found:

- Ho Chi Minh City and Binh Duong areas are likely to emit the most waste glass.
- First, waste glass is collected by units, then it will be recycled into recycled glass at domestic facilities or sold to neighbouring countries such as China.
- Coloured waste glass is currently not significantly recycled in Vietnam.

3.6 Blast furnace slag

Initial assessment results show that currently, BFS at cast iron- steel plants in Vietnam is mainly fast-cooling blast furnace slag, i.e. granular blast furnace slag. The whole country has 8 cast iron- steel factories with blast furnaces in operation: the north (5 factories), the central region (02 factories) and a BFS processing factory in Ba Ria-Vung Tau. In the Southern region, BFS is mainly used by some cement factories as input materials for the production of special types of cement such as slag cement, sulphate resistant cement... Through research results and reality, granulated blast furnace slag is much more difficult to grind than cement clinker; At the same time, finely ground blast furnace slag has begun to be produced on an industrial scale and has been used in some construction projects. Both blast furnace slag and finely ground blast furnace slag currently bring economic value to cast iron- steel smelting units and blast furnace slag grinding plants.

Field survey at BFS grinding plants conducted by consultant team is illustrated in below Table 9:

#	Survey content	Survey information
1	Unit name	CHC Resources Vietnam Co., Ltd - Ba Ria-Vung Tau Branch (as CHCV-BRVT)
2	Material	granulated blast furnace slag
3	Amount of input material	By October 2023: 623,000 tons. The factory has a warehouse to store up to 60 thousand tons of raw materials.
4	Main product	Finely ground blast furnace slag, 2 types S95 (super fine) and S75
5	Product capacity	Design capacity is 1 million tons of grinded slag/year. The factory has 4 silos grinding crushed slag with a total capacity of 32,000 tons
6	Main clients	Cement factory, concrete pile factory, concrete mixing plant. For example: Hoang Son Fly ash and cement Joint Stock Company; Chiwan Eternal Co., Ltd.; Bach Loc Phat Trading and Service Company Limited...
7	Quantity	Sold out
8	Purpose of purchasing unit:	Used in cement and concrete production
9	Remaining BFS amount	No stock
10	Distance to Can Tho	214 km

Table 9. Survey at CHC Resources Vietnam Company Limited - BRVT Branch

Survey shows that:

- By October 2023, the amount of finely ground blast furnace slag will reach 63% of the design capacity. Therefore, it is likely that by the end of 2023, output will not reach design capacity.
- The factory's finely ground blast furnace slag is sold to cement factories, concrete pile factories, and concrete mixing plants and there is no inventory.

Thus, up to now, blast furnace slag in the South has been utilised to produce finely ground blast furnace slag. The amount of finely ground products is consumed to produce construction materials, bringing high economic value. However, it can be seen that the reserve of finely ground blast furnace slag is quite small, not enough to meet the need to replace river sand in the Mekong Delta and HCMC. On the other hand, the distance from the factory to the centre of the Mekong Delta is also quite far, about over 200 km.

3.7 Rubber waste

Through initial assessment, this material is currently used as raw material for FO & DO oil factories, and these factories are located in the city. HCM and Binh Phuoc.

Based on identifying the distribution location, the authors surveyed at the factory producing oil from waste rubber (waste tires) of Binh Phuoc Green Solution Production and Trading Joint Stock Company. Some survey information at the factory is presented in Table 10 as follows:

TT	Survey scope	Information
1	Location	Binh Phuoc
2	Number of FO-R factories in the South	In the South: FO oil production; There are 02 licensed factories in the South: (1) Binh Phuoc Green Solution Company; (2) Company in Vung Tau. In addition, there are 03 semi-official factories (not enough legal documents)
3	Main products	FO and DO
4	Materials	Mainly truck and container tires.
5	Material price	The price of raw tires is proportional to the price of crude oil, currently priced at 3,000 VND/1 kg of tire.
6	Suppliers	Buy at the factory gate. Mainly collected from the southern provinces; sometimes lacking
7	Material capacity	100 tons of tires/day; equivalent to 30,000 tons of tires/ year. Raw material reserve capacity: 1000 tons
8	Main product capacity	40 tons of oil/day, equivalent to 12,000 tons of oil/year. There is almost no inventory
9	Quality	Meets company facility standards, built from relevant ASTM standards.
10	Product price	Door-to-door delivery prices are always 10-15% lower than traditional FO and DO prices.
11	Secondary product	Soot; steel and flammable gases
12	Secondary product rate	By-products account for 30, 10 and 5% respectively.
13	Utilisation	Carbon black: raw material, sold to units used as reinforcing additives; Steel: sold as scrap
14	Distance to Can Tho	252 km

Table 10. Survey at Binh Phuoc Green Solution Production and Trading Joint Stock Company

Through actual survey, it was found that:

- Currently, in the Southern market in particular, waste rubber is used to produce FO and DO fuels to replace traditional FO and DO oils (produced from petroleum). This result is similar to the initial assessment.
- In the South, there are only 02 units fully licensed for rubber waste recycling production activities, including Binh Phuoc Green Solution Production and Trading Joint Stock Company. According to this company, tire prices are proportional to oil prices and are delivered at the factory gate. However, almost all rubber tires in the southern region are not enough to supply all factories (including factories that have been fully licensed, are in the process of applying for full licensing, and are operating illegally).). Meanwhile, the price of finished fuel is delivered to factories in need at a price 10-15% cheaper than traditional fuel.

Thus, like some other alternative materials, waste rubber has been utilised and brought economic value. This waste output is no longer surplus to consider the potential to replace river sand in the future. Current location, at the same time the distance to the centre of the Mekong Delta is quite far, not an advantage.

3.8 Bottom slag

The results of desk evaluation are as follows:

The amount of bottom slag generated and accumulated in the Southern region is as follows:

- Calculate the amount of bottom slag generated and accumulated based on the designed coal consumption capacity and average ash level of coal; Bottom slag accounts for 10% of the ash and slag at the plant.
- The annual amount of bottom slag generated from thermal power plants in the Southern region is about 267,000 tons, of which 201,000 tons in Tra Vinh province; in Dong Nai province is 12,000 tons; in Hau Giang province is 54,000 tons.
- The accumulated amount of bottom slag generated from the date of closing the power grid to November 2023 is about 1.63 million tons, of which in Tra Vinh province is 1.31 million tons; in Dong Nai province is 0.17 million tons; in Hau Giang province is 0.15 million tons.

Field survey results:

The implementation team contacted two establishments, Lee&Man Vietnam Paper Co., Ltd. and Duyen Hai Thermal Power Company, representing two types of coal burning technology being used in Vietnam (layer coal burning technology). boiling

and spray coal combustion technology), detailed information surveyed is given in the Appendix, some main information used to calculate bottom slag emissions is given in Table 11 below:

TT	Survey scope	Lee&Man Vietnam Paper Company Limited	Duyen Hai Thermal Power Company
1	Source of raw materials used	Imported coal	Duyen Hai 1 Thermal Power Plant uses domestic coal; Duyen Hai 3 and 3 thermal power plants expanded to use imported coal.
2	Amount of coal usage	253.749 tons/year	Duyen Hai 1 and 3: 300 tons of coal/hour; Duyen Hai 3 expansion: 330 tons of coal/hour. Maximum operating hours 6500 hours/year
3	Coal burning technology	Fluidized bed combustion	Spray coal burn
4	Power generation capacity	50 MW	Duyen Hai 1: 2x 622.5 MW; Duyen Hai 3: 2x 622.5 MW; Duyen Hai 3 Expansion 1x 688 MW.
5	Amount of bottom slag generated	12,430 tons/year	Duyen Hai 1: 5,000 tons/month; Duyen Hai 3: 1500 tons/month; Duyen Hai 3 expansion: 1,000 tons/month
6	Distance to Can Tho	23 km	150 km

Table 11. Survey at companies with coal burning activities and bottom slag generation

Thereby, prepare a table of indirect calculation data and direct investigation data at 02 facilities as follows:

TT	Thermal power plant (with generator set)	Burn technology	Wattage (MW)	Total Wattage (MW)	Amount of ash and slag generated, tons/ year		Rate
					Calculations	Surveyed	
1	Duyen Hai-1	PC	2x622	1244	123.156	60.000	0,49
2	Duyen Hai-3	PC	2x622	1244	29.856	18.000	0,60
3	Duyen Hai-3 extension	PC	688	688	16.512	12.000	0,73
4	Lee & Man	Circulating fluidized bed	50&75	125	24.750	12.430	0,50
Average							**0,58**

Therefore, with a coefficient of 0.58, the implementation group proposed that the expected annual reserve of bottom slag in the Southern region is about 155,000 tons/year, of which in Tra Vinh province is 117,000 tons; Dong Nai province is 7,000 tons; Hau Giang province is 31,000 tons.

The amount of new bottom slag generated every year is basically sold to offtake contractors and construction material production facilities in the region (accounting for 95% of the newly generated bottom slag), and the quality of the product is good. Basic bottom slag products comply with current standards. According to Decision 452/QD-TTg dated April 12, 2017 of the Prime Minister on "Approving the project to promote the treatment and use of ash, slag and gypsum of thermal power plants and chemical plants, Fertilizer as raw material for production of construction materials and in construction projects" has set a goal: by 2020, it is necessary to process and use ash, slag, and gypsum to ensure that the amount stored at the landfill is met. of each thermal power plant, chemical plant, fertilizer plant is less than the total emissions of 2 years of production, so currently most thermal power plants have issued projects and are conducting consumption and use. ash and slag as construction material.

In the list of thermal power plants in the Southern region, only 4 facilities operating before 2017 still store bottom slag outside the dump, the largest amount belongs to Duyen Hai 1 and Duyen Hai 3, according to calculations. Estimates will store about 1.2 million tons. However, according to the company's report, the remaining inventory is only about 200,000 tons and is currently being used as an internal road for vehicles to move in the storage yard.

Therefore, the potential to use bottom slag sources to replace river sand sources in the Mekong Delta region is low, because the reserves to use for this purpose are not much, despite the distance from the factories. This is quite close to the center of the Mekong Delta.

4. CONSULTATION WITH STAKEHOLDERS

While conducting this research, the consultants received many inputs and recommendations from the government agencies, local leaders, scientists, producers,... in meetings, workshops and field trips. Details of the recommendations are below:

4.1 Conversation on promoting M-sand and building waste recycle in Southern Vietnam

On October 13th, 2023, the consultants presented the research method and desk study results in the seminar: "Promoting M-sand and recycled building waste in Southern Vietnam", organised by WWF-Viet Nam and VIBM in HCMC. The seminar was participated by 7 leading M-sand producers in the South, leading experts of concrete, transportation, materials and delegates from relevant Department of Construction. Through the conversation, the consultant group has recognised many inputs from the delegates about the opportunities, limitations and recommendations to promote M-sand and recycled building materials in the South. In particular:

Sea Lion company:

- From 2000: Peikin and Shanghai banned completely natural sand, and replaced it with M-sand from stone and recycled building materials. Replacing riversand with M-sand brings many benefits such as allowing the production of high grade concrete.
- TCVN 9205 standard: the content of the standard is not associated with grinding technology. This is the key to distinguishing different types of M-sand and controlling quality.

Hung Vuong Company:

- This is the first company in Vietnam to update the most modern technology in the world, providing clean M-sand sources and ensuring the quality of finished concrete products.
- However, users are still hesitant to use products made from M-sand and the price is higher than river sand. To change traditional habits, local departments (for example, the Department of Construction) need to take action to show local people that using M-sand to replace part of river sand is an inevitable and mandatory need. .
- Besides, there are standards and compliance with regulations, but there are no economic and technical norms. Therefore, it is necessary to develop norms for each case such as airport roads, highways, for the production of components, high-strength concrete, and high-quality concrete.

Thanh Dai Phu My Company:

- A company that collects and processes steel slag in Vietnam. In the South, the factory capacity is around 1 million tons per year in Vung Tau.
- Steel slag has been used as aggregate in concrete production with better abrasion resistance than normal, meaning it can replace about 30%-50% sand and stone.

Vietnam Green Building Council

- Extended Producer Responsibility (EPR) will take effect in early 2024, however, the EPR does not mention the construction industry, which is responsible for more than 40% of waste.
- The most important thing is to create a legal framework regulating the mandatory recycling rate, then the waste market, including construction waste, self-regulates.
- -VGBC is eager to coordinate with WWF-Vietnam to include the mandatory recycling rate of construction waste in the new EPR

Vietnam Institution for Building Science and Technology - Concrete Institution

- Among the eight alternative materials proposed by the research team, some materials should be given priority, specifically M-sand. The group should also consider fly ash because incorporating fly ash into concrete production, in addition to being a cement substitute, can also replace sand. The reserves of other materials are insignificant.
- It is recommended that WWF should combine the development of a guidebook/ handbook on recommendations for using sand in each application. For example, when producing high-quality concrete, river sand must be used, and for low-quality concrete, M-sand should be used instead.
- The construction industry does not produce a lot of emissions, but rather consumes a lot of waste from other industries. Therefore, the new EPR needs to stipulate mandatory recycling rates for construction waste.
- Revising M-sand standards is a legitimate requirement and requires the cooperation of relevant parties to be completed in the near future.

Transportation UniversityT

- It is necessary to systematise standards related to sand and M-sand.
- Encourage businesses to declare compliance with standards and regulations after processing, instead of spending time building standards and facility standards.

4.2 Recommendations for processing and production facilities during the survey

During the field survey in the South, the research group received many recommendations from the alternative material production, processing, and collecting facilities. Table 12 summarises the recommendations for each alternative material.

#	Alternative material	Recommendations from production facilities
I	**M-SAND**	
1	Phuoc Hoa Fico Jsc. (BA Ria Vung Tau)	Issue using norms of M-sand in State capital projects.
2	Hoa An Stone 1 Company (Ba Ria – Vung Tau)	Simplify legal procedures for licensing and mining.
3	Thanh Tam Jsc. (Ba Ria Vung Tau)	MOC examine and research to utilise crushed stone to use in suitable construction.
4	Hung Vuong Construction Company Limited - Binh Phuoc Branch (Binh Phuoc)	Issue norms for using M-sand for precast concrete products and fresh concrete to include in estimates of state capital projects.
5	Hoang Hai Company Limited (Dong Nai)	Establish Mechanisms, policies, and instructions for use with low quality stones.
6	Branch of Hung Vuong Construction Co., Ltd. (Dong Nai)	Changing the perception of M-sand so that it can be applied more widely.
7	BMT Construction Materials Production and Trading Joint Stock Company (Dong Nai)	Product classification and additional instructions for using crushed sand.
8	An Giang Stone Exploitation and Processing Company Limited (An Giang)	There is a lack of norms for using crushed sand for precast concrete products and fresh concrete. Proposal to include projects using state capital in the estimate.
9	Kien Giang Construction Materials Production Joint Stock Company (Kien Giang)	There is a lack of norms for using crushed sand for precast concrete products and fresh concrete. Proposal to include projects using state capital in the estimate.
II	**SUGARCANE BAGASSE ASH**	

#	Alternative material	Recommendations from production facilities
1	Soc Trang Sugar Joint Stock Company (SOSUCO)	Currently, it is difficult to maintain raw material areas.
III	**CONCRETE WASTE**	
1	Ho Chi Minh City Urban Environment Company Limited (Citenco)	Currently, the Company is investing in the project "Building a construction waste recycling centre" at the Northwest Cu Chi Wastewater Treatment Complex. Hope it gets approved soon. Propose access to appropriate classification lines and recycling technologies for construction waste. The idea of using construction materials to replace river sand is good, but the current volume is not sufficient.
2	District 1 Public Service Company Limited	Currently, It is reasonable for HCM to use construction waste for levelling.
3	Tin Duc Construction Services Trading Company Limited	Currently, It is reasonable for HCM to use construction waste for levelling.
IV	**RUBBER WASTE**	
1	Binh Phuoc Green Solution Production and Trading Joint Stock Company	Hướng tận dụng cao su phế thải hiệu quả nhất vẫn là nhiệt phân, thế giới cũng chỉ làm cái này. Đề xuất nghiên cứu TCVN về FO từ cao su thải; có các hướng dẫn, quy định để cấp phép cho các đơn vị đủ điều kiện hoạt động loại hình này.

Table 12. Recommendations from processing and production facilities

Through the above recommendation, there are some main points:

- Most stone mining and M-sand production companies have proposed to review the current TCVN for M-sand and issue norms for using M-sand for use in state-owned capital projects. Besides, there are some opinions on simplifying legal procedures for licensing and mining. Along with research to take advantage of crushed stone and powdered stone products to use for suitable projects,...
- Surveyed at a facility that generates bagasse ash in the South, however, the sugar factory is currently having difficulty maintaining raw material areas, and at the same time recommends further research on the feasibility of replacing Sand potential of sugarcane bagasse ash.
- Companies with typical activities of dismantling, collecting, and transporting construction waste in Ho Chi Minh City in the public and private sectors almost all believe that the direction of utilising this waste for levelling is appropriate at the present time and not enough to recycle for concrete or mortar production. In

addition, Citenco also proposed to support access to appropriate classification lines and construction waste recycling technology.

- Similar to bagasse ash, the group only surveyed one facility with activities related to waste rubber in the South. Thereby, this company proposed that the most effective way to utilise waste rubber is still pyrolysis to produce DO and FO, and also proposed to study TCVN on FO from waste rubber, with instructions, regulations to licence qualified companies to operate this.

4.3 Presenting research results to consult with Can Tho PPC

On the morning of December 13, 2023, within the framework of the meeting between WWF-Vietnam and the People's Committee of Can Tho City, the research team presented the results to the leaders of the People's Committee of Can Tho City and representatives from the Department of Construction, Department of Natural Resources and Environment, Department of Agriculture and Rural Development of Can Tho City for the purpose of consultation.

Can Tho city is the largest city in the Mekong Delta region. According to the Mekong Delta Master Plan for the period 2021-2030 with a vision to 2050, Can Tho City will be the economic and cultural centre of the region in the future. To implement the plan, Can Tho City needs a huge amount of river sand for construction and levelling. Therefore, the leaders of Can Tho City People's Committee and local departments are especially interested in alternative solutions for the very scarce river sand source. Leaders evaluate research on the sand budget and river sand replacement materials as very necessary and highly practical. At the same time, there were some recommendations as follows:

RECOMMENDATIONS OF CAN THO PPC LEADERS:

The group's research content is a very hot issue in the Mekong Delta in general and Can Tho in particular. This is not only related to climate change and the environment, but currently and in the near future Can Tho is and will need a huge amount of river sand, up to about 100 million m^3. Specifically, sand demand for highway projects is about 13 million m^3. Besides, the VSIP industrial park project phase 1 alone needs about 9.5 million m^3 and phase 2 needs about 20 million m^3, ...

The research results have correctly identified that the potential replacement material for current river sand is M-sand with very large reserves in the southern provinces. However, to be able to put it into practical application, there are still many problems. Recommend to clarify and do more research on cost, crushing capacity, and mining techniques.

In addition to M-sand, representatives of Can Tho city leaders proposed to do more research on saline sand and sea sand in terms of environment and cost.

In addition to alternative solutions using materials, consider also solutions to change

construction techniques. For VSIP Can Tho industrial park, the City proposed to lower the levelling level to save levelling materials. According to previous planning of the city. Can Tho's levelling level is 3.1 m, however the current water level is only about 2.2 m, so the City proposes to only level it to a level of 2.7 m and at the same time build a closed embankment. Industrial park in parallel with construction of a pump system. Can Tho is making recommendations and submitting them to leaders at all levels and the Ministry of Construction for comments.

RECOMMENDATIONS FROM DONRE

Highly appreciate the research, however, it is necessary to have deeper and more particular research in order to apply these in reality

RECOMMENDATIONS FROM DOC

Second Can Tho PPC's points of view, suggest paying attention to the other alternative sources and conduct deeper research.

4.4 RGSP reporting workshop

On the morning of December 13, 2023, within the framework of the meeting between WWF-Vietnam and the People's Committee of Can Tho City, the research team presented the results to the leaders of the People's Committee of Can Tho City and representatives from the Department of Construction, Department of Natural Resources and Environment, Department of Agriculture and Rural Development of Can Tho City for the purpose of consultation.

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RECOMMENDATIONS OF CAN THO PPC LEADERS:

An Giang representative shared that the province's M-sand has large reserves, so it has the potential to significantly replace river sand. However, currently the big problem is that there are no economic and technical norms for M-sand to replace river sand. Delegates proposed that the Ministry of Construction soon research and issue norms for M-sand.

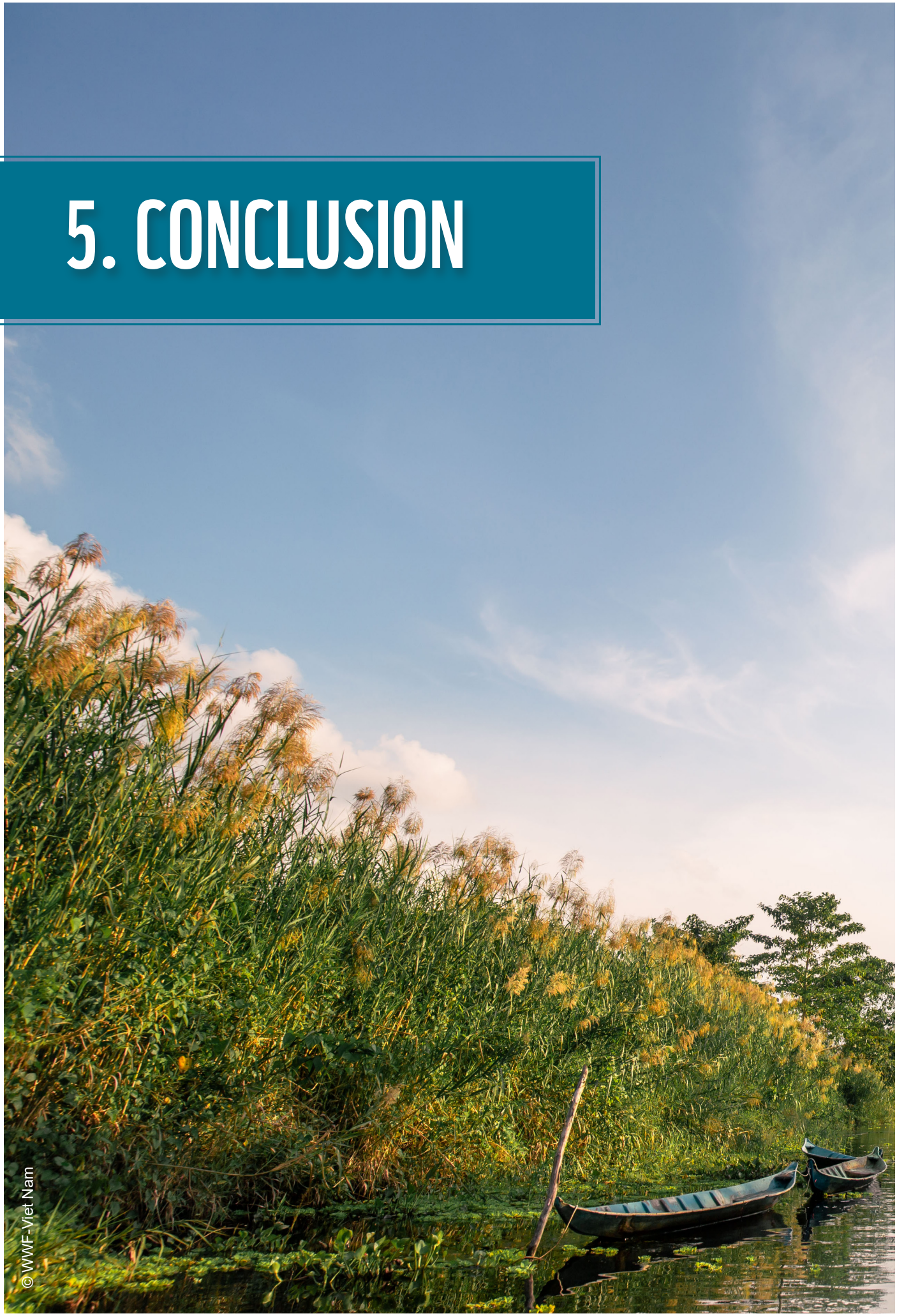
Regarding the assessment of the potential replacement of materials for river sand,

there is also a need for research on the cost of river sand. Specifically, currently, resource taxes in river sand business activities and other related costs are still low or do not include the cost of overcoming problems caused by river sand exploitation, so if calculating When calculating all the costs for river sand, the actual price of river sand will be much higher. At that time, not only M-sand but also the remaining alternative materials currently being utilised in other directions will all be potential materials.

RECOMMENDATIONS FROM THE DEPARTMENT OF DYKE MANAGEMENT AND NATURAL DISASTER PREVENTION

Delegates from the Department of Dykes and Natural Disaster Prevention agreed with the research team's assessment of the solution of using M-sand to replace river sand. However, like the statements of other guests, in order to put it into practical application on a larger scale, it is necessary to research and perfect the norms of M-sand.

5. CONCLUSION



Through secondary document research and field surveys in the Southern provinces from August to the end of November 2023 to assess reserves/supply capacity, prices, distribution, and quality (if any) of 08 types of potential alternative materials for river sand. Combined with consultation with stakeholders from businesses, departments, and research experts from Universities and Research Institutes from October to December 2023, the research team has some conclusions as follows:

5.1 M-sand

M-sand is the most potential alternative material to river sand at the moment and in medium term in the South because:

- M-sand has been produced and used in the South East provinces, An Giang and Kiên Giang. Some companies with large M-sand production capacity or modern production technology in the South are as follows: Phuoc Hoa Fico Joint Stock Company, Hung Vuong Construction Company Limited - Binh Phuoc and Dong Nai Branches, BMT Construction Materials Production and Trading Joint Stock Company, An Giang Stone Exploitation and Processing Company Limited and Kien Giang Construction Materials Production Joint Stock Company.
- Although the entire market's M-sand production capacity in the South is about more than 5 million m^3/year, current factories can completely increase production capacity to a much larger level due to the volume of stone that can be used. used to produce M-sand currently reaches hundreds of millions of cubic meters and the availability of technology and equipment.
- M-sand is currently mainly used for the production of concrete,
- The selling price of artificial sand for concrete production at the mine is quite competitive (150,000 VND/ton) compared to river sand sold at the mine in Dong Thap (250,000 VND/m^3).
- The quality of M-sand is comparable to river sand and is largely produced in accordance with current technical standards.
- However, except for M-sand mines in An Giang and Kien Giang, the transportation distance of M-sand from the remaining provinces in the Southeast to the Mekong Delta is greater than 100km.
- In addition, the technical standards for M-sand issued in 2012 have revealed many limitations and are no longer suitable for the new situation of the construction materials production industry. There is also a lack of technical and economic norms for mortar and concrete applied uniformly across the country.

- M-sand production in the South in particular and Vietnam in general lacks regulations to manage M-sand production more sustainably for the environment and society.

5.2 Construction waste

Construction waste is a potential alternative material in the long term. Although currently most construction waste is still concentrated in Ho Chi Minh City and tends to decrease suddenly after the Covid 19 pandemic from at least 1,300 tons/day to over 170 tons/day. All construction waste has been fully utilised as levelling material in the city. HCM. However, research and practice in developed countries prove that the volume of construction waste will arise in the long term when high-rise buildings in Ho Chi Minh City and neighbouring cities enter the demolition phase. around 2040 or later.

Ho Chi Minh City Urban Environment Company Limited (CITENCO) is the leading state-owned company in collecting and treating construction waste in Ho Chi Minh City.

Research shows that waste is collected and classified at source according to legal regulations. According to Article 64 of the Law on Environmental Protection 2020, it is clearly stipulated that environmental protection must be protected in construction activities, including construction, renovation, repair, and demolition of construction works. must ensure environmental protection requirements. Waste from renovation and demolition activities of households and individuals in urban areas must be collected and transferred to facilities with treatment functions according to regulations of the Provincial People's Committee... However, there is still no clear regulation on the mandatory recycling rate for the entire recycling chain as developed countries are applying. Besides, there is a lack of technical standards as well as economic norms for recycling construction waste for concrete and mortar production purposes.

5.3 Rice husk ash, bagasse ash, furnace bottom slag from thermal power plants, blast furnace slag, waste glass, waste rubber

- Rice husk ash and sugarcane bagasse slag are distributed in the Mekong Delta, so the transportation distance to the place of consumption is very short. However, most of the ash and slag have been completely utilised for other purposes (fertiliser production, ...). Besides, there is no Vietnamese standard for sugarcane bagasse slag.
- Although there is a TCVN for kiln bottom slag, however, kiln bottom slag emitted from coal-burning power plants or paper production plants has been recycled almost entirely to serve the production of cement, tiles, and backfilling. , ... currently, although the factories are distributed in the Mekong Delta, there is only a negligible amount of inventory left for internal use within the factory premises.
- There is no TCVN for waste rubber in Vietnam, almost all waste rubber in the South is mainly collected to produce DO/FO oil. The application of this type of waste in the construction industry is currently very limited.
- Blast furnace slag has almost been recycled for concrete production and is no longer in stock to serve the needs of the Mekong Delta.

6 . RECOMMENDATIONS

Based on the results from this study and recommendations from businesses and production facility owners, through direct interviews at production facilities/emission source owners in the South. Combined with sharing and recommendations obtained from experts from Universities, Research Institutes, and businesses at seminars on the current status and opportunities for development of M-sand and Construction Waste Recycling in the South , workshop reporting the results of the Plan to maintain river morphological stability in the Mekong Delta, reporting the results to leaders and representatives of relevant departments under Can Tho City, the research team has a number of recommendations as follows to promote research and development of renewable resources for river sand in the Mekong Delta in particular and the South in general, thereby reducing pressure on river sand and moving towards complete use of renewable resources.

First and foremost, it is necessary to review the value of river sand, thereby valuing river sand more accurately and appropriately. Specifically, the indirect costs of river sand mining such as the cost of river and coastal embankments, landslide migration near the sand mining area, etc. need to be included in the price of river sand mining. Thereby, businesses that develop artificial sand or other types of materials for river sand can compete with river sand. Next, the research team proposes separate recommendations for the following types of Alternative materials:

M-SAND

- Analyse the cost-effectiveness of M-sand production to provide economic evidence for policy makers to promote M-sand development.
- Researching and editing the current TCVN for M-sand is no longer appropriate due to changes in technology,
- Research and promulgate economic and technical norms for using M-sand to replace river sand in concrete and mortar production to be applied nationwide so that M-sand can be used for projects, especially projects using state capital.
- Propaganda aims to change public awareness and policy makers about the use of M-sand so that it can be applied more widely in the construction industry in Vietnam.
- Research to assess impacts on biodiversity, environment and society to promote more sustainable development of M-sand in Vietnam.
- Research to optimise M-sand transportation methods to reduce costs when M-sand is transported to construction sites in the Mekong Delta as well as reduce emissions, while reducing pressure on the current road system.
- The state needs to have tax incentive policies and access to preferential capital sources to promote M-sand production,

- Research and develop mechanisms, policies, and instructions for use with low-quality rocks/by-products from crushed stone/sand processing facilities.

CONSTRUCTION WASTE

- Continue to research the classification and application of construction waste from construction projects, including waste concrete as construction materials.
- Research and complete technical standards and economic norms for recycling debris for concrete and mortar.
- Issue regulations requiring mandatory recycling rates of construction waste in construction projects, especially public projects,
- Propaganda to raise people's awareness about classifying, collecting, transporting and treating all types of household waste, including waste concrete.

OTHER THEORETICAL POTENTIAL MATERIALS

Research and compare the technical, economic and environmental aspects of potential materials to replace river sand in the direction of current utilisation and use as construction materials.

However, the Mekong Delta is a delta with an average elevation of about 2m above sea level, and is in a state of shrinking and gradually sinking [15]. This is combined with the limitation related to the large transport distance (>100km) transporting raw materials from the Southeast to the Mekong Delta while requiring very large volumes of backfilling sand for important projects in the next decade. Therefore, the key here is to change construction and levelling techniques in the direction of saving backfill materials to be able to solve the current and future sand shortage problem. Specifically, it is necessary to reconsider the levelling level combined with building dikes using pumps as proposed by Can Tho City.

Besides, the solution of building highways with viaducts is a technique that also contributes to reducing the need for river sand and maintaining the sediment and water connection between the river bed and the delta.

RECOMENDATION

[1] "Điều tra khảo sát tình hình sản xuất và sử dụng cát nghiền thay thế cát tự nhiên trên phạm vi cả nước, đề xuất các giải pháp tăng cường sử dụng cát nghiền thay thế (đề tài sự nghiệp kinh tế, Bộ Xây dựng)," 2021.

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