INTERNATIONAL CONFERENCE ON ENVIRONMENT, CLIMATE CHANGE AND ENERGY FOR FUTURE CHALLENGES: BEST PRACTICE AND INNOVATION FOR CONSERVATION AND RESTORATION

(VIRTUAL CONFERENCE)

26 JUNE 2023

SIRINDHORN INTERNATIONAL ENVIRONMENTAL PARK

CHA-AM, PHETCHABURI, THAILAND

พระชนมายุ ๔๘ พรรษา

อุทยานสิ่งแวดล้อมนานาชาติสิรินธร

Preface

It is a great opportunity to have organised the Virtual International Conference on Environment, Climate Change and Energy for Future Challenges: Best Practice and Innovation for Conservation and Restoration hosted on-line on 26th June 2023 by the Sirindhorn International Environmental Park (SIEP) in collaboration with Silpakorn University (Phetchaburi IT Campus), Kasetsart University (Kamphaeng Saen Campus), Phetchaburi Rajabhat University, RCE Cha-am (Regional Centre of Expertise on Education for Sustainable Development in Cha-am) Thailand, Institute of Scientific and Technological Research (TISTR), Department of Climate Change and Environment (DCCE) (former Department of Environmental Quality Promotion: DEQP), Ministry of Natural Resources and Environment, the Kingdom of Thailand, and Blue Renaissance Co., Ltd.

The Virtual Conference used the on-line communication as a "new normal" technological platform to reach international target groups; university students, researchers, representatives from governmental and private sectors and the general public. Ninety individuals participated in the Conference, with 57% from Thailand and the others from the Philippines, Germany, Pakistan, Sri Lanka, Indonesia, Cambodia, Myanmar, Laos, India, Bangladesh, Uganda and Liberia. They were affiliated with 38 organisations in Thailand, the Philippines, Japan, Pakistan, Indonesia, Cambodia, Myanmar, Laos, India, Bangladesh, Liberia and Vietnam.

The Conference encouraged and supported the dissemination and exchanging of knowledge in various aspects derived from the results of research, best practices, and innovation for conservation and restoration in relation to the future challenges on environment, climate change and energy. The proceedings comprised some full papers of articles presented in the Conference including the conclusion of presentations from keynote and guest speakers. We hope all provided outcomes can be extended to the development of your profession, study or research in your countries.

We would like to express our profound gratitude to Prof. Mario T. Tabucanon, Emeritus Professor, Asian Institute of Technology (AIT), and Visiting Professor, United Nations University – Institute for the Advanced Study of Sustainability (UNU-IAS), who served as adviser to the Academic Committee for his advice and great contribution to the success of this Conference.

The Conference Organising Committee

Opening Remarks

Prof. Dr. Sanit Aksornkoae

Chairman, Office of the National Economic and
Social Development Council,Thailand

Committee, Sirindhorn International Environmental Park Foundation
under the Patronage of HRH Princess Maha Chakri Sirindhorn

- Pol. Lt. Gen. Prapun Chantaim, Managing Director of Sirindhorn International Environmental Park and Energy for Environment Centre / Chairman of Organising Committee of the Virtual Conference
- Prof. Mario T. Tabucanon, Advisor to the Academic Committee of the Virtual Conference
- Prof. Anil Kumar Anal, Keynote speaker from Asian Institute of Technology (AIT)
- The guest speakers:
- Dr. Theresa Mundita S. Lim
  Executive Director, ASEAN Centre for Biodiversity (ACB)
- Mr. Jen Radschinski
  Regional Expert on Art.6 and Carbon Pricing
  UNFCCC/IGES – Regional Collaboration Centre for Asia and the Pacific, Bangkok
- Co-organisers
- All speakers and participants

It is my great pleasure and honour to address the opening remarks for the Virtual International Conference on Environment, Climate Change and Energy for Future Challenges: Best Practice and Innovation for Conservation and Restoration. This On-line International Conference is organised by the Sirindhorn International Environmental Park, together with its co-organisers; Silpakorn University (Phetchaburi IT Campus), Kasetsart University (Kamphaeng Saen Campus), Phetchaburi Rajabhat University, Regional Centre of Expertise on Education for Sustainable Development in Cha-am (RCE Cha-am), Thailand Institute of Scientific and Technological Research (TISTR), Department of Environmental Quality Promotion (DEQP), Ministry of Natural Resources and Environment, and Blue Renaissance Co., Ltd.

This Conference aims to utilise the “new normal” technological platform, that can efficiently reach international target groups that are researchers, students, representatives from governmental and private sectors, and the general public as well as to encourage and support the dissemination of knowledge derived from the results of research, best practices, and innovation for the conservation and restoration in relation to the future challenges on Environment, Biodiversity, Climate Change and Bio-Energy.

Nowadays, the crises of environmental deterioration, biodiversity loss both in species and number, and the changing climate are more severe and widely affected on our planet. In addition, the increasing demand for bio-energy is significant. All these extremes require solutions and are to be minimised through the collaboration of all sectors. Best practices and innovation for the conservation and restoration of natural resources are essential to steer the solution and mitigation of the crises. It has been revealed that currently some countries implement studies that obtain substantially successful results.

This Virtual Conference will provide opportunities for us to learn and exchange knowledge and experience, and enable participants to utilise the applied knowledge for the successful conservation and restoration of natural resources in your country. Thailand is well-aware of the significant effects of these crises and therefore strongly supports the study and research on the natural resources and environmental deterioration as well as the related issues.

It is clearly seen that Thailand's 20-year National Strategy (2018-2037), which is Thailand's first long-term development strategy, has been adapted to implement national policy and plans for the development path to the country's conservation and protection of environment, climate change effect resilience and mitigation, and increasing its bio-energy supply. Thailand also adopted the 13th Thailand National Strategic Plan for five years (2023-2027) which addresses the significance of the crises on biodiversity loss, climate change and the demand for bio-energy. Furthermore, the governmental sector joined hands with the private sector, academic institutions and the general public to support the research and innovation, of which the results are wisely applied, to reach efficient achievement. Moreover, the BCG Economy (Bio-Circular-Green Economy) is particularly focused in order to achieve the Sustainable Development Goals. Today's keynote presentation entitled "Bio-Circular Green Economy in the Food and Agriculture: Perspectives and Technological Interventions" is thus tremendously interesting.

Furthermore, I hope there will be the extension of knowledge from this platform to provide fruitful results for your organisation and your country in the future. Finally, I wish this On-line International Conference to be successful and all your goals for participating in this Conference are greatly achieved. Thank you very much.

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Keynote: "Bio-Circular Green Economy in the Food and Agriculture: Perspectives and Technological Interventions"

By Prof. Anil Kumar Anal, Keynote Speaker
Professor of Food Engineering and Bioprocess Technology
Food Innovation, Nutrition, and Health
Department of Food, Agriculture and Bioresources
School of Environment, Resources and Development
Asian Institute of Technology (AIT)

The world's population is projected to reach 9.1 billion by 2050, which is 34 percent higher than the present day. An emerging challenge will be providing enough food for the larger and more urbanised population and overall food production will need to increase by 70 percent. Along with this issue is malnutrition, and the number of undernourished people in the world was estimated to be 821 million in 2017, while one-third of all food produced is wasted. Therefore, a sustainable food supply with equitable distribution is a primary focus.

Sustainable food production systems require technologically-innovative solutions to make them more climate-resilient with reductions in environmental impacts since the food production supply chain contributes to 30 percent of the greenhouse gas emissions worldwide. Increased circularity with low-cost innovations and efficient use of resources will help improve food security and sustainability, but more needs to be done in terms of research and implementation. Also, community engagement and government policy formulation play an essential role in food waste management. The general public needs to be educated about the potential of using uneaten food as well as the negative impacts that wasted food pose on the environment.

Up to 54 percent of food loss and waste can be attributed to upstream processing and post-harvest handling where as 46 percent can be lost through processing, distribution and consumption. By comparison, food wasted at the consumption level is up to 60 percent in developed countries while as low as five percent in Sub-Saharan Africa. In terms of food waste hierarchy, the greatest emphasis should be placed on source prevention, then food redistribution and repurposing, followed by recycling and energy recovery, and finally disposal.

The food waste from agricultural production is a growing concern especially when it contributes to environmental degradation in the forms of land, air and water pollution. Land use is changed by clearing forests with slash-and-burn practices to increase farmland area and field residues from stalks and leaves are often burned releasing carbon emissions. Agricultural by-products and waste can be converted into animal feed and efficient sources of protein. Waste such as rice bran and rice straw can be utilised as a rich source of essential amino acids using low-cost technologies.

Alternative food sources should be promoted to counter food insecurity.

Incorporating traditional, fermented foods into one's diet exhibit solutions to reducing food waste such as a prolonged shelf-life and increased nutritional properties such as health-promoting, bioactive compounds. Alternatives to animal protein such as plant-based protein including the super foods millet and legumes should be more widely consumed since they are readily available and nutritious and produced with a lower carbon footprint.

Insect proteins can also be a suitable replacement to livestock proteins as well as other alternative food sources such as the in-vitro production of cultured meat using cell culture and tissue engineering technology. Cultured meat production can reduce the related GHG emissions by up to 96 percent with 99 percent less land use and 96 percent less water use.

The by-products and waste produced in the agro-industry possess numerous benefits as protein sources including egg shells and egg shell membrane, poultry feathers and shrimp shells. Also, waste from agro-industry can be used to produce biopesticides, biofuels, bioplastics, bio-colourants, sustainable eco-packaging, and antimicrobial and antioxidant packagin

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PARALLEL SESSION I

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“Climate Change: Navigating Global Response and Local Challenges in Thailand”

By Mr. Jens Radschinski, Guest Speaker
Regional expert on Art.6 and Carbon Pricing
UNFCCC/IGES-Regional Collaboration Centre for Asia and the Pacific

The Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) is the UN entity that supports the global response to the threat of climate change and assists countries in their efforts to reduce and stabilise their greenhouse gas concentrations at levels to prevent dangerous anthropogenic interference with the climate system. The Paris Agreement aims to strengthen the global response to the threat of climate change by keeping an average global temperature rise below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 degrees Celsius.

The Intergovernmental Panel on Climate Change (IPCC) estimated in 2022 that greenhouse gas emissions (GHG) need to be reduced by 43 percent by 2030 using 2019 as a baseline. The new paradigm of multilateral agreements incorporates a “Bottom-up” approach where 193 parties decide on their own commitments which are communicated through their Nationally Determined Contributions (NDCs) to keep the global average temperature increase as close as possible to 1.5 degrees Celsius. As of November 2022, the NDCs of countries aiming to reduce their carbon emissions are estimated to result in a greater than 95% chance of exceeding a global temperature increase of 1.5 degrees Celsius by 2100, and current commitments will increase emissions by 10.6 percent by 2030.

Thailand is a developing country highly vulnerable to the impacts of climate change and is ranked the 9th country in the "extreme risk" category that is most vulnerable to future climate change impacts over the next thirty years. In terms of mitigation, Thailand intends to reduce its greenhouse gas emissions by 30 percent from the projected business-as-usual (BAU) level by 2030, and could increase up to 40 percent with adequate and enhanced support. The energy sector has been the largest contributor to Thailand’s GHG emissions, accounting for 69 percent of total emissions in 2018. The Climate Change Master Plan 2015-2050 of Thailand focuses on climate change mitigation, adaptation, capacity-building and cross-cutting issues while its 20-Year National Strategy aims to increase the country’s forest cover to 55 percent by 2037.

According to The Nature Conservancy, implementing natural climate solutions (NCSs) globally could prevent 10 billion tons of carbon dioxide emissions annually by 2030, and could be financed through carbon markets. The NCSs fall into four categories, namely; reforestation and improved forest management, coastal and wetland preservation including mangroves, restorative agricultural practices that build soil carbon and crop rotation with improved livestock management, and ocean-based practices to restore and expand marine ecosystems.

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Promising Clones of Bio-Energy Sugarcane

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***Abstract*— Thailand's annual energy demand is approximately 85,966 kilotonnes of oil equivalent (ktoe) and is likely to increase continually. It is expected to rise up to 131,000 ktoe per year. Currently, 55% of the energy consumed within the country is imported from abroad. Thailand aims to reduce fuel imports and increase the proportion of renewable energy production from 15% to 30% in 2036. Sugarcane is one of the economic crops that can be used as an energy crop which can take various advantages from all parts of sugarcane like heat energy production, biogas production, and ethanol production. The Department of Agriculture (DOA) Thailand, is the government agency which responds to the research on sugarcane. The DOA has continued to develop and improve initiatives especially for energy from sugarcane varieties. The DOA has started the breeding program at the Suphan Buri Field Crops Research Center and Khon Kaen Field Crops Research Center, and from that, it was evaluated at other DOA research centers and farmers' fields. Meanwhile, there was a study on the potential of bio-energy production in the form of biogas and ethanol, including the study of the reaction to red rot wilt disease, with the purpose to obtain the best sugarcane varieties that have the potential to produce bio-energy and resistance to red ret wilt disease. The research and development project for the energy from sugarcane varieties could enhance Bio-Economic value in 2021-2023. It started from the product evaluation of the bio-energy cane on standard trials at (2018-2037) the Khon Kaen Field Crops Research Center (KKFCRC) and Nakhon Ratchasima Agricultural Research and Development Center (NRARDC). This study is based on the potential of biogas and ethanol production of promising clones by the Agricultural Production Science Research and Development Office. Likewise, there was research and development on rapid and accurate techniques for detecting the reaction of red rot wilt disease at Khon Kaen Field Crops Research Center. The result has shown that the promising clones were able to yield high methane gas and ethanol from juice, bagasse while being moderately resistant to red rot wilt disease namely; UTe05-110 UTe05-112 KK07-250 KK07-599 KK12-050 KK12R-076 and KK13-203.**

***Keywords*— bio-energy sugarcane, biogas, ethanol, batch fermentation**

I. INTRODUCTION

Thailand has a growing demand for energy but has to rely on external energy, especially fossil fuels that are decreasing and more expensive. Therefore, it is necessary to find renewable energy from other sources that are more sustainable, especially renewable energy from plants that can be produced every year. For year 2036, the government has a policy to increase the proportion of renewable energy production from 15 percent to 30 percent (EPPO, 2015). Sugarcane is a potential and sustainable crop to be used as a renewable energy crop. Because Thailand has a lot of sugarcane production with the sugarcane planting area of 12 million rai per year and can produce 128 million tons of sugarcane per year, every part of sugarcane production can be used as energy in the forms of electricity, biomass, fuel, etc.

Sugarcane is a fast-growing plant and has the potential to produce energy, but there is also the concern that it will go to extract raw materials in the sugar industry. Therefore, sugarcane varieties must be developed for bio-energy production, and the Department of Agriculture and the Khon Kaen Field Crops Research Center has developed a bio-energy sugarcane variety by crossing commercial sugarcane (*Saccharum officinarum*) with wild sugarcane (*Saccharum spontaneum*) and a related plant genus Lao (*Erainthus sp*.). This hybrid cane produces high yields, a deep root system, a good ratooning ability and good drought tolerance. In addition, the Suphan Buri Field Crops Research Center has been developing sugarcane varieties that have the potential to produce ethanol since 2004. There are promising sugarcane clones with good yield potential. However, the potential of biogas, ethanol and biomass production has not been studied. Therefore, a promising sugarcane clone was evaluate the yield trials at the Khon Kaen Field Crops Research Center and the Nakhon Ratchasima Agricultural Research and Development Center, along with studying the potential of biogas and ethanol yields at the Agricultural Production Research and Development Bureau, to study the potential of biogas and ethanol production of the promising sugarcane clone which could be an alternative energy crop for farmers while being a raw material for energy production of community power plants. Farmers and communities can use clean energy produced by the community. and there is also a return to the community could provide strong and sustainable communities.

II. MATERIALS AND METHODS

2.1 Standard trials were implemented in 2021-2022 at KKFCRC and NRARDC, one plot each. There were three replications in the RCB experiment design, consisting of promising 19 varieties/clones with four checks of U-Thong 2 (UT2), Khon Kaen 3 (KK3), K88-92 and LK92-11 in each experimental site. Yield and yield components were collected at 10 months.

2.2 A study on biogas yield potential of promising sugarcane clones was conducted at the APFDRD laboratory in 2021-2022 to evaluate the potential of sugarcane bagasse as a substrate for theoretical methane production and anaerobic fermentation. The theoretical biochemical methane potential was calculated by a stoichiometric equation based on the atomic composition (C, O, H, and N) of sugarcane bagasse. Methane production from bagasse by anaerobic microorganisms was conducted in 120 ml serum bottles with a working volume of 70 ml. Theoretical and experimental methane yield will be used to assess the potential of sugarcane bagasse as a substrate for methane production.

2.3 A study on ethanol yield potential of sugarcane promising clones was conducted at the APFDRD laboratory in 2021-2022. The yeast seedling culture of *Saccharomyces cerevisiae* SK-19 was prepared by incubating yeast malt medium at 35 °C for 48 hours. Then sugarcane juice was extracted and separated the bagasse. The juice was analyzed for total sugar content. The bagasse was chopped into a small size and analyzed for the composition, namely cellulose, hemicellulose and lignin and then stored at -20 °C for preservation and maintaining specific constituents throughout the experiment. The sugarcane juice, bagasse and chopped bagasse with sugarcane juice was processed into ethanol by batch fermentation with *Saccharomyces cerevisiae* SK-19 yeast cultures, then incubated at 35-37 °C, and shaken on an incubator at 150 rpm. Samples were collected every four hours and analyzed for the ethanol content with high-performance liquid chromatography (HPLC) using the Aminex HPX-87H column. The total sugar content was analyzed with the phenol-sulfuric acid method, and total solids (TS) and volatile solids (VS) were analyzed according to APHA standard methods (APHA, 1997).

The ethanol yield (Yp/s) is calculated from the amount of ethanol produced in grams per gram of sugar used, while the ethanol productivity, Qp, was measured in grams per liter per hour (Equation 1) and yield efficiency of ethanol production, Ey, was calculated in Equation 2 as follows:

$$Qp = P/t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

$$Ey = (Yp/s \times 100) / 0.538 \quad \ldots\ldots\ldots\ldots \text{(2)}$$

- where P is the concentration of ethanol produced, in grams per liter
- t is the maximum ethanol concentration time in hours
- 0.538 is the theoretical maximum yield of ethanol production from sucrose

2.4 The study of reactions to red rot disease in energy cane 19 varieties/clone was conducted by using the E-heiw variety, which is a susceptible check. The cultivation of the fungus *Colletotrichum falcatum* was grown on PDA medium for two weeks at room temperature and inoculated by two methods: 1. Wound pin prick method in the midrip leaves (modified from Dela Cueva et al.,2019). Disease incidence was assessed at two weeks after inoculation. Evaluate symptoms on the midrib that appear as external symptoms, spread, and expansion of the wound. There are six disease levels: very resistant (HR) with a wound size of 0-0.9 cm, resistant (R) with a wound size of 1.0-4.9 cm, and moderately resistant (MR) with a wound size of 5.0-10.9 cm. Moderately weak (MS) is a wound size of 11.0-20.9 cm, weak (S) is a wound size of 21-29.9 cm, is very weak (HS) is a wound size of more than 30 cm.

2. The wound plug method in 8 months-old sugarcane by inoculating the 3rd internode above the ground, and two months after inoculation, the disease severity was assessed by cutting the stem lengthwise and counting the spread of the infection internode. The findings were classified by the severity levels into six groups: very resistant, resistant, moderately resistant, moderately susceptible, susceptible, and very susceptible (adapted from Sirinivasan and Bhat (1961)).

III. RESULTS AND DISCUSSION

3.1 Sugarcane yield trial: Standard trial at KKFCRC. Sugarcane was harvested at the age of 10 months on November 8, 2022. K88-92 varieties provided the highest yield of 129.3 tons/ha, however, not statistically different from varieties/clones KK07-250, KK07-599, KK12-050, KK13-203, KK13-330, LK92-11, UT2 and KK3 (Table 1).

At NRARDC, it was found that KK13-203 gave the highest cane yield of 220.6 tons/ha, not statistically different from KK3 and K88-92 (Table 1). It showed that the data of KKFCRC and NRARDC could be analyzed for the covariance of cane yield. KK13-203 provided highest average cane yield of 158.7 tons/ha, higher than that of K88-92 and KK3 (Table 1).

3.2 At KKFCRC, it was found that the U-Thong2 variety gave the highest theoretical biogas yield of 9,938 m^3CH_4/ha, followed by KK07-250, KK07-599, and LK92-11, but there were three promising clones that had the high experimental potential to produce biogas, and they were KK13-203, KK13-483 and KK13-330, which gave biogas yields of 5,006, 3,169 and 3,050 m^3CH_4/ha respectively (Table 2). The same as the experimental results at NRARDC, all three clones gave biogas yields from the experiment of 10,981, 6,525, and 6,144

m^3CH_4/ha respectively and higher than KK3 8, 7 and 3% respectively (Table 2). When averaging the two locations, it was found that sugarcane clone KK07-250 gave the highest theoretical biogas yield at 12,016 m^3CH_4/ha, followed by KK3, KK13-330, KK07-599, KK13-114, and K88-92, but the experimental biogas yield, sugarcane clone KK13-203 gave the highest biogas yield followed by KK13-483, KK13-330 KK3 K88-92 and KK07-250. As a result, KK13-203 has the highest biogas production efficiency of 74%, followed by KK13-483, KK13-330, KK3, K88-92, and KK07-250 with biogas production efficiency of 61, 40, 38, 36 and 25% respectively. It can be seen that NRARDC gives a higher yield of sugarcane than in KKFCRC and has a higher impact on biogas production as well.

3.3 In the case of the potential of sugarcane juice and bagasse in ethanol production of 18 clones/varieties, it showed that sugarcane variety K88-92 provided the highest ethanol yield from juice and bagasse theoretically at 5,244 and 10,481 liters/ha (summed up to 15,725 liters/ha) at KKFCRC but its ethanol yield from juice and bagasse experimentally were not so high, 769 and 638 liters/ha (summed up to 1,407 liters/ha), respectively (Table 3).

At NRARDC, the KK3 variety gave the highest ethanol yield from sugarcane juice and bagasse of 8,775 and 18,663 liters/ha theoretically (summed up to 27,438 liters/ha) but the clone KK13-203 provided the highest ethanol yield from juice experimentally of 6,969 liters/ha. Moreover, K88-92 gave highest ethanol yield from bagasse experimentally of 838 liters/ha. (Table 3).

As averaged of the two sites, it was found that the theoretical ethanol yield from juice was highest in the standard varieties K88-92 and KK3, but the experimental one was higher in clones KK13-203, KK07-250, KK11-158, KK12-050 and KK12R-076. KK3 gave the highest theoretical ethanol yield from bagasse, higher than that of K88-92, but gave a lower experimental ethanol yield from bagasse at 369 liters/ha for KK3 and 738 liters/ha for K88-92. The promising clones which gave higher theoretical ethanol yield from bagasse than K88-92 were KK13-330, KK07-250, KK13-171 and KK07-599, and the ones giving higher experimental ethanol yield from bagasse than KK3 consisted of KK13-203 and Ute05-110 (Table 3). The promising clones providing ethanol yields close to that of K88-92 were KK13-203, UTe05-110, UTe05-112 and KK07-250. Most of them had high ethanol yield efficiency.

The theoretical and experiment ethanol yield from bagasse will be very different, and the theoretical will give and average ethanol yield of 10,481 liters/ha, but from the experiment yielded 300 liters/ha representing 2.9%.

3.4 When evaluating the reaction to red rot disease of bio-energy cane, it was found that the wound pin prick method assessed the disease more quickly after only two weeks, but the two methods give the same results. There are three promising clones that are resistant (R), namely KK07-250, KK07-599, and KK13-470. Most of them have moderate resistance (MR) (Table 4).

IV. CONCLUSION

The promising sugarcane clones which showed high potential for methane gas and ethanol production from juice and bagasse (at 10 months old harvest) were composed of KK13-203, UTe05-110, KK07-250, KK12R-076, KK13-483, KK13-330, and KK11-158, and these would be used as genetic resources for energy cane varietal development and an alternative energy crop for farmer community enterprises and power plants in the future.

ACKNOWLEDGEMENT

The research team would like to send many thanks to the Director of the Field and Renewable Energy Crops Research Institute, the Director of the Khon Kaen Field Crops Research Center, the Director of the Nakhon Ratchasima Agricultural Research and Development Center, the Director of the Agricultural Production Factors Research and Development Division and their concerned government employees and agricultural experiment workers. Finally, we thank the National Research and Innovation Information System (NRIIS) for supporting the research budget.

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Table 1 Cane yield of varieties/clones of bio-energy cane in Standard Trail at KKFCRC and NRARDC on 2021-2022

Varieties /Clones	Cane Yield (Tons/ha)		
	KKFCRC	NRARDC	Mean
KK13-203	96.8 a-d	220.6 a	158.7
K88-92	129.3 a	182.9 bc	156.1
KK3	76.9 bcd	207.8 ab	142.3
KK07-250	108.6 ab	172.8 bcd	140.7
KK13-330	92.4 a-d	171.9 bcd	132.2
KK12R-076	89.0 bcd	163.1 cde	126.0
KK07-599	94.4 a-d	147.9 c-g	121.2
UTe05-110	88.6 bcd	152.1 c-f	120.3
KK12-050	92.1 a-d	146.7 c-g	119.4
KK13-483	73.3 bcd	162.1 cde	117.7
DOA KK4	84.8 bcd	143.8 c-h	114.3
KK13-114	60.7 d	163.0 cde	111.8
KK13-470	80.6 bcd	142.8 c-h	111.7
U-Thong2	107.5 ab	110.6 gh	109.0
LK92-11	102.8 abc	113.8 fgh	108.3
KK13-171	64.7 cd	143.7 c-h	104.2
KK11-158	65.0 cd	135.8 d-h	100.4
UTe05-112	81.9 bcd	108.9 gh	95.4
Mean	96.8	220.6	158.7
CV (%)	24.1	14.8	

Means in the same column followed by the same letter are not sigificances at p=0.05 by DMRT.

Table 2 Biogas yields and biogas production efficiency of varieties/clones of bio-energy cane in Standard Trail at KKFCRC and NRARDC on 2021-2022

Varieties /Clones	KKFCRC		NRARDC		Mean		Eff (%)
	T	E	T	E	T	E	
KK13-203	6,744	5,006	14,794	10,981	10,769	7,994	74
KK13-483	5,206	3,169	10,725	6,525	7,966	4,847	61
KK13-330	7,663	3,050	15,450	6,144	11,556	4,597	40
KK3	6,850	2,450	16,763	6,006	11,806	4,228	36
K88-92	9,556	3,475	12,594	4,581	11,075	4,028	36
KK07-250	9,631	2,431	14,400	3,631	12,016	3,031	25
KK12R-076	8,119	1,913	13,706	3,231	10,913	2,572	24
KK11-158	4,456	1,625	9,131	3,331	6,794	2,478	36
KK12-050	8,513	1,850	13,075	2,844	10,794	2,347	22
KK13-470	6,463	1,613	11,706	2,919	9,084	2,266	25
DOA KK4	8,338	1,444	9,725	2,388	9,031	1,916	21
UTe05-112	7,344	1,656	9,000	2,031	8,172	1,844	23
KK13-171	7,344	894	15,444	1,875	11,394	1,384	12
U-Thong2	9,938	1,294	9,706	1,263	9,822	1,278	13
KK13-114	5,131	675	14,263	1,681	9,697	1,178	12
LK92-11	8,538	763	8,719	781	8,628	772	9
UTe05-110	5,925	331	10,019	563	7,972	447	6
KK07-599	9,375	244	13,638	356	11,506	300	3
Mean	7,507	1,882	12,381	3,396	9,944	2,639	27
CV (%)	25.2	23.2	20.4	15.2			

T = Theory E = Experiment Eff = Efficiency

Table 3 Ethanol yields and ethanol production efficiency of varieties/clones of bio-energy cane in Standard Trail at KKFCRC and NRARDC on 2021-2022

Varieties /Clones	KKFCRC T	KKFCRC E	NRARDC T	NRARDC E	Mean T	Mean E	Eff. (%)
KK13-203	10,831	3,363	23,031	7,500	16,931	5,431	32
KK07-250	14,256	3,088	21,750	5,056	18,003	4,072	23
KK11-158	7,606	2,594	15,763	5,169	11,684	3,881	33
UTe05-110	10,438	2,900	17,238	4,638	13,838	3,769	27
KK12R-076	11,438	2,519	20,088	4,875	15,763	3,697	23
U-Thong2	13,888	3,625	14,788	3,713	14,338	3,669	26
KK12-050	12,838	2,844	19,975	4,381	16,406	3,613	22
KK13-114	8,800	1,806	21,406	5,113	15,103	3,459	23
KK07-599	13,606	2,613	19,881	4,275	16,744	3,444	21
LK92-11	13,344	2,881	14,744	3,256	14,044	3,069	22
DOA KK4	11,894	2,381	18,925	3,731	15,409	3,056	20
KK3	10,719	1,556	27,438	4,425	19,078	2,991	16
UTe05-112	11,675	2,306	15,131	3,131	13,403	2,719	20
KK13-330	11,994	1,881	20,644	2,631	16,319	2,256	14
KK13-470	10,256	2,163	18,313	1,525	14,284	1,844	13
KK13-171	9,425	1,094	20,156	2,438	14,791	1,766	12
K88-92	15,725	1,406	20,950	1,844	18,338	1,625	9
KK13-483	8,013	581	16,919	1,338	12,466	959	8
Mean	11,486	2,311	19,285	3,835	15,386	3,073	20
CV (%)	25.6	30.1	16.7	17.5	7.4	7.2	

T = Theory E = Experiment Eff = Efficiency

Table 4 The interaction and reaction of bio-energy promising sugarcane clones to red rot disease

Varieties /Clones	Interaction WPP method	Interaction WP Method	Reaction
KK07-250	R	R	R
KK07-599	R	R	R
KK13-470	R	R	R
KK13-171	R	MR	MR
KK12R-076	MR	R	MR
UTe05-102	MR	MR	MR
UTe05-110	MR	MR	MR
KK12-050	MR	MR	MR
KK13-203	MR	MR	MR
KK13-483	MR	MR	MR
K88-92	MR	MR	MR
LK92-11	MR	MR	MR
KK3	MR	MR	MR
DOA KK4	MR	MR	MR
KK13-330	MS	MS	MS
KK13-114	MS	MS	MS
UTe05-112	MS	MS	MS
U-Thong2	MS	S	S
KK11-158	S	MS	S
E-hiew	S	S	S
KK13-263	HS	HS	HS

WPP = Wound pin prick method
WP = Wound plug method

Energy Potential of Cocoa Pod Husk in Selected ASEAN Countries

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***Abstract*— Bioenergy has the potential to provide a range of benefits, including increasing energy security, promoting economic gain, fostering rural development, and reducing greenhouse gas emissions. One important agricultural field residue that has been studied as a potential source of bioenergy is Cocoa Pod Husk (CPH). This study aimed to identify the potential of CPH as an energy source in selected ASEAN countries (Indonesia, Malaysia, the Philippines and Thailand). The study reviewed and measured the thermochemical characteristics of CPH, estimated its potential in each selected country, and evaluated its energy potential. The thermochemical characteristics of CPH were studied through proximate analysis and calorific value determination.**

Theoretical and technical potential calculations were performed to evaluate the energy potential of CPH. The results showed that the average moisture content and ash content values of CPH were respectively 13.54% on a wet basis and 10.67% on a dry basis. The higher heating value (HHV) of CPH ranged from 15.15 to 20.5 MJ/kg on a dry basis. The study also assessed the theoretical and recoverable energy potential of CPH.

The findings revealed that Indonesia had the highest technical energy potential for CPH, estimated to be 5,803,308 MJ, compared to other selected ASEAN countries. Based on the results, only Indonesia has the potential to increase cocoa seed production among the selected countries. Establishing small scale heat and power plants using CPH as an energy source in Indonesia could result in successful outcomes, both in terms of energy generation and waste reduction. In summary, the study highlights the potential of CPH as a valuable source of bioenergy in ASEAN countries. By utilizing CPH as a renewable energy source, it is possible to reduce waste, create economic opportunities, and contribute to sustainable development.

***Keywords*— Bioenergy, Cocoa Pod Husk (CPH), Thermochemical Characteristics, Bioenergy potential**

I. INTRODUCTION

Numerous studies highlight the depletion of fossil fuel sources and environmental degradation due to energy generation to powering economies. The scientific sources revealed that fossil fuels are the source of 80% of global energy generation [1]. Global CO_2 emissions from fossil fuels have been recorded at a notable level which is 36.8 billion metric tons of CO_2 [2]. Similar to the global trend, the current ASEAN energy mix relies on 80% fossil fuels but the policy within the region is planning to employ more clean energy generating techniques. Government policy scenarios are focused on increasing the share of renewable energy systems such as solar, wind, geothermal, hydro, and biomass [3]. Thailand has taken major steps toward applying bioenergy within the year 2020, and significant shares of electricity and heat energy were produced using biomass.

The primary sources of biomass are trees and plantations, while agricultural residues, animal manure, municipal solid wastes, and industrial waste serve as secondary sources for energy production [4]. The production of biofuels from energy crops may lead to adverse effects, including the expansion of the agricultural frontier, deforestation, mono-cropping, and challenges to food security [5, 6]. Therefore, it is essential to focus on studying readily available and cost-effective biomass sources as the primary means of energy production.

The conversion pathways of biomass to energy (biological, physical, chemical, or a combination of processes) depend on their type and characteristics [7]. Biomass is a complex material that contains several natural polymers, extractable materials, and inorganic compounds. Thermal decomposition of these materials is preferred for energetic utilisation [8]. Thermochemical conversion of microalgae biomass via pyrolysis, hydrothermal liquefaction, gasification, torrefaction, and direct combustion is used for bioenergy production from microalgal species [9]. Lignocellulose biomass is converted to bioenergy via kinetic modules such as pyrolysis, gasification, and combustion [10].

Thermochemical characterisation of biomass is one of the mandatory steps during the selection of biomass for bioenergy generation. As factors of potential energy yield from the selected biomass, selecting the ideal biomass to energy conversion process, identifying the biomass composition and the potential emissions, and evaluating possible economic feasibility of the conversion process by measuring the efficiency [11]. The main objective of this study is to identify the composition of the CPH and evaluate the potential of using CPH as a biomass source within the ASEAN region.

The Higher Heating Value (HHV) can assist in determining the potential energy yield of CPH, as well as the energy content of CPH when used for combustion, and the efficiency of combustion processes. HHV can also be used for comparing the energy content of CPH with other fuels, such as other potential biomass sources, coal, natural gas, and petroleum products.

This research project is focusing on assessing the potential of CPH as an energy source in selected ASEAN countries and determine its contributions to energy generation, waste reduction, and sustainable development.

II. METHODOLOGY

The complete research framework of this study is stated in Fig. 1. The research approach was to first prepare samples and then applied thermochemical characterisation tests to evaluate the bioenergy potential. A detailed thermochemical analysis was conducted on samples collected from selected ASEAN countries (Thailand, Indonesia, Malaysia, and Philippines), with a specific focus on proximate analysis and determining the heating value of CPH. These evaluations provided key insights into the calorific value and composition of the husks. Furthermore, theoretical and recoverable energy potential were also calculated using the available data. These steps are crucial in determining the effectiveness of using CPH as a potential energy source.

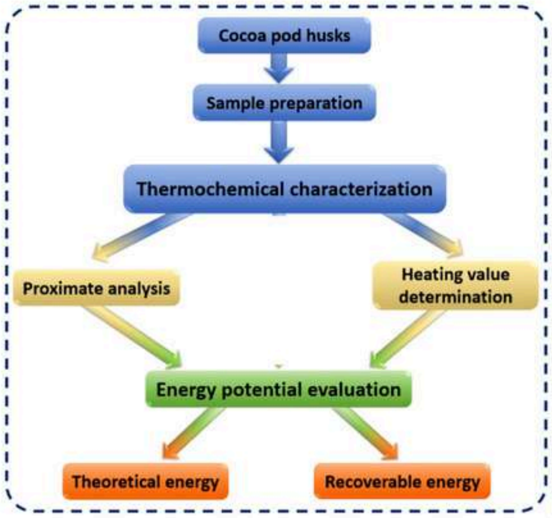

Fig.1 The research framework

A. Sample preparation.

Cocoa fruits were sourced commercially and halved to extract the seeds. The seedless CPH underwent a five-day, sun-drying process to eliminate excess moisture. Samples were located within the closed solar dryer to prevent any external contamination. For the drying process, sun-drying was chosen due to cost-effectiveness compared to oven-drying and also readily available sunlight within the region [12].

Subsequently, the dried CPH was reduced to a 2-cm particle size. Using a Tefal store-in grinder, the dried CPH was further ground into powder. Thermal characteristic examinations were conducted on two samples of cocoa husk powder, with each sample containing 1g, at the AIT Energy Laboratory [13].

Fig. 2 Sample preparation for the thermochemical characterization process

B. Thermochemical analysis

Proximate analysis and HHV parameter in calorimetry were only focused on this research framework due to limited machinery availability within the institution.

1. Proximate analysis

Proximate analysis was performed to measure the moisture, volatiles, ash contents, and fixed carbon of the sample. The analysis followed the ASTM D7582 standard method (ASTM International) and was conducted using the TGA 701 thermogravimetric analyser [14], [15].

2. Calorific value identification

The calorific value (heating value) of cocoa pod husk (CPH) samples was determined at the AIT Energy Laboratory using a bomb calorimeter (AC500 Isoperibol Calorimeter) in accordance with the ASTM D5468 method (ASTM International). The calorific value of CPH was determined by the AC500, measuring the heat released after the combustion of a CPH sample. The computer-based operating system employed an electronic thermometer accurate to 0.0001°C, measuring the temperature every six seconds. [16]

The weight of the sample plus the cup was determined, and then a fuse wire was inserted into the sample. Subsequently, 10 ml of distilled water was added to the combustion vessel, and the vessel was filled with oxygen before tightening. A water-filled bucket was placed into the bucket chamber, and the combustion vessel was inserted into the bucket, with the combustion vessel fuse connected.

C. Energy potential evaluation

Residue potential estimation includes various methods, such as theoretical, technical, economic, implementation, and sustainable biomass residue potentials. The primary approaches for assessing biomass potential are theoretical and technical [17].

In the theoretical calculation of CPH potential, the total available CPH for collection and utilisation is considered. This involves utilising cocoa production statistics to determine the theoretical potential. The calculation involves multiplying the annual crop production by the residue-to-product ratio (RPR) (Eq. 1) [18].

Eq. 1

Theoretical CPH potential (kg/year) = Annual crop production (kg/year) x Residue/Production ratio (kg CPH/kg cocoa)

On the other hand, the technical CPH potential acknowledges that not all biomasses may be practically available and usable due to economic, social, and environmental factors. Consequently, the technical CPH potential value is anticipated to be lower than the theoretical CPH potential value.

Eq. 2

Technical CPH potential (kg/year) = Theoretical CPH potential (kg/year) x Recoverable fraction of CPH

The theoretical energy potential of CPH in megajoules per year (MJ/year) is calculated by multiplying the theoretical CPH potential in kilograms per year by the higher heating value of sun-dried CPH in megajoules per kilogram. This higher heating value is determined through a combination of average values from literature and measured values.

Subsequently, the technical or recoverable energy potential value of CPH in megajoules per year is obtained by multiplying the theoretical energy potential of CPH (MJ/year) by the recoverable fraction of residues.

D. Thermochemical analysis

The results presented in Table 1 shows the proximate analysis (on a dry basis) and heating value data derived from various studies conducted in different countries along with the resulting measures from this study.

In the current study conducted in Thailand, the biomass sample showed a moisture content of 12.61%, a volatile matter content of 61.48%, a fixed content of 13.81%, and an ash content of 10.29%. The heating values, both HHV and LHV, are measured at 15.15 and 14.32, respectively. The biomass sample from the current study in Thailand presents a moderately moist and highly volatile composition, with a moisture content of 12.61% and volatile matter content of 61.48%, suggesting favorable combustibility.

A comparison with the study conducted by Titiloye et al. in 2013 [19], where the country is not specified, reveals differences in the biomass composition, with a moisture content of 10.29%, a volatile matter content of 68.4%, and a higher volatile matter content of 68.4%, emphasizing its combustible nature. The fixed content of 10.43%, and an ash content of 10.81%, the HHV is reported at 19.30, while LHV is not provided.

Another study conducted in Ghana by Drift et al. in 2000 [20] indicates a higher moisture content of 16.1%, a volatile matter content of 49.9%, a fixed content of 20.5%, and an ash content of 13.5%, with an HHV of 17 and LHV not specified. Drift et al.'s study in Ghana demonstrates a biomass composition with a higher fixed content of 20.5%, indicative of a greater concentration of solid residues.

Lastly, Angel et al.'s study in 2015 [21], with the country unspecified, exhibited a wide range of moisture content (56–73.7%) and volatile matter (12–32.5%), fixed content (1.5–14.3%), and ash content (43.5–50%). The HHV and LHV are reported at 15.39 and 14.25, respectively.

These findings underscore the variability in CPH composition across different studies and geographical locations, emphasising the importance of understanding regional variations in biomass characteristics for applications.

TABLE 1
COMPARISON OF THERMOCHEMICAL CHARACTERISATION RESULTS OF CPH

Study	Country	Proximate analysis (dry basis)				Heating value	
		Moisture Content (%)	Volatile Matter (%)	Fixed Content (%)	Ash (%)	HHV	LHV
This study	Thailand	12.61	61.48	13.81	10.29	15.15	14.32
Titiloye et al., 2013	Not stated	10.29	68.4	10.43	10.81	19.30	-
Drift et al., 2000	Ghana	16.1	49.9	20.5	13.5	17	-
Angel et al., 2015	Not stated	56 – 73.7	12 – 32.5	1.5– 14.3	43.5-50	15.39	14.25

E. Energy potential evaluation

Indonesia exhibits the highest potential for CPH with a volume of 670,128 tons, signifying a significant availability for utilisation. Malaysia, on the other hand, follows with a CPH volume of 2,452 tons, suggesting a notable potential for bioenergy production. Similarly, the Philippines demonstrates a considerable CPH volume of 4,994 tons, highlighting its potential as a valuable bioenergy resource.

In comparison, Thailand possesses a lower CPH volume of 132 tons, indicating a relatively lower potential for bioenergy production. Notably, among these countries, Indonesia stands out with the highest CPH potential of 5,803,308 MJ, emphasising its exceptional suitability for bioenergy production.

Initiating developments for CPH power and heat-generating plants in Malaysia and Thailand is not advisable due to the reduction of cocoa bean production in these countries. This recommendation is based on the fact that the decline in cocoa bean production directly impacts the availability and sustainability of CPH as a feedstock for bioenergy generation.

As a result, alternative biomass sources would be ideal compared to CPH for bioenergy initiatives in Malaysia and Thailand to ensure long-term viability and success.

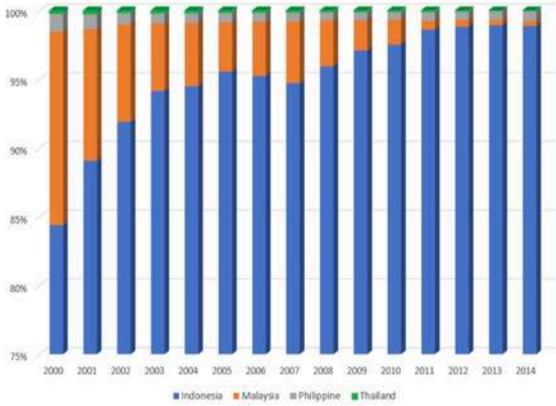

Fig. 3 Recoverable energy potential of CPH in selected ASEAN countries

IV. CONCLUSIONS

The thermochemical characteristic experiments in this study were carried out only on CPH samples cultivated in Thailand. These characteristics may vary according to the country due to differences in soil types and climate variations. The study primarily considered theoretical and technical energy estimations, but it can be extended to estimate economic CPH potential. Additionally, extending the study to estimate the economic CPH potential would help assess the feasibility and cost-effectiveness of utilising CPH for bioenergy production. Economic analysis can consider factors such as CPH availability, market prices, conversion technologies, and potential revenue streams.

Limited studies are available on the RPR, and it is suggested to estimate RPR values for cocoa pod husk in the ASEAN region.

Furthermore, studying GHG emissions from CPH conversion to heat and power is crucial for evaluating the environmental sustainability of CPH-based bioenergy systems. This analysis can assess the carbon footprint and potential mitigation strategies associated with CPH utilisation, aiding in the development of environmentally-friendly bioenergy solutions.

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Energy Potential of Cocoa Pod Husk in Selected ASEAN Countries

Enhancing Energy Resource Data Management through the Department of Energy's Policy: A Focus on Achieving Data Management Harmonization

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***Abstract*— This study examined the Philippine Department of Energy's (DOE) policy on data management in terms of collecting, processing, and storing information about the country's indigenous energy resources, such as petroleum, coal, and renewable energy. Through the implementation of a Service Contract System, where the government and the private sector sign an agreement to explore, develop, and utilize the country's energy resources, the management of the country's energy resources data was examined. In conducting this study, the data management practices of the Energy Resource Data Management Bureau (ERDB) and the Renewable Energy Management Bureau (REMB) were investigated by means of interviews, surveys, and documentary research. The study revealed that there is no significant difference in the management of energy resource data between ERDB and REMB. However, further analysis of the data management practices between each division revealed a significant difference in terms of the processing of external data, and the collection and processing of internal data. This research also highlights that the country's central repository of energy resource data, the Energy Data Center of the Philippines, is not fully utilised for data storage. Instead, most of the divisions under ERDB and REMB store the collected data individually. Such scattered and individual actions on the management of energy resources data may promote or lead to data loss. The study recommends that DOE adopts a policy to harmonize data management in terms of collecting, processing, and storing data from both external and internal sources to promote better public service transparency that generate additional public value.**

***Keywords*— data management, data stewardship, energy resource data, public administration**

I. INTRODUCTION

The Department of Energy [1] (DOE) is the government agency responsible for the Philippines' plans, programs, projects, and activities related to energy resource exploration, development, and utilization, amongst other mandates. In achieving this mandate, although the government can itself conduct the exploration activities, the private sector is usually tapped by means of a service agreement (SC) [2]. This SC contains the role and obligations of the government and the private sector in the exploration, development, and utilisation of the country's indigenous energy resources. Among the obligations of the developer is the submission of necessary energy resource data to the DOE for documentation, analysis, and use for energy planning. However, the different SC templates for petroleum, coal, and renewable energy resources also contain different provisions on what data to collect, and how and when to collect it. Also, the different DOE bureaus that supervise the activities for such energy resources – Energy Resource Development Bureau (ERDB) for petroleum and coal, and Renewable Energy Management Bureau (REMB) for renewable energy resources such as geothermal, solar, wind, biomass, hydropower, and ocean – also present different evaluation and processing methods of the collected data.

This paper investigated and analysed the procedures and methods of the different divisions / units under ERDB and REMB in the collection, processing, and storage of energy resource data from both external and internal sources. The objective of this paper is to improve the administration of energy resources data which can lead to better data governance and an improved delivery of public services. Through the assessment of the current policy on data collection, processing, and storage, this paper identified areas for improvement and provided recommendations for better data management practices. Ultimately, the study hopes to contribute to the development of more effective policies and strategies for managing energy resource data, which can lead to decision-making and more sustainable energy development.

II. METHODOLOGY

This research follows the Theory of Change (TOC) [3] in investigating and analysing the management of energy resource data of the DOE. This paper used the TOC as a basis and focused on the collection, processing, and storage of energy resource data from both external and internal sources. In line with the objectives of this paper which is to determine and suggest appropriate data and information reporting to the DOE based on the SC system, evaluation guidelines, and centralized data storage policies, this paper's conceptual framework was devised as shown in figure 1.

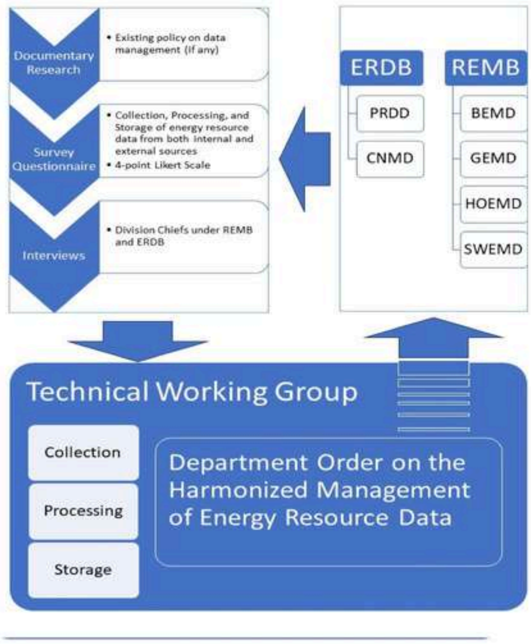

***Figure** 1: Conceptual framework of the study showing the methodologies and envisioned result. PRDD - Petroleum Resource Development Division, CNMD - Coal and Nuclear Minerals Division, BEMD - Biomass Energy Management Division, HOEMD - Hydropower and Ocean Management Division, GEMD – Geothermal Energy Management Division, SWEMD-Solar and Wind Management Division*

A mixed quantitative and qualitative evaluation method, or mixed methodology, and documentary research to determine the data management practice of ERDB and REMB was used for this paper. The focus of the paper on DOE's management of energy resource data covers the variables described on Table 1. A stratified random sampling was conducted to determine the sampling size from the ERDB and REMB. From a total population of 123, the number of actual respondents who gathered was 95. The respondents consisted of rank and file staff with backgrounds in engineering and geology. The duties and responsibilities of the staff revolve around the administration of the developers' obligations under each respective SC and other similar functions in attaining energy self-reliance of the country.

Table 1: Description of the research variables

Category	Description
Collection of data from external sources	External data pertains to the data and reports generated by energy developers from their Service / Operating Contracts
Processing of data from external sources	Processing pertains to the evaluation and or validation process of the collected data from developers
Collection of data from internal sources	Internal data are the types of data generated by DOE in their resource assessment activities
Processing of data from internal sources	Processing pertains to the analysis of internal data to be able to produce additional energy resource information
Storage of energy resource data	Storage of energy data describes the storage capability within the respective offices of the respondents in this research

This paper used a four-point Likert Scale, with 4 as the highest and 1 as the lowest. The options are as follows: 4 – strongly agree, 3 – agree, 2 – disagree, and 1 – strongly disagree. The use of the four-point Likert Scale can also be called a forced-choice scale because of the omission of the neutral choice. It is only logical in this paper because the results from an evaluation should not present a neutral option. The means (μ) were interpreted based on the paper of Pimentel (2010) [4] that discourages the tendency for author bias by distributing the interval between options equally.

An interview was likewise conducted among the five (5) division chiefs to gather additional information on the management of energy resource data. A thorough research within the DOE and online sources for documents, references, policies, and guidelines related to ERDB and REMB's management of energy resource data was likewise conducted.

III. RESULTS AND DISCUSSION

The collection of energy resource data from external sources, particularly data generated from energy developers through the SC system, although with different provisions, are implemented properly. This means that the SC systems are enough to compel the submission, and therefore, collection of energy resource data from the private sector. However, the SC provisions on data collection still need improvement, especially in terms of specifying the type of data from the developers or the regular data requirements needed by the DOE, but are absent from the SC.

In terms of processing or evaluation of collected data from external sources, this research revealed that the DOE has no publicly available manual or guidelines to serve as basis by the evaluators. Instead, this research revealed that the evaluators rely mostly on their experience, technical knowledge, and available general books and other similar reference materials for the processing or evaluation of the collected energy resource data. While there are a number of DOE issuances on data collection and processing, these are limited and difficult to find in both online and physical locations. It is only for coal resources that there exists the Philippine Mineral Reporting Code which provides guidelines on the reporting of exploration results. As for the collection and storage of data from internal sources, there are also no publicly available manuals or guidelines.

This research also confirmed that the storage of energy resource data in both Bureaus are practically the same, that is, and it is done independently using their own filing cabinets and simple online shared folders. It is evident that there are no storage manuals or protocols in place on how to store and access the energy resource data properly and securely. While there is a separate unit within the DOE that caters to the proper handling and storage of energy resource data called the Energy Data Center of the Philippines (EDCP), it is not properly used to its full potential as the central repository of energy data.

IV. CONCLUSION

Energy resource data can be collected from both external and internal sources. External sources pertain to the data collected from energy developers obliged under the SC system. This study revealed that the implementation of the SC system is sufficient in compelling the developers to submit the required energy resource data to be used for government planning related to the country's goal of energy sufficiency. To further the collection of energy resource data, the DOE also conducts its own resource assessment activities to gather and collect additional data on areas often ignored by the private sector.

While the collection of energy resource data is established, the processing or evaluation of the collected data from both internal and external sources are done without a published manual or evaluation guidelines that should serve as the reference for both the DOE evaluators and the developers. While there may be some DOE similar issuances, these are scattered and limited in scope. It is only for the evaluation of exploration results for coal that has the specific technical guidelines for public reporting.

On storage of the energy resource data, the individual units of REMB and ERDB use their own filing cabinets and limited online shared folder for storage. There are also no existing protocols for the storage and access of the collected data. The DOE's central repository of energy data is not used to its full potential for safe, secure, and organized storage.

In order to improve the DOE's management of energy resource data, this study recommends the issuance of appropriate policy such as a Department Order or other similar issuance to harmonize the data management practices of REMB and ERDB. In order to do this, it is recommended that a Technical Working Group should do the following:

1. For Collection of data from external sources. Review the DOE mandate on energy resource data management, align data collection provisions of all energy SC, and inventory and tally the existing data and reports against the total number of issued SCs.
2. For the processing of data from external sources. Identify the guidelines used by the DOE so it can be used by the developers, identify the needed software and hardware necessary, and create internal evaluation guidelines.
3. For the collection and processing of data from internal sources. Identify the guidelines and references used in data collection and processing, identify the needed software and hardware, and create a specific manual or guidelines for resource assessment.
4. For data storage. Use the EDCP as the main storage facility of all energy resource data, and review and update the EDCP's procedure on data storage and access.

ACKNOWLEDGMENTS

This is to acknowledge and offer our sincerest appreciation to the Department of Energy and the Polytechnic University of the Philippines for the opportunity to publish this paper.

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Cr. Sirindhorn International Environmental Park's photo contest project

PARALLEL SESSION I

ROOM B: ENVIRONMENT, BIODIVERSITY AND NATURAL RESOURCES

Conclusion

Biodiversity in the ASEAN Region

By Dr. Theresa Mundita S. Lim, Guest Speaker
Executive Director of the ASEAN Centre for Biodiversity (ACB), Philippines

The ASEAN region covers three percent of the world's surface area, 25 percent of all known plants and animals of which 37 percent are endemic to the region, and 173,000 kilometres of shoreline. Of these countries, Indonesia, Malaysia and the Philippines are considered to be the MegaBiodiverse countries; Cambodia, Laos, Myanmar, Thailand and Vietnam are in the Indoburma region; Brunei, Indonesia and Malaysia are in the Heart of Borneo; and Singapore represents the area of Urban Biodiversity. These areas combined possess an enormous biodiversity resource potential of ecosystem services from mangroves and tropical forests, coastal and marine ecosystems and urban areas.

The various aspects of the region's biodiversity also play a vital role providing cultural, social, economic and biological benefits for sustainable development. The ecosystem services expand to the areas of provisioning, regulating, supporting and cultural.

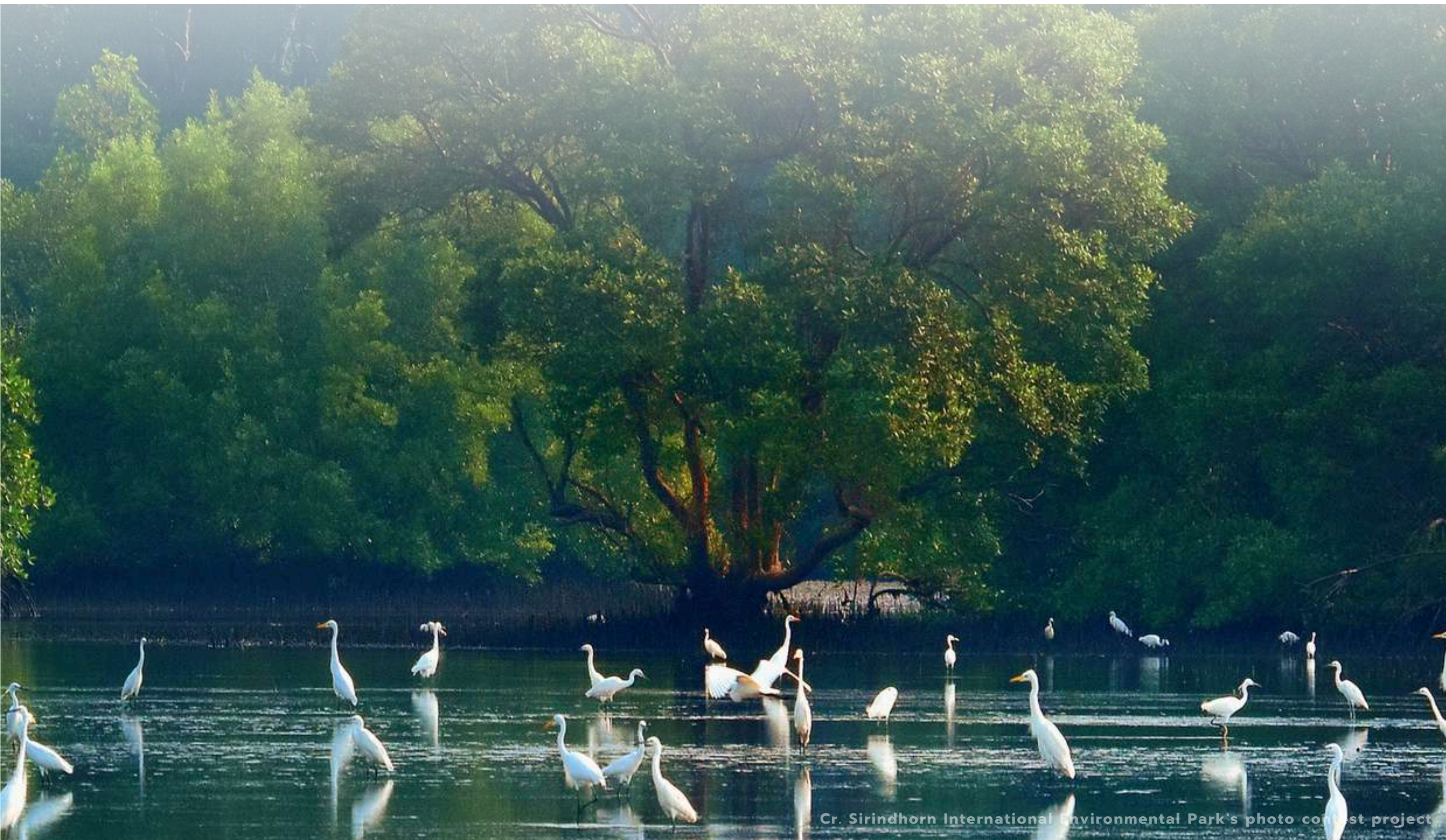
The ASEAN Centre for Biodiversity (ACB) facilitates and coordinates regional efforts of climate change adaptation and mitigation, it mainstreams biodiversity considerations across sectors and pillars, and encourages and engages various sectors to shift to renewable energy. There is a vast interconnectivity of biodiversity with areas and migration routes for waterbirds depending on wetlands for food and water while regulating the population of pests and disease-carrying insects. The ACB coordinates with the other member states to preserve and protect the wetland areas for migratory birds through its ASEAN Flyway Network.

Its Sea Turtle Marine Protected Area Network Project supports the interconnectivity of biodiversity to monitor the nesting and feeding grounds for migratory marine turtles in Southeast Asia. The ACB has conducted research in the interconnectivity of species genetics through a comprehensive molecular phylogeny for hornbills in the region. The ACB works with local stakeholders to develop partnerships for community-based biodiversity conservation to share information on hornbills and flying foxes and their habitats.

Climate change and extreme weather events have made Southeast Asia is one of the most disaster-prone areas in the world. From 2012 to 2018, there have been 1,218 climate-related disasters in the region with an estimated yearly damage of USD 15.9 billion, three times ASEAN's collective annual GDP. There is a 98 percent chance of at least one year between 2023 and 2027 that will exceed the warmest year on record and a 66 percent chance that the global near-surface temperature will be over 1.5 degrees Celsius above pre-industrial temperatures for at least one year in the same 5-year time period.

Coastal and marine ecosystems are natural buffers to storm surge and strong waves and ASEAN's 12 types of forests protect against strong winds and absorb heavy amounts of rainfall, both acting as nature-based solutions to climate change.

The Phu Khieo Wildlife Sanctuary and the Phu Kradueng National Park in northeastern Thailand have been nominated to become ASEAN Heritage Parks (AHP) for their uniqueness, diversity and outstanding values. The Mount Apo Natural Park in the Philippines is and AHP that engages the Bagobo-Tagabawa tribe in forest conservation and is the home to Mount Apo geothermal power plant providing inexpensive, clean and stable power while protecting the endemic Philippine eagle and other species. The ASEAN Green Initiative is a regional medium and large-scale reforestation effort to increase biodiversity and ecosystem services while providing nature-based solutions to climate change.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Collective Actions in Tackling the Triple Planetary Crisis: Thailand

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***Abstract*— The United Nations identifies three interconnected environmental challenges; pollution, climate change, and biodiversity loss. These constitute the Triple Planetary Crisis, threatening global progress towards the UN Sustainable Development Goals (SDGs). Uncoordinated actions addressing these challenges can multiply risks and potentially impact 80% of the SDGs. Climate change alone contributed to extreme weather events in 2019, causing at least USD 100 billion in damages. Projections estimate cumulative damage by 2050 from climate change and environmental degradation to reach USD 8 trillion, reducing global GDP by 3%, and disproportionately impacting poorer regions.**

Thailand, a Southeast Asian biodiversity hotspot with 9% of the world's known species, faces these challenges. To raise awareness and understand the Triple Planetary Crisis' impact, this study reviews the development and implementation of four major Thai initiatives; (i) UN Global Compact Network Thailand, (ii) Thailand Business and Biodiversity Network Alliance, (iii) Thailand Mangrove Alliance, and (iv) PPP Plastics. The study analyses their role in addressing environmental issues, alignment with the SDGs, and contribution to the Kunming-Montreal Global Biodiversity Framework.

***Keywords*— Biodiversity loss, Climate change, Pollution, Thailand, Triple Planetary Crisis**

I. INTRODUCTION

The 21st century presents a unique challenge, the Triple Planetary Crisis. This interconnected web of environmental threats – climate change, biodiversity loss, and pollution – demands our immediate attention. Each element exacerbates the others, creating a cascading effect that jeopardises the planet's health and our well-being.

The consequences of climate change are already upon us. Rising temperatures fuel extreme weather events – heatwaves, floods, and wildfires – while wreaking havoc on infrastructure, livelihoods, and ecosystems. These disruptions threaten food security, water availability, and public health, while disproportionately impacting vulnerable populations.

Biodiversity, the intricate web of life on Earth, is unraveling. Species are disappearing at an alarming rate, jeopardising the very foundation of healthy ecosystems. These systems provide essential services; clean air and water, fertile soil, and climate regulation. Their decline threatens food security, weakens natural defenses against environmental changes, and diminishes humanity's capacity to adapt to a rapidly changing world.

Pollution – from industrial waste to plastic debris and chemical contaminants – poisons our air, water, and soil. It suffocates ecosystems, therefore disrupting vital life cycles. The health impacts are severe with respiratory illnesses, waterborne diseases, and neurological disorders plaguing communities across the globe. Furthermore, pollution disproportionately burdens the most vulnerable, exacerbating social inequalities and creating environmental injustices.

Understanding the Triple Planetary Crisis is critical. Its interconnected nature demands a holistic approach. By acknowledging the gravity of the situation, we can prepare for the challenges ahead and work towards a sustainable future.

Thailand's Response to the Triple Planetary Crisis

This study aims to contribute to the global conversation on tackling the Triple Planetary Crisis by examining ongoing initiatives in Thailand. We specifically review the development and implementation of four major Thai initiatives:

- *(i) The United Nations Global Compact Network Thailand (UNGCNT)*: This network focuses on promoting the Sustainable Development Goals (SDGs) within Thai businesses and encouraging responsible practices that contribute to a more sustainable future.
- *(ii) Thailand Business and Biodiversity Network Alliance (B-DNA):* B-DNA highlights the importance of biodiversity in business sustainability. They work to integrate biodiversity considerations into corporate strategies and operations.
- *(iii) Dow and Thailand Mangrove Alliance:* This alliance focuses on coastal restoration and conservation efforts. Mangroves play a crucial role in coastal protection, biodiversity, and climate change mitigation.
- *(iv) PPP Plastics*: This public-private partnership tackles plastic pollution by promoting a circular economy approach. It includes strategies for reducing plastic waste, increasing recycling, and developing innovative solutions.

By analysing these initiatives, this study explores how Thailand is addressing the Triple Planetary Crisis. We will examine their effectiveness in tackling environmental challenges, their alignment with the SDGs and the Kunming-Montreal Global Biodiversity Framework, and their potential for broader application.

II. METHOD

This study draws upon data collected through the author's direct involvement with the following initiatives from 2018 to 2023.

Fig. 1 A Framework of Thai Initiatives Addressing the Triple Planetary Crisis

III. RESULTS

This study identified four key business-led initiatives in Thailand tackling the Triple Planetary Crisis: climate change, biodiversity loss, and pollution.

i. *The United Nations Global Compact Network Thailand (UNGCNT):* This network with over 100 member companies promotes business sustainability aligned with the SDGs. Notably, UNGCNT advocates for the global goal of conserving 30% of the planet by 2030.

ii. *The Thailand Bio-Diversity Network Alliance (B-DNA):* Established in 2018, B-DNA is the nation's first platform dedicated to strengthening the private sector's role in nature conservation. They focus on biodiversity, contributing to achieving the SDGs and Aichi Biodiversity Targets. B-DNA offers member companies capacity-building and collaboration opportunities on conservation projects. While currently focused on the automobile industry, a notable achievement was mobilising 2,100 employees for a coastal clean-up in 2019, removing 2.8 metric tons of waste.

iii. *Dow and Thailand Mangrove Alliance:* This partnership platform, led by the Dow Thailand Group with IUCN Thailand and the Department of Marine and Coastal Resources, focuses on business engagement in coastal ecosystem restoration and livelihood improvement for coastal communities. The initiative highlights the connection between mangroves as carbon sinks and vital habitats, emphasising the need for integrated climate change and biodiversity actions.

iv. *Thailand Public Private Partnership for Plastic and Waste Management (PPP Plastics):* Established in 2018 during a plastic pollution crisis, PPP Plastics is led by the Thailand Business Council for Sustainable Development (TBCSD) in collaboration with industry leaders. Recognising the importance of multi-sector collaboration, PPP Plastics works with government, public and private sectors, international organisations, and educational institutions to drive sustainable plastic waste management. This includes pilot projects in Bangkok and Rayong.

IV. CONCLUSION.

These initiatives demonstrate the Thai business sector's growing commitment to addressing the Triple Planetary Crisis. Their activities highlight the potential for collaboration between businesses, government, and other stakeholders in achieving environmental sustainability.

V. RECOMMENDATION

The Thai business sector has shown commendable initiative with the four projects identified in this study. However, to effectively address the interconnected challenges of the Triple Planetary Crisis, further collaboration across these business networks and alliances is recommended. Here are some key areas for improvement:

- *Cross-Sectoral Collaboration:* Encourage joint projects between initiatives like UNGCNT, providing business sustainability expertise, and B-DNA or Dow Thailand Mangrove Alliance, with their focus on biodiversity and coastal ecosystems. This fosters a holistic approach, integrating business practices with environmental solutions.
- *Knowledge-Sharing Platforms:* Establish a central platform for knowledge-sharing between the initiatives. Best practices, successful project outcomes, and emerging technologies can be shared across networks, fostering innovation and accelerating progress.
- *Joint Advocacy Efforts:* Combine the advocacy power of UNGCNT, Thailand Mangrove Alliance and B-DNA to push for stronger environmental policies. This unified voice from the business sector can influence government regulations and inspire broader societal change through nature-based solutions.

By fostering stronger collaboration across these networks and alliances, the Thai business sector can amplify its positive impact and emerge as a leader in addressing the Triple Planetary Crisis. This requires a commitment from all stakeholders to share resources, knowledge, and advocacy efforts, creating a unified and powerful force for environmental change.

ACKNOWLEDGEMENT

We would like to thank the Dow Thailand Group for the providing financial support for the implementation of the Dow and Thailand Mangrove Alliance.

Cr. Sirindhorn International Environmental Park's photo contest project

Upcycling Particleboard: A Product Made of Giant Mimosa and Marine Debris

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***Abstract*— The Sirindhorn International Environmental Park (SIEP) is located along the seaside in Cha-am district, Phetchaburi province, around 200 kilometers south of Bangkok, Thailand. The park area comprises mangrove, beach and land forests. All the forest plantation area has been invaded by Giant Mimosa (*Mimosa pigra*) which is a rapidly-spreading alien species, and very difficult to eliminate. Moreover, along the beautiful beach of the park, many kinds of marine debris are found. Consequently, during 2020-2022, the Research and Development Group of the Sirindhorn International Environmental Park in collaboration with the Department of Forest Products, Faculty of Forestry, Kasetsart University (KU) in Bangkok, held a pilot research project that involved development of innovation; upcycling particleboard made from Giant Mimosa and solid waste, i.e. marine debris. The research aimed to determine how a mixture of scraps of marine debris namely, PET, PE, PP, Nylon from fishing nets, EVA foam from slipper shoes and particles of Giant Mimosa at various ratios could make particleboard through an upcycling process. Laboratory tests were furthermore implemented to analyse the properties of samples of particleboard. In this research, particles of Giant Mimosa and scraps of each kind of marine debris were mixed in different ratios and pressed together using no glue or adhesive under appropriate pressure (35 kg/cm^2) and temperature (200° C) for around 10 minutes. The results showed that particles of Giant Mimosa and PET mixed in any ratio could not be adhered together. At the same time, PE and PP could adhere well especially at ratio of 50:50. In addition, the particleboard made of Giant Mimosa (40): PE (30): Nylon (30) and Giant Mimosa (50): Nylon (50) represented fair waterproofing quality. Giant Mimosa (50): PE + EVA foam from slipper shoes (50) did not adhere well, therefore the portion of PE should be increased. In 2021, the KU researchers extended to the production of a quality Japanese folding table and name card boxes made of upcycling particleboard. This research involved an upcycling innovation called "Upcycling particleboard made of Giant Mimosa and marine debris" to serve the circular economy, and induced a good practice to help reduce marine pollution caused by marine debris, and assist waste management for the conservation of the environment and rehabilitation of marine ecosystems. It also could be applied and extended to other relevant research and study. Furthermore, the dissemination of knowledge in the local community could lead to upcycling activities in the future, if encouraged by the government and supporters.**

***Keywords*— Giant Mimosa, marine debris, particleboard, upcycling, circular economy**

I. INTRODUCTION

Following the concept of Bio-Circular-Green Economy (BCG) which is geared to achieve the Sustainable Development Goals (SDGs), and the upcycling of products which is promoted to support the circular economy, a pilot research project was undertaken that involved the development of innovation by upcycling particleboard made of Giant Mimosa and solid waste, i.e., marine debris during 2020-2022 by the Research and Development Group of Sirindhorn International Environmental Park in collaboration with Department of Forest Products, Faculty of Forestry, Kasetsart University.

II. MATERIALS AND METHODS

A. Materials

Materials used for this research are as follows:

1. Particle size of Giant Mimosa
2. PET (Polyethylene terephthalate)
3. PE (Polyethylene)
4. PP (Polypropylene)
5. Nylon (Un-plasticised Polyvinyl chloride: uPVC) from fishing nets
6. EVA (Ethylene Vinyl Acetate) from slipper shoes

B. Methods

1. Preparing particle size of Giant Mimosa
   a. Cutting Giant Mimosa
   b. Drying in solar house
   c. Chipping the wood
   d. Crushing into particle size

Wood cutting Drying in solar house

Wood chipping Wood chips

Particle size of Giant Mimosa

Fig. 1 Preparing particles of Giant Mimosa

2. Preparing small pieces of PET, PE, PP, EVA and nylon

PET (Polyethylene terephthalate)

PE (Polyethylene)

PP (Polypropylene)

EVA (Ethylene vinyl acetate) from slipper shoes

Cutting PET, PE, PP and Eva foam into small pieces @ approx. 0.5-1 cm

Cutting Nylon (Un-plasticised Polyvinyl chloride: uPVC) from fishing nets into small pieces @ approx. 1-1.5 cm

Fig.2 Preparing small pieces of PET, PE, PP EVA and Nylon

3. Setting up the formula (ratio of materials)
    1. Giant Mimosa : PET (50:50)
    2. Giant Mimosa : PET (60:40)
    3. Giant Mimosa : PET (70:30)
    4. Giant Mimosa : PE (50:50)
    5. Giant Mimosa : PE (60:40)
    6. Giant Mimosa : PE (70:30)
    7. Giant Mimosa : MDI (95:5)
    8. Giant Mimosa : PE : Nylon (fishing net) (40:30:30)
    9. Giant Mimosa : PP (50:50)
    10. Giant Mimosa : Nylon (fishing net) (50:50)
    11. Giant Mimosa : PP+EVA from slipper shoes (50:50)
4. Mixing particles of Giant Mimosa and other materials (by ratio)
5. Forming a board
6. Pressing the mixture under appropriate pressure of 35kg/cm^2 and temperature of 200^o C for around 10 minutes
7. Laboratory testing on the properties of samples of particleboard

    Parameters for the laboratory tests on the properties of particleboard:

    1. Moisture Content (%)
    2. Density (g/m^3)
    3. Thickness Swelling: TS (%)
    4. Internal Bonding (MPa)
    5. Modulus of Rupture: MOR (MPa)
    6. Modulus of Elasticity: MOE (MPa)

Fig. 3 Mixing particles of Giant Mimosa and other materials (by ratio) then forming the board and pressing it under appropriate pressure of $35kg/cm^2$ and temperature of $200^{O}C$ for around 10 minutes

III. RESULTS

1. Giant Mimosa and PET cannot be glued together. All samples were not bonded, and were broken.

2. The properties test results shown in Table 1 reveal the following:

1) The samples of Giant Mimosa : PE (70:30) and Giant Mimosa : MDI (95:5) meet the standard value of Moisture Content.

2) No sample meets standard value of Density, while all meet Thickness Swelling (TS) Standard and Internal Bolding.

3) The samples of Giant Mimosa : PE (50:50) and Giant Mimosa : PE (60:40) and Giant Mimosa : PP (50:50) meet standard value of Modulus of Rupture (MOR).

4) Only sample of Giant Mimosa : MDI (glue) (95:5) meets standard of Modulus of Elasticity (MOE).

5) It is found that ratios of PE and PP have an effect on the quality of particleboard. The sample of PE or PP : Giant Mimosa at 50:50 provided the best result.

6) The ratio of PE at 50%, 40% and 30% provide slightly lower quality respectively.

7) The sample of Giant Mimosa : Nylon from fishing nets (50:50) is not as good as Giant Mimosa : PE (50:50) and Giant Mimosa : PP (50:50).

8) The portion of MDI at 5% must be increased in order to glue together the particles of Giant Mimosa efficiently.

9) The ratio of Giant Mimosa and PE or PP at less than 40% is not recommended.

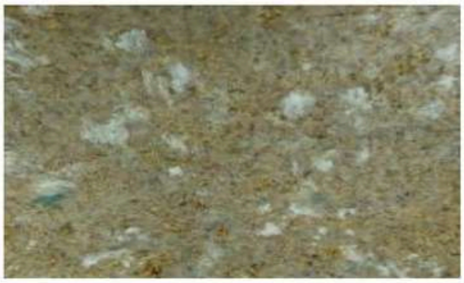
10) The samples of Giant Mimosa (40): PE (30): nylon (30) and Giant Mimosa (50): Nylon (50) represented fair waterproofing quality.

11) The sample of Giant Mimosa: PE + EVA foam from slipper shoes (50:50) is not glued together well, therefore the portion of PE should be increased.

Giant Mimosa : PET (All broken)

(50:50) (60:40) (70:30)

Giant Mimosa : PP (50:50)



Giant Mimosa : PE

(50:50) (60:40) (70:30)

Giant Mimosa : Nylon (fishing net)

(50:50)

Giant Mimosa : MDI (glue)

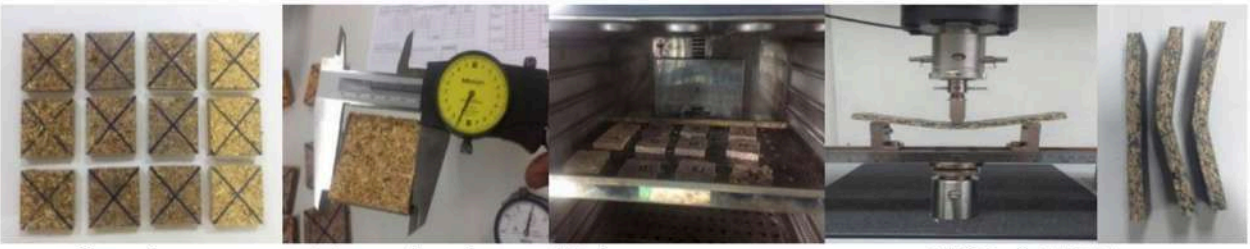
(95:5)

Giant Mimosa : PP+EVA from slipper shoes

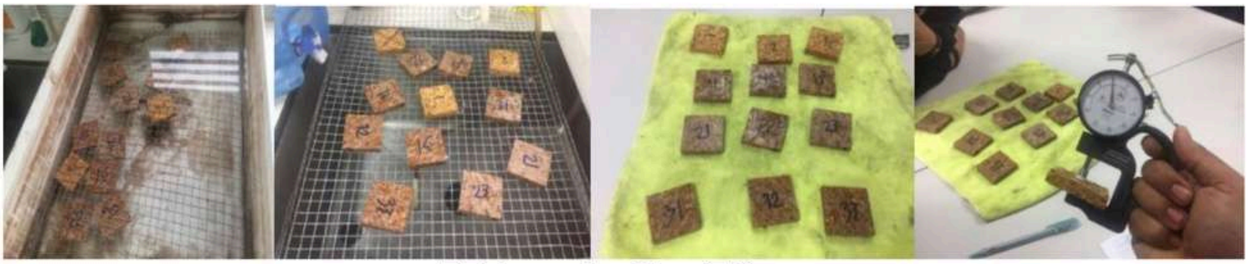
(50:50)

Giant Mimosa : PE : Nylon (fishing net)
40:30:30

Fig. 4 Particleboard made of mixtures of Giant Mimosa and marine debris (PET, PE, PP Nylon and EVA) at different ratios.



Samples | Measuring the size of sample | Moisture content test | MOR & MOE test



Thickness Swelling (TS) test

Internal Bonding test

Fig. 5 Laboratory testing on the properties of samples of particleboard

Table 1 Laboratory test results on the properties of samples of particleboard

Parameters / Particleboard	Moisture Content (%)	Density (g/m^3)	Thickness Swelling : TS (%)	Internal bonding (MPa)	Modulus of rupture : MOR (MPa)	Modulus of elasticity : MOE (MPa)
1. Giant Mimosa : PE (50:50)	2.36	0.77	2.31	2.94	15.74	1165.10
2. Giant Mimosa : PE (60:40)	2.78	0.74	0.85	1.48	15.36	1676.74
3. Giant Mimosa : PE (70:30)	4.01	0.81	7.87	0.64	5.60	648.53
4. Giant Mimosa : MDI (95:5)	6.29	0.79	6.91	1.00	10.00	2071.27
5. Giant Mimosa : PE : Nylon (fishing net) (40:30:30)	1.05	0.71	0.33	1.77	13.54	905.33
6. Giant Mimosa : PP (50:50)	2.92	0.68	0.24	1.47	15.48	1465.44
7. Giant Mimosa : Nylon (fishing net) (50:50)	2.41	0.73	0.28	1.50	10.63	1070.51
8. Giant Mimosa : PP + EVA foam (slipper) (50:50)	2.90	0.62	0.33	1.21	5.59	550.56
Standard value	4-13	400-900	≤ 12	≥ 0.40	≥ 14	≥ 1800

IV. CONCLUSION

1) The quality of particleboard from Best to Worst and its extension can be concluded as follows:

1. Giant Mimosa : PE (50:50) can make indoor furniture, wooden products

2. Giant Mimosa : PP (50:50) can make indoor furniture, wooden products

3. Giant Mimosa : PE (60:40) can make indoor furniture, wooden products

4. Giant Mimosa : PE : Nylon from fishing net (40:30:30) can make outdoor signs, tables, chairs

5. Giant Mimosa : Nylon from fishing net (50:50) can make outdoor sign, table, chair

6. Giant Mimosa : MDI (95:5) can make indoor furniture, wooden products

However, Giant Mimosa : PE (70:30) and Giant Mimosa : PP + EVA foam from slipper shoes (50:50) cannot be extended due to its low quality.

2) This research involved an upcycling innovation called "Upcycling particleboard made of Giant Mimosa and marine debris" to serve the circular economy, and induced a good practice to help reduce marine pollution caused by marine debris and assist waste management for the conservation of environment and rehabilitation of marine ecosystems. It also could be applied and extended to other relevant research and study. Furthermore, the dissemination of knowledge in the local community could lead to upcycling activities in the future, if encouraged by governments and supporters.

V. EXTENSION OF RESEARCH

1) In 2021, the KU researchers produced a quality Japanese folding table and name card boxes from upcycling particleboard.

Fig. 6 Japanese folding table and name card boxes made of Giant Mimosa and PE (50:50) particleboard

2) Dissemination of research results via display and official website of the Sirindhorn International Environmental Park.

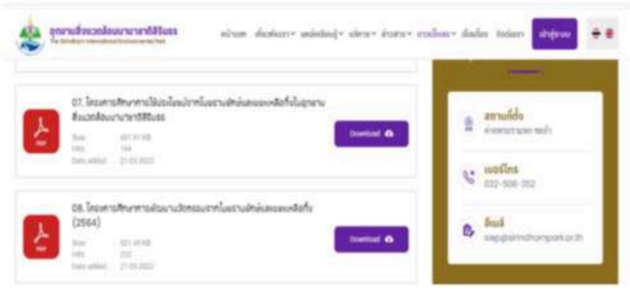


Fig. 7 Display and dissemination of research result via website

3. This research can be applied and extended to other relevant research and study.

VI. RECOMMENDATION

There should be knowledge transfer in the local community. The local administrative organisation or municipality should encourage local communities by providing funds and training for the implementation of this upcycling activity as a good practice to help restore the nature and conserve the environment while local people can also earn money from selling the upcycled products.

ACKNOWLEDGEMENT

We would like to thank Dr. Michel Pardos of Ranong Recycle for Environment Social Enterprise for his donation of fishing nets for our research.

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"Educating for Sustainability, Climate and Disaster Resilience"

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***Abstract*— More than 70% of India is rural and engaged in agriculture and animal husbandry which are susceptible to climate change. Rapidly increasing extreme weather events and other climate-induced disasters pose serious threats to livelihoods, food, nutrition, health, ecology and other securities. RCE Srinagar has been engaged in empowering communities with governance systems at grassroots levels, towards making India 'Climate Smart, Disaster Resilient and Sustainable'.**

Initiatives on improving environment, climate and disaster resilience warrants urgent attention. Our attempt is to strengthen the Panchayati Raj Institutions, the tertiary level of governance having elected representatives (58,218 Gram Panchayats; 915 Urban Local Bodies; 822 Block Panchayats; and 75 District Panchayats).

Schools are a good platform for inculcating environmentally-friendly attitudes in children and for reaching out to the community for a multiplier effect. Through teachers and students, Gram Panchayats (GPs) are being strengthened. School teachers and students help GPs in integrating environmental sustainability, climate resilience and disaster risk reduction preparedness in their 'Gram Panchayat Development Plan'. As a result, schools are making their 'School Disaster Management Plan' and the villages are creating their 'Village Disaster Management Plan'. With mock drills being organised, community members are becoming the first responders during disasters. People now are able to reduce their footprints and increase their handprints. This has been helping in cutting down 'Earth Overshoot' and increasing the community's contribution towards achieving 'One-Planet Living'. Schools doing environmental conservation projects and demonstrating them to Panchayati Raj Institutions are impacting local governance, encouraging them to focus upon skills development and other capacity-building efforts promoting efficient natural resource management, creating income and employment options locally, stopping migration and improving the overall wellbeing of the local population. It is making schools turn-key agents in strengthening the local community, the State and the Nation, with India holding the G20 Presidency this year proving to be an asset to it.

***Keywords*— Earth Overshoot, Gram Panchayat Development Plan, Handprint, One-Planet Living, Panchayati Raj Institutions**

I. INTRODUCTION

India is a federal union comprising 28 states and eight union territories for a total of 36 entities. The states and union territories are further subdivided into districts and subdivisions. At present, India has 764 districts, 6,311 Community Development Blocks, 240,561 Gram Panchayats and 4,041 Urban Local Bodies (ULB). Gram Panchayats and ULBs are key units for achieving the SDGs, and other local, national and global targets.

India is a vast country, recently surpassing China in population and now the world's most populous country. Though India has been making all-round efforts to contain its population, it seems that it will continue to grow up to five or six billion and then stabilize. So, we really need to plan for how to live with a six billion population.

Climate Change poses serious threats to the planet, people and prosperity. Rural India is highly vulnerable to climate change impacts. Climate-induced disasters such as floods, drought, fire, cold waves and heat waves destroy the livelihood options of people, aggravating poverty and forcing migration, turning them into climate refugees. Areas affected by floods and droughts have been increasing every year. The country sees floods in some areas and drought in others at the same time. Climate change impacts destroy much of the development achieved and in fact, reverse the progress made. Climate-proofing of development planning is much needed. India is largely rural and Gram Panchayats, the lowest level of Panchayati Raj Institutions (PRIs; a three-tier governance system in the country), mainstream DRR into their Gram Panchayat Development Plan (GPDP).

II. THE CHALLENGES

The state of Uttar Pradesh (UP), situated in the northern part of the country, has the highest population of 204.2 million, which is about one-fifth of India's total population. It has the highest population density of 828 people per sq. km, which is almost double of the national average of 481 people per sq. km. The state is faced with acute poverty, hunger, malnutrition, anaemia, high infant mortality, gender inequality, violence against women, female feticide, illiteracy, poor sanitation, health, hygiene, all kinds of pollution, and poor air quality. The state is highly prone to disasters, both natural and manmade. and suffers huge losses every year because of them. UP possesses a large proportion of India's vulnerable population. Eight districts of UP are 'aspirational districts' fairing lowest in the development index.

Having a large population, UP significantly influences Indian politics and decision making. UP achieving SDGs and other global targets will help India achieve the targets. However, UP ranks very low and its progress in most SDGs remains poor [2]. Extreme weather events, floods, drought, heat waves, cold waves, and fires pose serious threats to food, nutrition and health security. About 70% of the population lives in rural areas, engaged in agriculture and animal husbandry which are susceptible to climate change and thus making rural populations insecure.

III. INTERVENTIONS BY RCE SRINAGAR

RCE Srinagar has been working closely with the local governments and other needed stakeholders in advancing policy, capacity-building and skills development, mobilizing youth, generating action at the community level promoting sustainable development, progress and prosperity and through this helping the country achieve global targets. RCE Srinagar's projects awarded 'Outstanding Flagship Projects' by UNU-IAS during 2016 "Climate Smart and Disaster Resilient Communities in Indian Himalayan Region" in 2019 "Mainstreaming DRR Making India Climate Smart, Disaster Resilient and Sustainable", and in 2020 "Empowering Community for Combating COVID-19 Pandemic" [1]. Moving forward, RCE Srinagar got engaged in empowering villages and urban local bodies and the governance system at the grassroots level, towards making their development plans participatory, inclusive and integrating SDGs in them.

The state of UP held its Panchayat elections in May 2021. It is most appropriate and the need of the hour to build capacity of elected PRI members in making their development plans smart, participatory, inclusive, reaching out to the last mile, with the marginalized people, and integrating SDGs in them. PRI members need to be apprised of various schemes of Central and State governments that they can avail to benefit the development of their panchayats. PRI members need to be motivated in making their panchayats self-financed, generating their own income and reducing their dependence on government money. PRIs need to involve all concerned departments and agencies realizing convergence while implementing their development plans utilizing available resources most efficiently.

RCE Srinagar has been advocating this for more than the past five years. Working with local governments, RCE Srinagar has many concepts (like climate resilience, DRR) mainstreamed in government development plans and now joined the integration of SDGs into the 'Development Plans' of Gram, Block and District Panchayats.

A. Some Achievements

The activities helped in overhauling and strengthening the governance system at the community level, bottom-up approach. It built the capacity of elected PRI members and gave them skills for managing their constituency and serving them best in sustainable development, generating local action, making efficient use of the resources available, making convergence, bringing all the stakeholders together, making development inclusive, and making PRIs self-sufficient. The members elected have their term for five years. These trainings in the beginning of their term will prove very useful helping them serve their constituencies better for the remaining term. The SDGs and other global targets will become integrated in the development plans of the PRIs and we are sure this will help achieve all the targets in a successful manner making development sustainable, people-oriented, inclusive and driven by the community itself. Sustainable development becomes a reality when the community is empowered, and development plans emerge, made and implemented by the community. We need to encourage local skills, successful community initiatives, change agents and nurture them.

B. Lessons Learnt

For large scale, long-lasting results and sustainability of the interventions undertaken, it is important to liaison and partner with the government and get things mainstreamed. Government departments have constraints in reaching out to the last man, and RCEs can bridge this gap by taking government interventions and their benefits to the rural population. RCEs' expertise, if their own, and added with what is gathered from Regional and Global RCE events, is a fantastic and valuable resource to be made available to local governments to put it into practice and getting translated into action [1]. RCEs need to work closely with the governments to get the RCE community recognised, their credentials established and putting RCEs' strengths into local action achieving SDGs and making sustainable development a reality. Today, there are 190 RCEs globally of which 71 are in the Asia-Pacific Region. India has 14 and RCE Srinagar is one of them, and it was acknowledged by the United Nations University in September 2011.

C. Challenges and Limitations in the Way of Further Development

India's population, more so the UP's, is growing fast, depleting natural resources, with rampant and fast increasing inequality leading to the rich getting richer and the poor getting poorer, keep adding to the vulnerable population and the vulnerabilities making our efforts always falling short in achieving climate change, sustainability and DRR Preparedness. The rapidly increasing adverse impacts of climate change are very dynamic and require continuous efforts to deal with them. It requires more and huge resources to cope with the increasing risk. The widening gap between DRR Preparedness and the increasing risk will remain a challenge for quite some time unless the entire machinery and process of development is corrected and development is made sustainable. Climate change has been increasing extreme weather events which adds to the disasters especially floods and drought, the two being major disasters in UP. Except for earthquakes, most other disasters are climate change-induced and have been increasing very rapidly. State agencies don't have adequate capacity and resources to cope with the rapidly increasing risk of disasters. Projects though focused at Revenue Department officials have involved multi-stakeholders like schools, Gram Panchayats, municipalities, NGOs and the community. It builds DRR capacity across the board. The initiatives enhance synergy, partnership and collaboration amongst various departments and stakeholders.

IV. SAFETY OF ALL, EVERYWHERE, ALL THE TIME

A. The Link Between Schools & Community

Education systems, teachers, and students, constitute important stakeholders. They need to be informed about climate change issues and facilitated to take actions on climate solutions. Action-based climate change education to students and teachers at all levels - elementary, secondary, and higher education - is the need of the hour. It becomes easier to reach out to the community through students and teachers bringing multiplier effects. Students should be able to learn what they live and live what they learn, and knowledge gained needs to be translated into action, thereby bridging the gap between knowledge and action.

Every village has at least one school and bigger villages have more than one. The schools were made aware of DRR and helped in preparing their 'School Disaster Management Plan'. The schools and their Gram Panchayats work together for DRR of their citizens. School teachers and students become an asset to the Gram Panchayats in helping them to create DRR awareness and preparing 'Village Disaster Management Plans'.

B. Project 'Mustaidi'

One of our important initiatives of educating for sustainability, climate and disaster resilience worth mentioning is our work in Jammu & Kashmir during 2014 deluge. Besides distributing relief materials to the most affected people, psycho-social care programmes were organized for the children and efforts were made to restore the education in schools. Through the project named *Mustaidi* (in Urdu language) meaning readiness or alertness, DRR programmes were conducted for the children in schools and the larger village communities through an extensive community-based and disaster-risk management approach.

The Kashmir Valley being very prone to disasters, becomes a requisite that the residents of the Valley must be prepared to handle any disaster or emergency as well as bounce back to normalcy. Hence the project, *'Mustaidi'*- Promoting Community-Based Disaster Management was launched to mitigate the impact of disasters on life and property through disaster risk reduction awareness and preparedness amongst the community through the students and teachers.

DRR School Programmes have provided children the opportunity to mitigate the impact of disasters through education, awareness and capacity building of school teachers, children and education department representatives. The main purpose of DRR school programmes was to make schools safer, and at the same time facilitating schools to become centres for community action, training and coordination on DRR. These school programmes are committed to engaging children, teachers, parents, school management, local authorities and other key actors in disaster risk management. Being 'DRR Prepared', students and teachers now feel more confident in handling any disaster situation and they will be able to help themselves, and not become the victim, but become the first responder to help others in need.

Teachers play a crucial role in class especially in aspects of disaster education. School children are a very vulnerable group and, therefore, should learn to protect themselves against disasters and to act in the proper manner during emergencies. The teachers are also very effective in their capacity to raise awareness and encourage changes in the families and communities. Together they can help to educate their families and the community about natural disasters, ways to reduce risks and to be prepared for emergencies.

After school and during holidays children stay at home. A child, besides being in the school, has to be safe at home also, has to be safe everywhere. Safety of a child also includes safety of all his other family members and friends, and safety all the time. Therefore, the *'Mustaidi'* School Safety programme covered DRR preparedness in schools as well as villages (residences) involving students and teachers and the community and PRIs. Thus, our safety programme encompasses safety of all, safety everywhere, and safety all the time.

It's not just about the physical safety of the child but the overall well-being which includes social and psychological security. Awareness and education are the keys for building safe and disaster-resilient communities. Schools can play a vital role in reducing disaster risk through education and innovation. Teachers and students can play an active role in transferring knowledge and skills on disaster preparedness, prevention and mitigation to their families, friends and the larger community, consequently aiding in the development of a culture of safety in society. The community reached out through students - where they live and come from to schools – and is now able to make the contingency plans of their areas that come in handy during any disaster in future avoiding loss of life and property.

Community-based disaster risk reduction is an effort to reduce disaster threats and vulnerability of communities and improve the capacity of preparedness to handle disaster. These efforts are planned and implemented by the community as the main actor. In this, the community is actively engaging in reviewing, analysing, handling, monitoring, evaluating and reducing disaster risk that exist in the area, mainly by utilising local resources to ensure sustainability.

All the interventions piloted by us went mainstream and are being continued making significant reach helping people become environmentally sensitive and friendly, living in harmony with nature, adjusting to adverse impacts of climate change and developing resilience to disasters. As climate change is going to pose much bigger challenges in the years to come with the thread of sustainability further breaking down, educating for sustainability, climate action and disaster resilience attains high priority.

V. CONCLUSION

Humanity's ecological footprint having reached much beyond Earth's biocapacity; Earth Overshoot, manifests itself in breaking sustainability, environmental degradation, climate change, consequently extreme weather events, environmental catastrophes, disasters and enumerable other problems. We need to make the world climate-smart, disaster-resilient and sustainable. To make our dream of 'Green Earth, Blue Sky and Disaster Resilient Community' come true, we need to reduce our footprint, increase our handprint and get out of the Earth Overshoot achieving 'One-Planet Living' ensuring well-being of all, everywhere, all the time [3], [5], [6], [7]. Up until 1970, humanity was within 'One-Planet Living'. Since that Earth Overshoot started, at present there is requirement of 1.75 Earths. The Earth overshoot manifests in the form of all of the mosaic of problems humanity is faced with today.

'Handprint' (www.handprint.in) represents positive action towards sustainability. It was developed by the Centre for Environment Education, India (www.ceeindia.org) and introduced in 2005 during the launch of the 'Decade of Education for Sustainable Development'. November 27 is celebrated as the 'Global Handprint Day', and there is a handprint calculator like the footprint calculator.

India has been advocating LiFE (Lifestyle for Environment), for all of us to come together and take forward LiFE as a movement, instead of mindless and destructive consumption, and mindful and deliberate utilisation is the need of the hour. LiFE is a public movement to mobilize individuals to become 'Pro-Planet People' [4]. The Prime Minister of India introduced Mission LiFE to the world at the 26thUN Climate Change Conference of the Parties (COP26) in Glasgow, in year 2021. We need to bring about some changes in our lifestyle, not giving up comforts we are accustomed to but certainly by cutting out waste and being a little more conscious.

Mission LiFE is an India-led, global mass movement to nudge individuals and community action to protect and preserve the environment. India's per capita carbon footprint is 60% lower than the global average, and sustainability has always been a part of Indian tradition, culture and values. "PARAMPARA - India's Culture of Climate Friendly Sustainable Practices" is an excellent publication compiled by the Centre for Environment Education.

During the COVID-19 pandemic, the lockdown of 68 days (from 25 March 2020 to 31 May 2020) helped planet Earth regenerate and Earth Overshoot was cut down by 24 days in 2020. Since the lockdown was forced upon us to handle the pandemic, people faced hardships. However, regulating human activities voluntarily, not forced upon by any pandemic or disaster, will help achieve 'One-Planet Living' by 2050, even before. Cutting down Earth Overshoot by just five days every year will help us attain One-Planet Living by 2050 [3], [6], [7].

Action is the antidote to despair, action at a scale, commensurate with the magnitude of the problem, if the entire population of the planet [5] becomes sensitive and takes action, Earth will become sustainable, and all environmental problems will get solved.

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Cr. Sirindhorn International Environmental Park's photo contest project

Fostering a Green Economy and Disaster Preparedness through Supreme Audit Institutions: A Foresight Approach

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Abstract— **This research explores the crucial role Supreme Audit Institutions (SAIs) can play in fostering a green economy and enhancing disaster preparedness. As the world grapples with the twin challenges of environmental degradation and disaster risks, SAIs have a key role to play in ensuring effective use of resources, accountability, and transparency. This study uses a foresight approach to explore, anticipate, and shape the future role of SAIs in this context. The methodology integrates a systematic review of literature, expert interviews, and scenario planning to develop four potential scenarios based on identified trends and uncertainties. These scenarios - "Green Pioneers", "Green Gamblers", "Cautious Planners", and "Reactive Laggards" - represent different futures for SAIs in promoting a green economy and disaster preparedness. The study offers valuable insights and strategic recommendations for SAIs and policy-makers, contributing to policy design and implementation in fostering a green economy and enhancing disaster preparedness.**

I. BACKGROUND

As the global economy faces the escalating threats of climate change and environmental degradation, the green economy concept has gained significant attention. Supreme Audit Institutions (SAIs) have a key role to play in fostering a green economy and enhancing disaster preparedness. SAIs, with their mandate of auditing government revenues and expenditures, can support the transition towards a green economy and help in disaster management by ensuring the effective use of resources, accountability, and transparency. However, there is a need for a strategic approach that incorporates foresight methodology to effectively leverage the role of SAIs in this transition.

The concept of a green economy has been steadily gaining momentum over the past decade. It is based on the principle of sustainable development, which is the process of meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. This has become even more critical in the 'next normal' post the COVID-19 pandemic, as the world grapples with both recovery and the ongoing climate crisis.

The importance of the green economy in the next normal is manifold:

- Climate Change Mitigation: As we continue to witness the catastrophic effects of climate change, transitioning to a green economy is imperative for the reduction of greenhouse gas emissions and to mitigate the impacts of climate change.
- Economic Recovery and Resilience: The green economy can offer a sustainable path for economic recovery post the COVID-19 pandemic. It can generate new jobs and industries that are more resilient to future shocks, be it environmental, economic, or health-related.
- Sustainable Resource Use: A green economy emphasises sustainable resource use and circular economic principles, which are key to addressing resource depletion and waste issues.
- Social Equity: The green economy has the potential to address social equity issues by creating new, decent jobs and reducing pollution-related health problems that disproportionately affect disadvantaged communities.

The role of Supreme Audit Institutions (SAIs) in supporting the green economy and disaster preparedness is crucial:

- Ensuring Accountability and Transparency: SAIs have the mandate to audit government revenues and expenditures. By auditing environmental and disaster management policies and programs, they can ensure that funds are being used effectively and efficiently, promoting accountability and transparency.
- Promoting Good Governance: Through their audits, SAIs can encourage governments to integrate sustainability and disaster preparedness into their policies and programs, promoting good governance.
- Risk Identification and Mitigation: SAIs can play a significant role in identifying and assessing risks related to environmental degradation and disasters. Through their audit findings and recommendations, they can help governments mitigate these risks.
- Capacity Building: SAIs can facilitate knowledge and capacity building in the government sector by highlighting best practices and areas for improvement in environmental management and disaster preparedness.

Therefore, the role of SAIs in fostering a green economy and enhancing disaster preparedness is fundamental, necessitating a strategic approach that effectively leverages their potential. This research aims to explore how a foresight approach can help SAIs meet this role effectively.

II. RESEARCH QUESTION

How can Supreme Audit Institutions (SAIs) foster a green economy and improve disaster preparedness through a foresight approach?

III. RESEARCH OBJECTIVES

1. To explore the role of SAIs in promoting a green economy and disaster preparedness.

2. To understand the potential of the foresight approach in enhancing the effectiveness of SAIs.

3. To design scenarios based on the foresight approach for SAIs' role in a green economy and disaster preparedness.

4. To provide actionable recommendations for SAIs and policy-makers to implement these scenarios.

IV. RESEACH METHOD

This study uses a foresight methodology which integrates systematic review of literature, expert interviews, and scenario planning. The foresight approach is employed to identify emerging trends, challenges and opportunities in the context of SAIs, green economy, and disaster preparedness. Four potential scenarios are developed based on the identified drivers and trends.

The foresight approach is an effective methodology for exploring, anticipating, and shaping the future, particularly useful in the context of complex and uncertain environments. It involves a systematic, participatory, future-intelligence-gathering and medium-to-long-term vision-building process to inform present-day decisions and mobilise joint actions. Here's how we can use this approach in our research:

Step 1: Horizon Scanning

The first step involves gathering data about current trends, emerging issues, and future uncertainties related to the green economy, disaster preparedness, and the role of Supreme Audit Institutions (SAIs). This can be achieved through a systematic review of academic literature, policy documents, industry reports, and news articles, as well as expert interviews.

Step 2: Trend Analysis

After collecting the data, we'll identify and analyse key trends, challenges, and opportunities. This analysis helps in understanding the driving forces behind these trends and their potential implications on the green economy and the role of SAIs.

Step 3: Scenario Development

Based on the identified trends and uncertainties, we'll develop a set of plausible future scenarios. Each scenario will represent a different version of the future where SAIs play varying roles in fostering a green economy and disaster preparedness. This step will include a creative, participatory process involving a diverse group of stakeholders.

Step 4: Implication Analysis

For each scenario, we'll analyse the potential implications for SAIs and the broader society. This step helps in understanding the risks and opportunities associated with each scenario, informing strategic decision-making.

Step 5: Strategy Development

Based on the scenario and implication analysis, we'll develop a set of strategic recommendations for SAIs to foster a green economy and improve disaster preparedness. These strategies will be designed to be robust across multiple future scenarios, enabling SAIs to navigate uncertainty and change effectively.

Step 6: Monitoring and Updating

Finally, as the foresight approach is an ongoing process, it's important to regularly monitor the external environment and update the scenarios and strategies as necessary. This can involve setting up a 'watchtower' to monitor key indicators and trends, and organising regular workshops or meetings to discuss and update the scenarios and strategies.

Throughout this process, we'll use various foresight tools and techniques, such as PESTEL analysis (Political, Economic, Social, Technological, Environmental, Legal), SWOT analysis (Strengths, Weaknesses, Opportunities, Threats), and Delphi surveys (a method for consensus building among a panel of experts).

By using this foresight approach, we aim to provide SAIs and policymakers with a robust foundation for strategic planning and decision-making, helping them to navigate the complexities and uncertainties of fostering a green economy and enhancing disaster preparedness.

V. CONTRIBUTION OF STUDY

This study contributes to the existing body of knowledge by exploring a novel perspective on the role of SAIs in fostering a green economy and disaster preparedness. It introduces the foresight approach to this context, providing a strategic tool for SAIs and policy-makers. Moreover, the study offers actionable scenarios and recommendations, contributing to policy design and implementation.

VI. REVIEW OF LITERATURE

The literature review focuses on three key areas: the role of SAIs in promoting a green economy and disaster preparedness, the concept of the green economy and its relation to disaster preparedness, and the application of the foresight approach in strategic planning and policy-making. The review reveals that while there is substantial research on the individual roles of SAIs, green economy, and disaster preparedness, there is a significant gap in understanding how these can be integrated using a foresight approach.

The literature review for this research will focus on three primary areas of study: the role of Supreme Audit Institutions (SAIs) in promoting a green economy and disaster preparedness, the concept of the green economy and its relation to disaster preparedness, and the application of the foresight approach in strategic planning and policy-making.

- *Supreme Audit Institutions (SAIs) in Green Economy and Disaster Preparedness*

Studies in this area examine the critical role of SAIs in promoting sustainable development, environmental protection, and disaster preparedness. These institutions have a mandate to audit government revenues and expenditures, ensuring that funds are used effectively and efficiently. Literature reveals that SAIs, through their audit functions, can ensure accountability and transparency, promote good governance, identify and mitigate risks, and facilitate knowledge and capacity building in the government sector.

- *Green Economy and Disaster Preparedness*

The green economy is a development model that fosters economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. The literature suggests that transitioning to a green economy has the potential to generate new jobs and industries, reduce greenhouse gas emissions, use resources sustainably, and enhance social equity. Moreover, it has been argued that a green economy can enhance disaster preparedness by promoting sustainable land and resource use, reducing vulnerability to climate change impacts, and fostering resilience.

- *Foresight Approach in Strategic Planning and Policy-making*

The foresight approach, used extensively in strategic planning and policy-making, involves exploring, anticipating, and shaping the future to inform present-day decisions. It incorporates a systematic review of literature, expert interviews, and scenario planning. The literature shows that this approach can help organisations and governments navigate the complexities and uncertainties of the future, making them better equipped to handle changes and challenges.

The review reveals that while there is substantial research on the individual roles of SAIs, green economy, and disaster preparedness, there is a significant gap in understanding how these can be integrated using a foresight approach. This research aims to fill this gap and contribute to the existing body of knowledge.

VII. RESULTS

Four scenarios were developed considering different combinations of two key factors: the level of commitment to a green economy and the degree of disaster preparedness. The scenarios ranged from ***"Green Pioneers"*** (high commitment to green economy, high disaster preparedness), ***"Green Gamblers"*** (high commitment to green economy, low disaster preparedness), ***"Cautious Planners"*** (low commitment to green economy, high disaster preparedness), and "***Reactive Laggards***" (low commitment to both).

Level of Commitment to green economy / Degree of disaster preparedness	High	Low
High	Green Pioneers	Green Gamblers
Low	Cautious Planners	Reactive Laggards

Four scenarios were designed to reflect different potential futures for Supreme Audit Institutions (SAIs) in promoting a green economy and disaster preparedness. The scenarios were developed based on two critical factors: the level of commitment to a green economy and the degree of disaster preparedness.

Scenario 1: Green Pioneers - This scenario envisions a future where there is high commitment to a green economy and high disaster preparedness. SAIs in this scenario actively audit environmental policies and disaster management strategies, ensuring accountability and transparency. They play a significant role in promoting sustainable development and resilience, contributing to a robust green economy and well-prepared society.

Scenario 2: Green Gamblers - This scenario represents a future where there is high commitment to a green economy but low disaster preparedness. While SAIs contribute to the promotion of sustainable practices and green growth, their role in auditing disaster management strategies is lacking, leading to potential vulnerabilities.

Scenario 3: Cautious Planners - This scenario, there is low commitment to a green economy but high disaster preparedness. SAIs focus more on auditing disaster management strategies and less on environmental policies, missing opportunities to foster sustainable growth.

Scenario 4: Reactive Laggards - This scenario envisions a future where there is low commitment to both a green economy and disaster preparedness. SAIs in this context tend to maintain a traditional focus on financial audits, missing opportunities to promote sustainability and resilience.

Each scenario presents different challenges and opportunities for SAIs and society at large, providing a comprehensive understanding of potential futures. They serve as a tool for strategic planning, helping SAIs and policy-makers navigate the complexities and uncertainties of fostering a green economy and enhancing disaster preparedness.

VIII. RECOMMENDATIONS AND CALLS FOR ACTION

1. SAIs need to incorporate a foresight approach into their strategic planning to proactively address future challenges and opportunities.

2. SAIs should play a more active role in auditing environmental policies and disaster management strategies.

3. Capacity-building in SAIs is crucial to equip them with the necessary skills to audit for a green economy and disaster preparedness.

4. Policy-makers should create an enabling environment for SAIs to contribute more effectively to fostering a green economy and disaster preparedness.

5. Further research should be conducted to explore the implementation of the foresight approach in SAIs in different contexts.

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Balancing Economy Productivity and Community Well-Being: Impacts of Urban Green Spaces in Valenzuela City's Infrastructure Development

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***Abstract*— With the emergence of the Fourth Industrial Revolution, also known as "Industry 4.0", the Philippines has experienced economic dynamism and urbanisation, necessitating further infrastructure developments. However, the rapid pace of urbanisation has resulted in the congestion of common-pool resources and a decline in ecological sustainability, particularly in highly urbanised areas. Moreover, the presence of economic activities in cities has limited space for local communities to thrive. Thus, the study aims to emphasise the importance of striking a balance between economic productivity and the well-being of local communities by promoting the establishment of urban green spaces and implementing innovative practises. The objective of this research is to analyse the significant impacts of infrastructure development projects in Valenzuela City, particularly the implementation of urban parks and green spaces. Ultimately, the research highlights the need for sustainable development that benefits both the citizens, economy and the environment. The findings of the study have significant implications for the implementation enhancement of urban green space projects in Valenzuela City.**

***Keywords*— Economic Productivity, Ecological Sustainability, Green Space, Infrastructure Development, Urban, Urbanisation, Valenzuela City**

I. INTRODUCTION

The Philippines has the second-highest average urban density in the East Asia and Pacific region, leading to rapid urbanization and the conversion of vegetation, forests, and agricultural lands into industrialized and high-rise buildings (Ichimura, 2003). This statement was corroborated by Baker et al. (2017), in expressing that without corresponding investments in urban infrastructure, the rapid urbanisation will result in congestion, diseconomies, lack of basic services, increased risk of natural disasters and pollution, and rising commuting costs. This being said, planning and managing green spaces, particularly in densely-populated areas, can be challenging. Urban Green Areas (UGAs) are strategically significant for enhancing urban life (Fasihi, 2019), supporting urban ecology and identity, and improving air quality and encouraging physical activity (Celik et al., 2021).

Urban parks are influenced by socioeconomic, political, and cultural values due to the fact that urban green spaces are open for consumption to all citizens. This statement was confirmed by Dharmawan and Rachmanyah (2020), stating that local governments may prioritize economic growth and reducing UGAs, potentially negatively impacting the environment. Planning decisions regarding land resources are tied to institutional frameworks (Chan & Wang, 2019). Reliable statistics on managing UGAs are essential for effective urban planning and management. Whether the urban green infrastructure is maintained as a holistic system or as isolated islands that fall under the purview of many stakeholders determines the ability of urban green areas to benefit urban residents (ecosystem services). Urban green infrastructure planning, management, and research face significant hurdles due to the diverse datasets for urban green space based on various definitions, data sources, sampling procedures, periods, and scales (Feltynowski et al., 2018).

Park development is an essential component of urban development that aids cities in attaining environmental sustainability (Nobles, 2023). According to a thorough analysis by Konijnendijk et al. (2013), urban parks have a favorable impact on the economy, society, and environment. Building sustainable cities necessitates achieving these benefits, which include increasing property values, promoting tourism, and improving local residents' health and well-being. However, human activities, such as urbanisation and industrialization frequently cause environmental deterioration, such as soil compaction, nutrient depletion, and biodiversity loss (Seifollahi-Aghmiuni, 2022). As a result, the Philippines ranks 111th out of 180 countries in the Environmental Performance Index in terms of ecosystem health and vitality (Wendling et al., 2020). To deal with this problem, local government units (LGUs) have implemented sustainable infrastructure development projects that consider the environment's carrying capacity in order to balance economic growth and environmental conservation.

Valenzuela city, located in the northern part of Metro Manila, Philippines, has been at the forefront of this movement towards sustainable development. Valenzuela has a population of over 700,000 people and a total land area of 45.75 square kilometers (PSA, 2022). Its strategic location near major thoroughfares and ports has made it an ideal location for various businesses and industries. The city has 45 parks and playgrounds, which are recognized as essential components of urban ecology and biodiversity. The World Wildlife Fund (WWF) (2016), has cited Valenzuela City as one of the few cities successfully integrating biodiversity conservation into local development plans.

This makes Valenzuela City an excellent city to conduct research on redeveloping parks and achieving ecological sustainability through infrastructure development. As urbanization continues to bring about environmental challenges, such as biodiversity loss, air pollution, and climate change, exploring innovative solutions promoting sustainable urban development is crucial. By focusing on Valenzuela City's parks and open spaces, researchers can examine the effectiveness of infrastructure development in creating a more eco-friendly and liveable urban environment.

Moreover, this research explores factors contributing to the city's liveability, particularly focusing on ecological and socio-economic aspects. It aims to address the challenges posed by underlying environmental crises and seeks innovative solutions to ensure progress without compromising sustainability. Additionally, identifying the most relevant and trustworthy green space data sources can help bridge the gap in evaluating the programme and serve as a basis for enhancing policy implementation.

Ultimately, the results of this research can offer valuable suggestions for potential realignments of objectives and improvements in the implementation and maintenance of green infrastructures in Valenzuela City.

II. METHODOLOGY

This research used mixed method research design in data gathering, data analysis, and interpreting of the findings. According to Wilson (2016), "Mixed Method Research" is referred to as the use of data gathering techniques that gather both quantitative and qualitative data. The use of a mixed method approach enhances the possibility that the total amount of data gathered is richer, more significant, and ultimately more effective in addressing the research questions. Mixed method research recognises that all approaches have inherent limitations and flaws. Combining two methods may be preferable to using just one since it is more likely to yield insightful information about the research phenomenon that cannot be fully comprehended by utilising only qualitative or quantitative methods. Multiple data sources can be integrated and combined in a mixed method approach to help with the analysis of complicated situations (Poth & Munce, 2020). The use of mixed method research entails deliberate data consolidation, which enables researchers to seek a broad perspective for their study by allowing them to see an event from multiple perspectives and research lenses (Shorten & Smith, 2017).

As stated by Elderbrock et al. (2020), mixed method design has been empirically shown to significantly contribute to the evaluation and development of urban green space. Gathering qualitative or quantitative data enables green space development to concentrate on the most important urban ES that the target land area can actually supply.

To ascertain the significant implications of urban parks and green spaces within an urban setting, researchers utilise various forms of assessments and investigations to ensure the accuracy and reliability of the findings. The researchers meticulously select qualified respondents whose viewpoints are relevant to the study and apply diverse methodologies to analyse the responses provided by participants. The outcomes derived from these responses are then used to formulate well-informed conclusions. Finally, comprehensive analysis of the findings leads to the formulation of recommendations based on the study's outcomes and insights from the respondents.

In terms of data gathering, the researchers used a literature review to gather and analyse existing hypotheses and assumptions of studies conducted prior to the development of this research. This literature review covers six themes, which are as follows: The Role of Urban Parks for a Liveable City, which argues that urban parks improve livability, foster well-being, mitigate climate change, improve the urban environment, and address social and environmental issues. Understanding Urban Space Parameters, which concludes Urban green spaces boost well-being by providing ecological services, promoting multi-functionality, accessibility, and creating convivial surroundings, benefiting all members of the community. Ecological Balance through Urban Green Space concludes urban green spaces promote ecological balance, biodiversity conservation, climate change mitigation, and sustainable development, proper planning, distribution, and maintenance are essential for their effectiveness. Institutional Programs for Developing Urban Green Spaces concludes institutional programmes for urban green spaces aim to improve residents' well-being, promote sustainability, and address environmental and social challenges. Environmental Sustainability and Resilience concludes encouraging sustainability and resilience in urbanisation requires community engagement, context-sensitive design, and clear definitions. Balancing Ecological and Socioeconomic Relationships concludes that achieving ecological preservation and socioeconomic growth in urban green-blue infrastructures (UGBIs) requires considering ecological capabilities, incorporating socioeconomic inter gradation, addressing landscape fragmentation, stakeholder involvement, and sustainable business strategies.

In addition, the researchers strategically used a survey questionnaire and semi-structured interview questionnaire to gather quantitative and qualitative information that would answer the statement of the problems identified in the study. A survey was administered to 150 park visitors obtained through a non-probability sampling technique. Subsequently, an interview was conducted for the key informants of the study, each set of questions was specifically designed based on their designation as policy implementers in the local government. In terms of data analysis and interpretation, each set of raw data was transcribed and analyzed by the researchers to extract and interpret a generalised view of the processed information.

III. RESULTS AND DISCUSSION

The study underscores key recommendations for Valenzuela City's environmental planning, emphasising the complete integration of green infrastructure. Firstly, prioritizing strategic incorporation of green spaces like parks and gardens within urban areas will enhance property values, tourism, and local businesses. Public-private partnerships can ensure their maintenance, fostering economic growth while preserving nature. Secondly, enforcing green construction components in future projects, including private institutions and zones, via building regulations, draws inspiration from successful models elsewhere. Ensuring consistent green standards in government and educational buildings and leveraging technology (e.g., green roofs, digital tools) maximize benefits. Lastly, community involvement through programs, workshops, and volunteer initiatives promotes ownership and cultivates a healthier society. Valenzuela City's harmonization of economic progress with green integration aims for resilience, inclusivity, and vibrancy, fostering social cohesion and well-being while setting an example for sustainable urban development.

Valenzuela City boasts five diverse parks tailored to various interests, each contributing significantly to urban planning and conservation efforts. These parks serve multifaceted roles, acting as natural filters that improve air quality by mitigating pollutants, managing rainwater flow to reduce flooding risks, and curbing disease-carrying insects. Moreover, they enhance the city's aesthetics, providing serene environments for relaxation and fostering community connections through diverse leisure activities. The survey findings showcase visitors' positive sentiment towards these parks, emphasising safety, accessibility, cleanliness, diverse amenities, cultural preservation, and their role as tranquil havens in the urban landscape. Additionally, demographic insights highlight diverse preferences among different age groups, genders, and educational backgrounds, offering valuable cues for catering to residents' varied park experiences and enhancing urban green spaces' appeal in Valenzuela City.

Regarding the effectiveness of urban green space infrastructure projects in Valenzuela City for ecological sustainability, these projects have demonstrated commendable success. They act as natural air purifiers and climate regulators, reducing air pollution, fostering a healthier environment, and creating breathable spaces in an industrialised area. Moreover, these green spaces serve as essential recreational hubs, promoting physical activities and social interactions while positively impacting the local economy by supporting businesses during community events. However, despite these achievements, challenges persist, such as insufficient integration of green components, financial integration of green components, financial constraints, and limited open spaces for green development. The proposed policy enhancement involves collaborative efforts among key departments, focusing on sustainable drainage systems, strategic planning, and public engagement. Monitoring and evaluation by the City Planning and Development Office are crucial to ensure the framework's effectiveness, offering recommendations for further improvements towards Valenzuela City's ecological sustainability.

IV. CONCLUSION

This study examines the impact of urban green spaces in Valenzuela City's infrastructure development with a view to assessing its effectiveness towards attaining ecological sustainability of Valenzuela City. In general, the findings of this study were consistent with the assumptions and hypothesis of the previous studies conducted in other countries that are incorporated in this research. The researchers found that urban green spaces demonstrate a positive impact to citizen's social, emotional, mental, and physical well-being. The result of the survey conducted empirically demonstrated that urban parks are beneficial in promoting social cohesion, relieves stress, meditation, and encourages urban dwellers to be physically active. This study adds to the body of research showing how parks and other green areas can improve the well-being of their communities. This study contributes to the growing body of research on the Philippines' efforts to achieve ecological sustainability in the environment.

Nonetheless, it becomes apparent that efforts aimed at developing urban green infrastructure need to be implemented more effectively. Notwithstanding the effectiveness, there are still certain glaring holes and difficulties that need to be fixed to improve the projects' overall execution. The improvement of communication tactics is one important area that needs focus. The advantages and effects of urban green areas are widely acknowledged, yet it is imperative to guarantee their tight integration into the planning and construction of forthcoming infrastructures and establishments. Effective implementation of more sustainable practices is greatly facilitated by enhancing community participation, improved local knowledge and better communication from the local government.

V. RECOMMENDATIONS

The study conducted by the researchers produced recommendations which highlight the significance of completely incorporating green infrastructure into the environmental planning of Valenzuela City. Firstly, integrating green spaces strategically within the urban infrastructure should be prioritised. Implementing a comprehensive urban planning approach that considers the incorporation of parks, green belts, and gardens into the city's layout will foster a harmonious coexistence between nature and development. Highlight the positive impact these spaces have on property values, tourism potential and local businesses. Encourage public-private partnerships to invest in and maintain these areas, fostering economic growth while concurrently preserving and enhancing the natural environment. Secondly, prioritising green construction components in forthcoming projects is imperative. Extending this initiative to encompass private institutions, residential zones, commercial hubs, and industrial zones is one of the keys. Building permit regulations that require green spaces could be a workable solution, inspired by successful models from other regions.

Furthermore, it is essential to guarantee consistency and aesthetic standards in all government buildings, particularly in educational establishments, in order to create a welcoming and consistent atmosphere. Leverage technology and innovation to maximise the benefits of urban green spaces. Implement smart design strategies such as green roofs, vertical gardens, and sustainable drainage systems to optimise space utilisation and environmental efficiency. Additionally, employ digital tools and apps to facilitate community involvement, promote environmental education, and monitor the health and maintenance of these green areas.

Lastly, community engagement and participation are pivotal in ensuring the success and utilization of these green spaces. Encouraging residents to actively participate in the maintenance and utilization of these areas through community programmes, educational workshops, and volunteer initiatives not only enhances the sense of ownership but also cultivates a healthier and more engaged society. By harmonising economic progress with the integration of urban green spaces, Valenzuela City can pave the way for a more resilient, inclusive, and vibrant community. This synergy will not only enhance the city's aesthetic appeal but also foster social cohesion, promote physical and mental well-being, and fortify Valenzuela's position as a model city for sustainable urban development.

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PLENARY SESSION II
CONCLUSION AND REFLECTION
CLOSING REMARKS

Conclusion & Reflections – Closing Remarks

By Prof. Mario T. Tabucanon, Advisor to the Conference's Academic Committee

Emeritus Professor, Asian Institute of Technology (AIT)

Visiting Professor United Nations University Institute for the Advanced Study of Sustainability

Prof. Mario T. Tabucanon stated that he was fascinated to listen to the insightful discussions of the keynote speaker Prof. Anil Kumar Anal on the "Bio-Circular Green Economy in the Food and Agriculture: Perspectives and Technological Interventions" and Dr. Theresa Mundita S. Lim's presentation on "Biodiversity in the ASEAN Region" as well as all the presenters' scientific topics at the International Conference on Environment, Climate Change and Energy for Future Challenges: Best Practice and Innovation for Conservation and Restoration.

All of the discussions at this conference are interrelated, and they all reflect upon the Planetary Crises that the world is facing, namely: climate change, biodiversity loss, and pollution. These issues are not in isolation of each other, but they are linked together. When we talk about sustainable solutions, best practices and innovation, the overlap of the issues is where innovation can take place. This is where the crises need to be addressed holistically. Prof. Mario emphasised the nexus of the three crises of climate, biodiversity loss and pollution, which comprise feedback loops.

Climate change affects biodiversity loss and it is also affected by biodiversity, which is a vicious circle that we need to speedily escape from. Climate change has impacts well beyond the atmosphere, the GHGs responsible for climate change come from sources that can also contribute to air pollution. Pollution is a major driver of biodiversity and ecosystem services loss. The private sector needs to be actively involved for collective action in tackling climate change, and need to be aligned with the SDGs.

We crossed the threshold of the earth's sustainability in 1972, caused by irresponsible production and exponential consumption patterns, compounded by the ever-increasing population. As a result, the biodiversity, or living index, is decreasing in terms of living species on earth. This conference has demonstrated a clear understanding of the challenges that we face.

We need to clearly understand climate change, biodiversity loss and pollution, and their interlinkages, and the innovations and best practices to address them. These planetary crises have also become drivers of environmental problems, and not just impacts, and we should treat them as both to address the problems. The SDGs also form a nexus, and these goals are not isolated from each other, they are all interrelated in varying degrees. When we do something in one area, it affects the others in some way, and that interconnectivity has been demonstrated in the presentations of this conference.

The SDGs are not only goals in themselves, but are also methodologies to accomplish other SDGs. The key cross-cutting themes are SDG 4: Quality Education and SDG 17: Partnerships, the key enabler of all the other SDGs. Transformative education changes behaviour, so it should not be just about learning, but it should also be about changing behaviour. Unfortunately, according to the UN ESCAP Asia-Pacific SDG Report of 2022, progress toward the SDGs has slowed in our region as the COVID-19 pandemic and climate change have exacerbated development challenges, and we are not on track to achieve any of the 17 SDGs. The Report indicates that it will take until 2065 to achieve the SDGs. In 2020, our progress of SDG 13: Climate Action was going backward, to below zero, and in 2021 it was getting even more negative, so we in the scientific community must do more to reverse this backward trend.

We need methodology, which is known as the BCG Economy Model; Bio-Economy, Circular Economy and Green Economy. The Bio-Economy refers to renewability, the Circular Economy is about efficiency and recycling, and the Green Economy is about balancing across all three dimensions; social, economic and environmental. In Thailand, there are four sectors of focus: food and agriculture; bioenergy, biomaterial and biochemical; tourism and creative economy; and medical and wellness to utilise the BCG model.

On climate change, the national agenda needs to be aligned with the global agenda to address local challenges. The UNFCCC urges countries to use the bottom-up approach to achieve their Nationally Determined Contributions (NDCs). In Thailand, the focus areas are Energy, Forestry and Ecosystem Restoration, and all of these issues were discussed in this conference. The issues to be addressed are policymaking, urban parks and green spaces, ecosystem and environmental conservation, and green economy. As we move forward, we need to develop the concept of academic research and intellectual enquiry should change from a linear fashion to become more circular, where the multi-stakeholders are involved much earlier in the process. The co-production aspect of knowledge and innovation needs to be emphasised in a circular rather than linear fashion as well. The pillars of addressing the issues of environment, climate change and energy for the future challenges, we need to include good governance, human resources, science and technology, research and innovation, international partnerships and collaboration, and finance and investment for funding of the research.

Looking forward to 2030 in pursuit of achieving the SDGs, the role of academia and the scientific community needs to have more interface and get closer with the development sectors, and knowledge should be more domesticated for local relevancy of the issues. The knowledge, learning and production processes need to expand in all directions, and research should be more sustainability oriented. Education needs to strengthen its critical role as the enabler and integrate the SDGs for Agenda 2030, and a multi-stakeholder partnership approach is required to collectively achieve the SDGs.

Prof. Mario expressed his profound gratitude to all the presenters and participants for actively engaging with the issues at hand as well. He also gave special thanks to the organising committee and management of the Sirindhorn International Environmental Park for a well-planned conference, and asked for everyone to share what we have learned with our colleagues so we all can be living in a better place.

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APPENDICES

PROGRAMME

International Conference on Environment, Climate Change and Energy for Future Challenges: Best Practice and Innovation for Conservation and Restoration

Virtual Conference (On-line)

Date: Monday 26th June 2023

Sirindhorn International Environmental Park
Cha-am district, Phetchaburi province, Thailand

8.30-10.00 hrs

Plenary Session I:

- Welcoming Speech - Pol. Lieutenant General Prapun Chantaim, Director of Sirindhorn International Environmental Park (SIEP)
- Opening Remarks - Prof. Sanit Aksornkoae, Chairman of Office of the National Economic and Social Development Council Committee,Thailand

  Committee, Sirindhorn International Environmental Park Foundation under the Patronage of HRH Princess Maha Chakri Sirindhorn
- Keynote Presentation on “Bio-Circular Green Economy in the Food and Agriculture: Perspectives and Technological Interventions” - Prof. Anil Kumar Anal, Department of Food, Agriculture and Bioresources, School of Environment Resources and Development, Asian Institute of Technology (AIT)

  MC – Dr. Pawat Sereetrakul, Silpakorn University (Phetchaburi IT Campus)

10.00-12.30 hrs

Parallel Session I:

- Room A: Climate Change and Energy

  Guest speaker- Jens Radschinski, Regional expert on Art.6 and Carbon Pricing UNFCCC/IGES-Regional Collaboration Centre for Asia and the Pacific

  Moderator - Dr. Jeeranuch Sakkhamduang, Thailand Environment Institute (TEI)
  Rapporteur - Prof. Rashed Al Mahmud Titumir, RCE Sundarbans, Bangladesh

- Room B: Environment, Biodiversity and Natural Resources

  Guest speaker- Dr. Theresa Mundita S. Lim, Executive Director, ASEAN Centre for Biodiversity (ACB), Philippines

Moderator - Siriporn Sri-aram, Blue Renaissance
Rapporteur - Alex Ahebwa, Kasetsart University

12.30-13.00 hrs

Plenary Session II:

- Conclusion and Reflection & Closing Remarks - Emeritus Prof. Mario T. Tabucanon, Asian Institute of Technology (AIT)

  Visiting Professor, United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS)


RCE Cha-am
TISTR
International Conference on
Environment, Climate Change and Energy for Future Challenges:
Best Practice and Innovation for Conservation and Restoration
Virtual Conference (On-line)
Date: Monday 26th June 2023
Time: 8.30 - 13.00 hrs (GMT+7)
Zoom Meeting ID : 320 341 3523
Plenary Session I
8.30 - 8.45 hrs Welcoming Speech
8.45 - 9.00 hrs Opening Remarks
• Prof. Sanit Aksornkoae
Chairman, Office of the National Economic and Social Development Council Committee, Sirindhorn International Environmental Park Foundation under the Patronage of HRH Princess Maha Chakri Sirindhorn
9.00 - 9.45 hrs Keynote Presentation
"Bio-Circular Green Economy in the Food and Agriculture: Perspectives and Technological Interventions"
• Prof. Anil Kumar Anal
Department of Food, Agriculture and Bioresources
School of Environment Resources and Development
Asian Institute of Technology (AIT)
Parallel Session I
10.00 - 12.30 hrs
Room A
Guest Speaker
List of Presentation and Speaker
Mr. Jens Radschinski
Regional Expert on Art.6 and Carbon Pricing
UNFCCC / IGES-Regional Collaboration Centre for Asia and the Pacific
Moderator: Dr.Jeeranuch Sakkhamduang, Thailand Environment Institute (TEI)
Room B
Guest Speaker
List of Presentation and Speaker
Dr. Theresa Mundita S. Lim
Executive Director
ASEAN Centre for Biodiversity (ACB)
Moderator: Ms. Siriporn Sri-aram, Blue Renaissance
Plenary Session II
12.30 - 13.00 hrs Conclusion & Reflection
Closing Remarks
• Prof. Mario T. Tabucanon
Emeritus Professor, Asian Institute of Technology (AIT)
Visiting Professor, United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS)
Free Registration
Please scan here!
Registration Deadline : 19th June 2023
Conference Programme
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International Conference
on
Environment, Climate Change and Energy for Future Challenges :
Best Practice and Innovation for Conservation and Restoration
Virtual Conference (On-line)
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International Conference on Environment, Climate Change and Energy for Future Challenges:

Best Practice and Innovation for Conservation and Restoration

(Virtual Conference)

26 June 2023

Sirindhorn International Environmental Park, Cha-am, Phetchaburi, Thailand

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(Virtual Conference)

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Sirindhorn International Environmental Park, Cha-am, Phetchaburi, Thailand

First edition	2024
Editor	Brian B. Anderson
Design and Layout Artist	Worawan Rujiwan
Coordinator	Areeporn Sittiyanpaiboon
Publisher	The Sirindhorn International Environmental Park Foundation under the Patronage of Her Royal Highness Princess Maha Chakri Sirindhorn
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