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## ***Conservation Practices and their Impact on Hawaiian Well-Being among Youth***

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Emma Broderick, Kupu HYCC Community Program, United States

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### **Abstract**

Research with Kupu alumni included the examination of the relationship between land, culture, health and Native Hawaiian well-being. In this process, using qualitative measures (NVIVO) to analyze youth speeches and journals, we sought to measure the level of impact that Kupu had on youth in terms of health and wellness, however at the conclusion of our work we learned much more than initially planned. We learned three ways Kupu youth believed that their lives had been impacted as a result of their guided land practices and experiences. Kupu alumni expressed an increased sense of pride. As a result of their experiences, youth were positively impacted in the daily routines of their lives. They also noted positive changes in self such as improved self-confidence. Youth noted an increased sense of purpose. Kupu alum shared that their eyes were opened to the value of touching land in changing their mindset on education. They also shared an enhanced motivation to improve and change the current education system to include more land cultivation practices for younger children. Kupu alumni also responded that their experiences had given them an increased recognition of Identity and cultural heritage. Alums expressed an increased effect on their connection to others/family, their history and an increase appreciation for life and sharing their lives with others. In sum, we learned that listening to youth voices, both expressed in written and oral formats, is essential to sustaining knowledge of land, culture and health from generation to generation and for Hawaii's future.

Keywords: Conservation, Culture, Hawaiian Well Being, Health, Youth

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## Introduction

As we began writing this report, we committed ourselves to being explicitly honest. Standing firm in our truth, we now know the information contained in this report only scratches the surface of the following three qualities of Hawaiian health and wellness: a) what is one's place of knowing, b) how does one's experience inform their health behavior, and c) how can excellence surrounding one's own health and wellness be shared (*aka: 'auamo kuleana + ho'opono*).

In this project, we worked collaboratively with Kupu alumni to examine the relationship between land, culture, health, and Native Hawaiian well-being. Specifically, we looked to measure the individual and collective level of impact that Kupu has had on youth in terms of health and wellness, which we believed would involve increasing knowledge about land conservation and culture. We wanted to better understand and recognize more about the significance of touching land and its effect on culture and education among youth. Furthermore, we sought to determine how touching land, as a Kupu alum, has impacted the overall wellness of Native Hawaiian young adults.

At the start of our project, we simply hoped to bring Kupu alums together to share and learn more from each other's experiences regarding local land conservation practices. We also wanted to hear from this community of youth on how these practices could improve an individual's overall wellness in terms of health and social conditions. However, after our 18-month project, we not only gained valuable feedback on conservation practices and ways youth can engage others to improve health by touching land, we also confirmed that alums are living examples of Kupu's two-fold mission of "preserving land while empowering youth." Evidence of our findings, that *pride, identity* and *purpose* among Kupu alums contribute to the relationship youth have to the land and to each other were revealed in our review of Kupu graduate artifacts and the peer research mentoring process.

### Main research question:

*What is the impact of cultural restoration and revitalization of Native Hawaiian health and wellness among youth?*

### Secondary Questions:

Our secondary questions arose from preliminary discussions with Kupu alum who were interested in furthering their work in land conservation and cultural restoration. These questions helped to guide the formation of our project into three phases.

- How do we show that knowledge of conservation among Kupu alum is transcultural/trans-historical/transformational?
- How do we assess the quality of the relationship alums have with Kupu?
- How do we quantify the place-based education alums have received from Kupu?

- How do we expand Kupus pipeline of employment for youth interested in working in land conservation across the state?
- What is needed to expand and then to sustain this project?

This project can be described in three phases. In the first phase of this work, two opportunities were created to foster the development of relationships among Kupu alumni and university partners and also to chart a course for this work. These two opportunities involved Kupu alumni, staff and UH West O‘ahu faculty coming together to touch land. The first opportunity was a group service project, (Moku ‘o Lo‘e Service Project) held at Coconut Island in Kāne‘ohe Hawaii. The second event was held at Kupus Ho‘okupu Center (formerly known as the Net Shed) in Honolulu, Hawai‘i. During both of these collaborative opportunities, *Mā‘awe Pono* was used as the “research methodology” to inform the path for project participants to find solutions to issues of cultural restoration and revitalizing health and wellbeing among Native Hawaiian youth.

During the second phase of this project, interested alumni, who attended one or both of the gatherings above, self-identified as wanting to learn more about drawing conclusions on the impact of local land conservation experiences among youth. Alumni were then introduced and welcomed into the peer research mentoring aspect of the project. Finally, alumni used the new skills gained in the peer research mentoring program to evaluate artifacts (qualitative data) of Kupu graduates.

### **Summary of Findings**

#### *A. A peer mentoring program established*

After opportunities for relationship building were made, ideas were provided on plausible next steps for a group of Kupu alumni to get involved in the research process. Over the summer of 2018, five Kupu Alumni were trained on how to utilize the qualitative software program, NVivo. Kupu Alumni attended four workshop trainings (May 2018-July 2018) on the software. The trainings covered workshops on types of data, content analysis, steps for using NVivo, and drawing conclusions from the qualitative data.

One of the most applicable and sustainable products of our work was the initiation of a peer research mentoring program in qualitative research. Our project used a peer led approach to foster learning among a group of Kupu alums. Together they were introduced to qualitative data techniques in a workshop-based setting. They then used the techniques they learned to dig deeper into their understanding of the impact of Kupu in their lives. Using a peer led design provided an avenue for peer engagement, and influence during the duration of our work. This approach was useful toward uncovering how youth viewed health and wellness at the conclusion of their Kupu programs.

The goal of each workshop training was to identify how qualitative data could be analyzed using NVivo. Kupu alumni reviewed available data by first reading artifacts (e.g. individual Kupu graduate journals and speeches from Kupus Hawai‘i Youth Conservation Corps Community Program- a program designed to provide youth with

a hands-on, outdoor field experience in land conservation) and then searching for reoccurring themes in the data. After being fully trained, Kupu alumni inputted the data into NVivo to help with verifying and maintaining accuracy of the results from reading each artifact.

At the conclusion of the trainings, peer researchers self-identified several themes related to cultural restoration and the significance that youth touching land has on culture and education. (See a snapshot of the themes below in Figure 1.)

**Figure 1. Peer Research Mentoring Themes**

Question	Categories-- Responses to the question were sorted into:
What level of impact does Kupu have on youth in terms of health and wellness?	Positive Changes in daily routines: waking up on time, access to food
	Work as Fun: wellness tied to joy, le'ale'a
	Pro Social Behavior: see value in volunteering, helping others, etc
	Positive Changes in Self: Increase in Self Confidence, see value in self, decrease in anger etc
How do Kupu youth recognize that touching land has significance on culture and education?	Learn New Things: first time learning, seeing or doing something connected to culture and education
	Educational Achievement: completing level of education they thought they couldn't, completing educational goal
	Changing Mindset about Education: viewing their abilities differently
	Educational Plans for the Future: wanting to continue on in their education
	Culture as Education: seeing land/culture as the teacher
How has touching land as a Kupu alum impacted the overall wellness of Native Hawaiian youth and young adults?	Sharing with Others: participants teaching others/positively impacting those outside of the program by sharing Hawai'i's land and natural resources
	Connection to Others: Increased sense of community within the program

Based on a review of artifacts, the peer research mentors (who were also Kupu Alumni) reviewed fifteen graduation speeches, five reflections, and ten “great stories” as they are called, in the form of written narratives. Findings revealed that Kupu Alumni largely believed that Kupu had the following three impacts on their lives:

- 1) A positive impact on the daily routines of their lives, positive changes in self and an increased recognition of purpose in life
- 2) Opened their eyes to the value of touching land in changing their mindset on education and motivation to improve/change the current education system
- 3) An increased effect on their connection to others/family, increased appreciation for life and sharing with others.

*B. Increase the engagement and interaction of people with the ‘āina correlates with increased social consciousness*

Our project demonstrates and supports the idea that there is value in touching land among youth. A review of artifacts from Kupu graduates further demonstrates that the mission of Kupu has been changing the mindset of youth on education and motivation to improve/change the current education system. Youth want to see more opportunities for education that requires interaction with ‘āina. Moreover, as evidenced by those who were a part of the peer research mentoring program, providing opportunities for touching ‘āina together increases connection to others/family and ultimately raises social consciousness.

**Favorite Youth Quotes that Bring Forth Key Highlights and Insights**

*A. Kūlia i ka nu‘u*

“I came here at first with low expectations of myself, and I doubted that I would make it to graduation because prior to Kupu I had never completed any plans I had made for myself. I had low self-esteem, hung out with the wrong type of people, believing they cared, and followed others with no real sense of who I was as an individual. From the day I joined Kupu until now, I have seen both small and profound changes in my thinking and values. Now I strive to be the best I can, I am persistent even when times are hard, the people I choose to hang out with are pretty positive (probably because I’m almost always hanging around at the Net Shed), and I actually have confidence in the choices I make and in myself as a person.” (Community Program Participant 2017)

An increase in self-confidence and self-worth were seen in many participants after successful completion of the Kupu Hawai‘i Youth Conservation Corps (HYCC) Community Program. Native Hawaiian health and wellness is improved when connection to ‘āina and community is reestablished. Mental health is often not spoken of because the connection to physical health is so much more obvious, but the wellbeing of the whole individual is essential for true health.

*B. I ulu no ka lālā i ke kumu*

“A wise team leader once told us that the best time to plant a tree was twenty years ago; and the next best time is now. We have truly grasped the essence of that mana’o through the bittersweet satisfaction of makaluhi. This poetic phrase simply translates to “tired eyes”- specifically those of the people who have been working hard on a community project. Experiencing makaluhi and admiring progress made after a hard day’s work has not only grown our relationship stronger to the land, but also with our community members and ultimately, with ourselves.” (Community Program Participant, 2016-2017)

Mālama ‘āina work puts the kumu back in kumu. It reminds us of the origins of the word. That without strong roots, a solid foundation and base, the main stalk or kumu would simply be unable to weather the storm. Culture, land and sea, these have always been our teachers.

C. *‘A‘ohe pau ka ‘ike i ka hālau ho‘okahi*

“When I first started the Kupu HYCC program, I thought I would never reach my goal of getting a C-BASE diploma. I thought I was just going to fail and disappoint myself again. I was scared of failure. My mother always said that failure was a part of success. I didn’t listen to her.” (Community Program Participant, 2017)

Cultural restoration and revitalization of our ‘āina, that which feeds us, has the capacity to not only positively impact the ‘āina and our lāhui, but also to powerfully change the individuals caring for their communities. Not only do these individuals see their environment differently, but they view themselves differently. After completing a six-month program with Kupus HYCC Community Program, members spoke differently about the importance of education and their ability to be successful in educational settings.

D. *‘Ike aku, ‘ike mai, kōkua aku, kōkua mai, pela iho la ka nohona ‘ohana*

“The staff and peers here became my family. They filled this gaping hole I have had inside my heart for such a long time.” (Community Program Participant, 2017-2018)

Mālama ‘āina work teaches its students about the reciprocal nature of life. Upon completing their Kupu experience, members spoke of an increased sense of community within the program and a better understanding of what it takes to build and maintain a connection to others. The vast majority of our Community Program participants have at least one or, in many times, several of the following as part of their reality: 1) incarcerated parent or family member; 2) houselessness, or in and off of the streets; 3) substance abuse in the household; 4) domestic violence in the household; 5) deceased parent or guardian; 6) in the foster care system; or 7) a single parent household.

Their experience of caring for and being cared for by the ‘āina allows them a safe place to practice building positive relationships and the potential to end a powerfully negative trajectory they were simply born into.

E. *Summation of Key Highlights and Insights*

The above highlights capture the strengths of Kupu as an organization in regards to the pride, purpose and sense of identity that it instills in youth.

**Project Strengths**

*We identified the following three (3) strengths of our project with Kupu:*

1. PRIDE

Organizations like Kupu provide the infrastructure and space for youth to acknowledge, accept, and understand their health and wellness in order to help with openness - often times indirectly.

2. IDENTITY

To feel connected is to feel that you belong- Organizations like Kupu provide space



for youth to create relationships with people, land, and themselves. Relationship affects one's health and wellbeing. If you ask an alumni what their greatest moments were during the program, chances are it involved building new relationships.

### 3. PURPOSE

Experiences with 'āina provide alumni with the confidence to pursue their passions.

## Conclusions “Our Kuleana”

### A. *Lessons Learned*

There are many ways of knowing. The challenge is being expansive rather than restrictive in how we understand what we see, hear, feel, and learn through our research. What questions are asked matters. Where the questions are asked matters. When the questions are asked matters. How the questions are asked matters. Who asks the questions matters. Why the questions are asked matters. We were intentional about the process of questioning in order to understand how 'āina impacts Hawaiian wellbeing, culture, and education. We also reflected on past questions and looked at how we can improve our questioning to better capture the life-changing experiences that doing mālama 'āina work has on our young adults.

Research is better together. Having a Hui of Alumni Researchers led by an experienced mentor, Dr. Camonia Graham-Tutt, created community in what can be an isolating data-filled world.

Emma (Kupu Alumni Researcher) was hired under this funding mechanism to continue this research and during this time was able to persuade her team on the value of continuous analysis of qualitative data at the conclusion of Kupu programs. Together the Hui of Alumni Researchers reviewed the artifacts and uncovered the positive impact the Kupu mission has on youth of providing hands-on experiences in land conservation. Kupu Community Program has purchased NVivo and will continue to use this qualitative data analysis software to understand the experience of participants and how the program can evolve to fit changing needs.

### B. *Next Steps*

We plan to compare the ideas found in this work on the value of touching land among youth to existing public policies that are being implemented elsewhere, and compare them to legislative proposals that were not exacted (yet).

We would generally like to look at addressing state laws to create better pathways for Kupu alums to work in conservation jobs with the state.

## Acknowledgements

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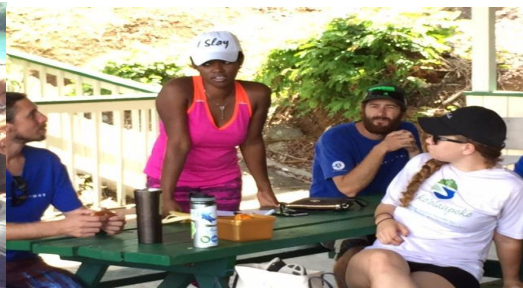
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A research project to affirm the qualities of Hawaiian health and wellness

### HD Photos



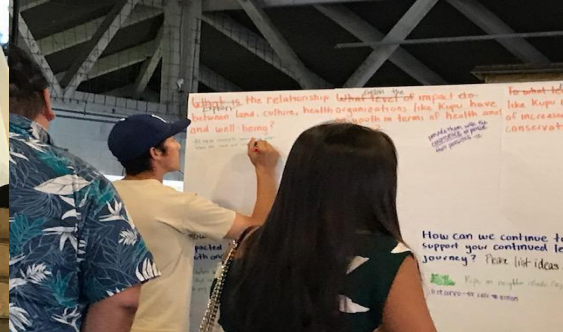
Kupu Alums @ Coconut Island



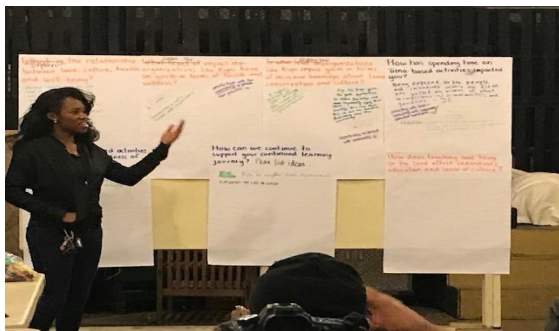
Camonia R. Graham-Tutt @ Coconut Island



Kupu Alums @ Netshed



Kupu Alums @ Netshed



Camonia R. Graham-Tutt @ Netshed



Kupu Alums @ Netshed

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***How to Support Immigrant Entrepreneurs to Succeed in a Foreign Culture?  
-A Multiple-Case Study from a Norwegian Context-***

May Olaug Horverak, Birkenes Learning Centre, Norway

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**Abstract**

When being an immigrant and starting as an entrepreneur, one may face many challenges in a foreign culture, for example difficulties with the language, understanding taxation rules and other regulations and understanding the potential customers. Of the many businesses that are registered in general, only a small percentage survives. To support immigrants in a tough market, we have carried out motivation courses called idealabs in the southern region of Norway for immigrants who have recently started or are about to start a business. This study is a pilot study presenting data from these courses which aimed at building resilience in the process of starting and running a business, by identifying and discussing goals, success factors and obstacles, and deciding on focus and necessary action to succeed. The participants generally reported that they appreciated both learning the method and meeting with other immigrant entrepreneurs, as they received useful advice and motivation to continue working with improving their business concepts.

Keywords: immigrants, entrepreneurship, motivation, resilience

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## Introduction

With increased globalisation and immigration, multiculturalism is the status quo for many western societies, and with this, challenges concerning integration and equality arise. In Norway, we generally have a low unemployment rate, as low as 2,7% in 2018, but the situation is somewhat different for one group: immigrants. For this group, the unemployment rate was 6,4% the same year (Statistics Norway, updated 14. Nov, 2018). This shows that people with an immigrant background have challenges succeeding with getting a job, and as a result, many of them turn to entrepreneurship. When developing businesses and new business concepts, immigrants become a source of economic revitalisation and social renewal (Aliaga-Isla & Rialp, 2013). In line with this thinking, a programme called «Multicultural value creation» has been run in the southern region of Norway, and the current study is part of this project.

Succeeding with entrepreneurship is not easy in a society where all needs are generally met, and with a cultural background very different from the majority of available customers. According to statistics, 75% of all startups fail (Blank, 2013), so it takes hard work and the ability to adjust to succeed with a business. The main reasons startups fail are that there is no market need (42%), they run out of cash (29%), or they do not have the right team (23%) (CBInsights, 2019, p. 4). For immigrants, it is likely to be particularly challenging to succeed with a business as they are dealing with a foreign culture and perhaps a language that is difficult to master for them. Acknowledging the challenging situation for immigrant entrepreneurs has led to the current pilot study, investigating the following research question; *How may a systematic approach to working with motivation support immigrant entrepreneurs to succeed with running a business in a foreign culture?* The target group of the study was entrepreneurs in the starting phase of establishing a business, and various nationalities were included. The data was collected from two-day courses called idealabs, where the participants learnt a five-step method for taking control of their own development, and discussed relevant issues, which again were to lead to increased motivation.

The method applied in this study builds on self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000; Deci & Ryan, 2000), stating that in order to experience intrinsic motivation, the basic needs of autonomy, competence and relatedness must be met<sup>1</sup>. Intrinsic motivation means that behaviours are «performed out of interest and for which the primary ‘reward’ is the spontaneous feelings of effectance and enjoyment» (Ryan & Deci, 2017, p. 14). On the opposite end of the motivation scale, we find extrinsic motivation, which means that behaviours are «instrumental for some separable consequence such as an external reward or social approval, avoidance of punishment, or the attainment of a valued outcome» (Ryan & Deci, 2017, p. 14). The aim of applying the five-step method described in this study was to facilitate for the development of intrinsic motivation.

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<sup>1</sup> The five-step method applied in this study was originally developed in the project «A Systematic Approach to Mastering life – the five-step Motivation method» (SAMM). This project has been carried out in an educational context (Horverak, Aanensen, Olsbu, P aplow & Langeland, in process; Horverak, Aanensen & Langeland, 2019; Horverak & Aanensen, 2019; Langeland, Horverak & Fagerhaug, 2018), and the method has been adjusted for the context of the current study. For more information about SAMM, see <https://samm.uia.no/en/frontpage/>

Several studies on immigrant entrepreneurship have focused on characteristics of immigrants and what determines whether they become self-employed (Aliaga-Isla & Rialp, 2013; Vinograd & Kolvereid, 2007, Kanas, van Tubergen & van der Lippe, 2009). In their systematic review on immigrant entrepreneurship, Aliaga-Isla & Rialp suggest that future research should focus on how immigrants recognize entrepreneurial opportunities in the country they have immigrated to, and what role “prior knowledge plays in the process of opportunity recognition” (2013, p. 18). In the idealab-courses, this was an aspect that was included in the introduction, how immigrants perhaps see opportunities that native Norwegians do not see, and how their prior knowledge from a different culture may be an advantage. Applying the five-step approach outlined in this study includes identifying motivating factors for starting a business and identifying success factors, such as prior knowledge from a different culture, that may help them succeed. The following analyses reveal how this approach affected what immigrant entrepreneurs thought about their own motivation and ability to set goals and solve problems when running a business.

### Methodology

The purpose of this pilot study was to investigate whether a systematic approach to working with motivation could support immigrants to succeed with running a business in a foreign culture. To investigate this, I have analysed data collected from courses where a five-step method was applied. The study applies a mixed method approach (Teddlie & Tashakkori) presenting qualitative data in the form of participant reflections from the idealab-courses and quantitative data based on the participants’ evaluations of the courses.

### Intervention: Idealab

The idealab from which the data is collected consisted of a course covering two evenings with a week in between. The five-step approach applied in the course is presented in figure 1 below.

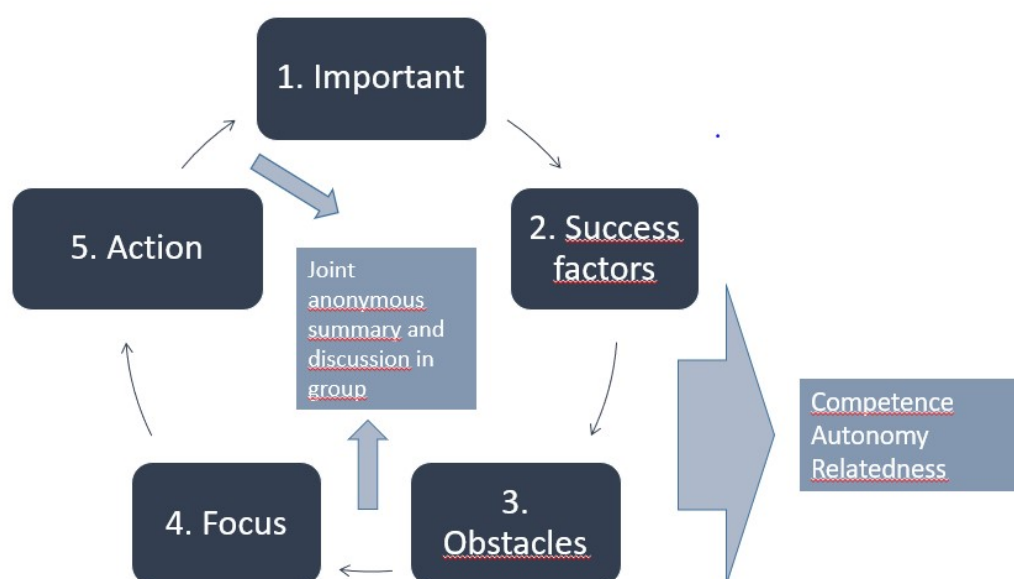


Figure 1. The five-step motivation method.

In the first session, after an introduction about the struggle to survive as a business, the participants discussed and wrote answers to the first three questions in the fivestep method: 1) What is the goal of your business? What is important in the near future? 2) What is good about your business right now, what do you already do well? 3) Is there something in yourself or your situation that stops you from reaching your business goals? We compared working with this method with walking up stairs, and emphasised that it is the entrepreneur's job to walk up the stairs and do the job of progressing with their business. The participants' notes were copied, so that these could be used to prepare for session two.

In the second session, Deci and Ryan's theory about intrinsic motivation and self-determination was presented, how this relates to the method applied in the idealab, and how some things are important and some are urgent and needs to be dealt with. Following this, the participants reflections from the first session were summed up, and there was a more thorough discussion on what is important to succeed with a business, and how the different obstacles listed could be overcome. The participants came up with suggestions of solutions to each other. Then they answered the following questions in writing: 4) What do you choose to focus on the next weeks to reach your business goals? and 5) What will you do to manage to carry this out?

### **Data material and analyses**

The participants' answers to the five questions in the fivestep method form part of the data in this study. Tendencies and examples of the answers are presented in the analyses. In addition, the participants gave oral feedback to how they experienced the course at the end of each course night, and their answers are summed up. A questionnaire was also distributed after the course with the following closed questions included in the analysis: A) how motivated were you to run your own business BEFORE the course? B) Has the course prepared you to solve problems that stop you from succeeding with your business, C) Has the course made it clearer for you what stops you from succeeding with your own business, D) Has the course contributed to make the goals for your business clearer for you? E) How motivated are you to run your own business AFTER the course? After the first two courses, the questionnaire was distributed through emails, but there was no response, so the three following courses, the questionnaire was distributed at the end of the second course day.

### **Sample**

In total, there were five courses of two days, and when adding the numbers of participants, 41 participated on the first day of the course and 26 completed both days of the course (see table 1 below). The number dropped somewhat from the first to the second day in all courses due to own illness or children who were ill.



Table 1 *Participants in course day 1 and 2*

<b>Course</b>	<b>Location</b>	<b>Day 1</b>	<b>Day 2</b>
Course 1	1 (city)	7	6
Course 2	2 ( small city)	7	3
Course 3	3 (small town)	15	8
Course 4	1 (city)	7	6
Course 5	2 (small city)	5	3
<b>Total</b>	<b>3 locations</b>	<b>41</b>	<b>26</b>

The gender distribution on day 2 was 17 women and 9 men. Some of the participants were running businesses in cities, others in small towns. The nationality and background of the participants differed. There were refugees from the Middle East and African countries and other immigrants from European countries, Asian countries and the USA.

Most of the participants had already started a business, and the business concepts varied a great deal. The following business concepts were represented: restaurants, catering, leisure centre, massage, other alternative treatments or beauty salons, shops or online shops and other types of sales such as designs or video productions, technological innovation, transport and automobile repair shops. Details about nationalities and business concepts are not included in this study as this would easily reveal the identity of the participants.

### **Reliability and validity of findings**

This study is based on self-reported data from course participants, and there is a chance that the evaluations are somewhat positively biased. The fact that these immigrant entrepreneurs were given the opportunity to get extra guidance and free courses could result in a positive evaluation, regardless of what approach had been applied. They expressed gratitude towards us for taking the time to help them, and that they were given this opportunity to come together, and this is something that may have resulted in unreliable results with a positive bias when they evaluated the course. To meet this challenge we encouraged the participants to reflect on what they had appreciated when they expressed a positive attitude, and what could have been improved.

This study only investigates how the participants of the idealabs perceived the fivestep approach, and not how this work affected their businesses, so it might be difficult to generalise findings and say that the approach supports immigrants to succeed with their businesses based on the findings here. To know more about the effect of the approach in the context of entrepreneurship, more extensive studies are needed. This is a small-scale pilot-study from the southern region of Norway with a limited sample. Nevertheless, this study may give some insights into a method that may help immigrant entrepreneurs develop resilience and not give up in a tough business market.

## **Results**

This study investigates how a systematic approach to working with motivation can support immigrant entrepreneurs to succeed in a foreign culture. The elements mentioned by the participants on each question from the fivestep method are presented to illustrate how this approach worked to help them identify goals, success factors and obstacles, and to decide on focus area and action to be carried out. Following this, the participants' evaluations are presented through bar diagrams, and their reflections about the course are presented to give a more detailed picture of what they thought about the idealab.

## **Goals**

Many of the participants wrote that their goal was to have happy or satisfied customers. A couple of them were also concerned about finding new and more permanent customers to expand their business. This was related to another goal mentioned, which is the goal of any business, namely to increase their income. Some wrote that they ran a business to earn money to support their family. Others wrote that their main concern was to enjoy work and to be independent. One of the participants wrote: «To work with what I like and be able to support myself from this. To be independent and help others or inspire others. My goal the first year is to earn 10 000 NOK.» Here we see many motivations for running a business, and we see a very specific and realistic goal in terms of income for the near future.

Those who worked with health and wellness businesses or with integration were also concerned with helping people or creating a better society. One of the participants wrote that «Most important for me is to engage and motivate young people from different religions or with different views on life to come to gatherings». Several of the participants also mentioned that they wanted to give back to society as they felt that society had given them a great deal.

## **Success factors**

Several of the participants wrote that they already had competence within their business field, or the knowledge they needed. Many had started with preparations, and some mentioned that they had passed tests obligatory for certain types of businesses. A couple of the participants mentioned that they had relations with relevant collaborators which they could make more out of. Many of the participants wrote that they had satisfied customers and that their services had high quality. Others reported that they had clear business concepts and something new to offer, either new designs or new business concepts that did not exist in Norway yet.

## **Obstacles**

When answering the question about what stops them from reaching their goals, language was a clear answer from most of the participants. Many of the participants could communicate in Norwegian, but some of the participants were more in the starting process of learning the language. In general, becoming sufficiently proficient in the language was defined a challenge. This also relates to another issue mentioned by several participants, that understanding forms and rules was an obstacle. In

addition to struggling with the language when reading about what is required to run a business in Norway, quite many expressed that the rules and regulations are really complex, and it is difficult to know where to go to find an answer. Low confidence was mentioned by one participant, and this could relate to both language challenges and the difficulties of understanding the system.

A major challenge expressed by several participants was also the high expenses in Norway. There are high taxations, including value-added tax. Finances was a challenge for many of the participants. Another related issue mentioned was low pricing in the market, that competitors offered the same service for lower prices, and in order to survive when running a business with sole proprietorship, the prices cannot be too low. The unpredictability of running a business was another obstacle mentioned - that some months, there are several customers, and another month, there are none - and this again leads to a challenge financially. Having the right location was also mentioned by a couple of the participants. For example, it could be difficult to get customers if the business was not on the first floor and potential customers did not see it. Another issue was whether to prioritise a central more expensive location or a cheaper less central location, which again is related to the worry that there will not be enough customers for the business to be viable.

### **Focus and action**

The participants answered very differently to the questions on what they were to focus on and how they were to carry it out to reach their business goals. Some answers were vague, while others were more specific. Some participants chose to focus on new products, and one of them wrote that in order to do so, he would «sit at least one hour a day producing new designs». One of the participants was in the process of changing his business concept to making wedding videos, and he decided to focus on editing videos and building up a portfolio. To achieve this, he would spend three hours at least on editing every day.

Several of the participants wanted to focus on getting more customers, for example through marketing or social media. One participant wrote that she would make one or two posts on social media every day, and a couple of the participants decided that they would create a website. One of the participants wrote that she would arrange special evenings with cultural focus in her restaurant and others would contact potential customers. One mentioned that she would make flyers for her beauty salon and collaborate with a local restaurant. Guests at the restaurant would then receive a discount at the beauty salon, an arrangement that could be beneficial for both businesses. How to attract new customers was a topic that was discussed in every course.

A third focus area mentioned by several of the participants was to learn more Norwegian, another issue discussed in every course. One participant wrote that she would talk to people at open kindergarten-meetings. Another participant wrote that he would take more courses to become better in Norwegian. Another wrote that she would watch Norwegian television or listen to radio.

## Evaluations

The intention of having the participants fill in evaluations was to find out whether they experienced an increased motivation to run businesses, and whether they felt that the idealabs helped them identify goals and obstacles, and finding solutions to these. When answering the questions on how motivated they were to run a business before and after the course, we see a clear increase in motivation (see figure 2).

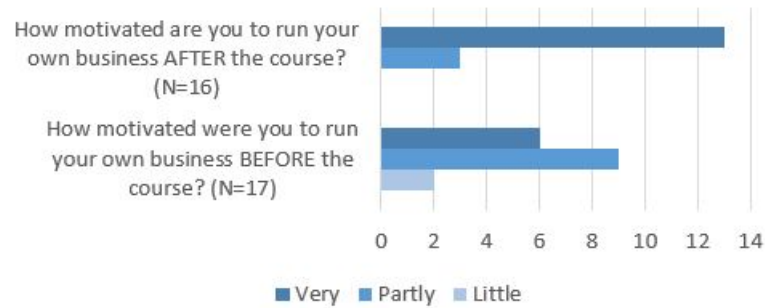


Figure 2. Motivation to run a business before and after the course.

Of the participants that completed the three final courses, we see that 13 of 16 report that they were very motivated after the course, whereas 6 of 17 report that they were very motivated before the course. Three of the participants were partly motivated after the course, whereas 11 were partly motivated before the course. After the course, none of the participants were a little motivated, while 2 were a little motivated before the course.

The participants were also asked whether the course prepared them to make goals for the future, identify what stopped them from succeeding and to solve these problems (see figure 3 below).

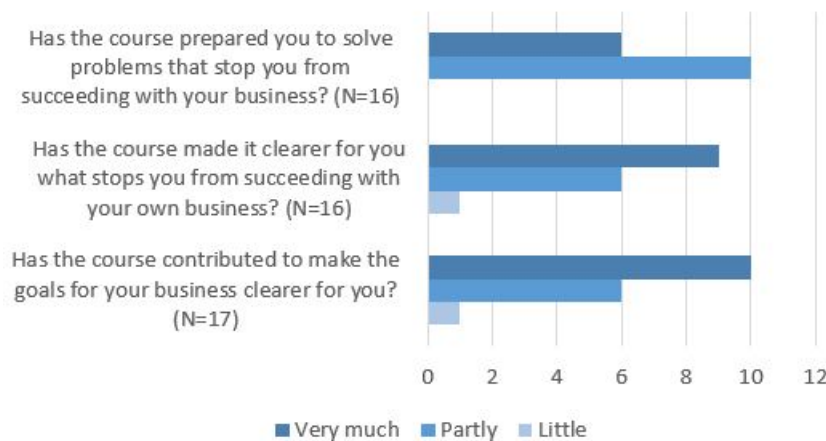


Figure 3: Outcome of the course

Of 16 participants, 6 agreed very much that the course had prepared them to solve problems that stopped them from succeeding with their businesses, and 10 agreed partly. Nine participants agreed very much that the course had made it clearer for them what stopped them from succeeding with their own business, 6 agreed partly and 1 agreed to a little degree. When asked whether the course had contributed to make

the goals for the business clearer, 10 agreed very much, 6 agreed partly and 1 agreed to a little degree.

When asked about how they experienced the idealab course, and what they found most useful, one of the dominant answers was that it was positive to exchange experience. They reported that it was encouraging and inspiring to listen to different perspectives and get new ideas from each others. As one of the participants said: «Even though we have very different businesses, there are ideas that I can use».

A second theme in the responses was that they felt support by being there with others that are in the same situation and have similar challenges. As one of them expressed: «We have a feeling that we are in the same boat». Language challenges was mentioned particularly, that is was good to meet with other entrepreneurs and discuss without being afraid that the others would judge them for not speaking good enough Norwegian. Another issue mentioned in relation to this was that the timing of the course was good, that having this type of support is useful in the starting phase: «It is important to be with others in the starting phase, it feels better not being the only one that can meet resistance. It is not easy to start a business. Many people think – now I have started the business, and this will be easy, but this is when it starts, many don't succeed, this is when the hard work begins.»

Another element of the course mentioned by several participants was that it was useful to reflect and make plans, especially to write things down. One of the participants stated: «I have identified my obstacles, and know now what I need to do next week». This is what several of the participants mentioned, that they were in a way pushed to decide on what to do now. Writing things down may be one way of committing oneself to do something, and to make a plan specific: «For me, it was good that I could sit here and write and think about what I wanted. It is often just talk and talk, now it is written here».

## **Discussion**

This study investigates how a systematic approach to working with motivation may support immigrant entrepreneurs to succeed with running a business in a foreign culture. The results show that the participants felt increased motivation after the course, and that the fivestep method applied helped them identify goals and obstacles, and find solutions to obstacles. In the more open reflections, we see that an additional aspect the participants appreciated much was to meet with others in similar situations, both for getting useful advice and new ideas and for feeling support by seeing that they struggle with the same issues.

It seems from the results here that it is not only the systematic work with identifying key elements as goals, success factors and obstacles and deciding on focus and action that led to increased motivation, but also the fact that they came together and felt part of a community consisting of their peers. These findings relate to the theory on which the fivestep approach is based, self-determination theory (Deci & Ryan, 1985), stating that human beings need three basic needs to be met: autonomy, competence and relatedness. It is not sufficient to feel competent and autonomous, relatedness is another important aspect. Human beings need to relate to others to feel intrinsically

motivated, and by organising opportunities for immigrant entrepreneurs to meet instead of giving only individual advice, we facilitate for this need to be met.

In the participants' goals, we see different motivations. Some of the participants run a business because they need employment. This finding corresponds to previous studies showing self-employment as an important factor for becoming an entrepreneur (Aliaga-Isla & Rialp, 2013). In their research on entrepreneurs in Germany, Constant and Zimmerman points out that immigrants may be pushed into self-employment because they feel that they are being discriminated (2006). The other responses differ from being on more idealistic ideas to being very specific on how much they aim to earn during a year. There is a tension revealed through these different answers that can be related to the tension between intrinsic and extrinsic motivation. What is most important to focus on when running a business, to have an extrinsically motivated goal of a monthly income, or to have an intrinsically motivated goal, such as enjoying what one is doing, helping people or giving something back to society? The answer to this question is probably that you need both types of motivation in this context. It is important to have a goal related to turnover in the business, but the idea behind the fivestep approach is that one should also remember what is important, or what one appreciates, and keep this in mind when moving on to planning more in detail what needs focus now, and what the goal in the near future is. Both idealism and realism is perhaps needed to succeed and endure when running a business.

## **Conclusion**

This study has contributed to find out how a systematic approach carried out in groups can support immigrant entrepreneurs. It may help them identify goals and obstacles, and find solutions. The study also shows that feeling related to others is an important aspect of becoming motivated. As this is only a short-term pilot study reporting on participants' experience of a two-days' course, further research is needed to investigate the potential of the concept of idealab, and how entrepreneurs of different origins experience this type of approach. There is a need to investigate whether this actually helps them succeed with their business, what the cause of a possible success is, whether it is related to participating in idealabs. Perhaps there is a need for a longer course as some of the participants reported, since two days are not much. Still, based on the findings in this pilot-study, my conclusion is that giving courses applying the fivestep motivation-method presented here through idealabs may be one way of supporting immigrant entrepreneurs to succeed with running a business in a foreign culture.

## **Acknowledgements**

Thanks to the Agder-counties in Norway and the Norwegian Directorate of Integration and Diversity for funding the project, and to the EVA-centre (Etablerertjenesten i Vest-Agder, a centre for giving guidance to entrepreneurs), and particularly Jens Anders Risvand, for good collaboration.

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***Effect of Carbonization Temperature and Reaction Time on  
Non-Recyclable PET bottle for Char Formation***

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**Abstract**

Carbonization experiments of non-recyclable PET bottles were carried out in using a 2.0 L autoclave reactor to determine the carbonization conditions on the yield of carbonization product. The effects of process variables; the operating temperature (320-480°C) and holding time (60-240 min) were investigated. The maximum yield of fixed-carbon of char 22.0 wt% was obtained at process conditions of 400-480°C and 240 min. The wax phase was also collected, and the characteristics were investigated using GC-MS analyzation, and quantified using HPLC. Results confirmed that wax was mostly made up of benzoic acid. The gaseous phase was quantified using GC-TCD and GC-FID analyzation. Results showed that the gaseous product was mostly made up of CO and CO<sub>2</sub> whereas a small trace of hydrocarbons such as methane and ethane were detected. In this study, it was clarified that high fixed-carbon yield char was obtained at 400-480°C while only less than 10 C-wt% of CO<sub>2</sub> was emitted during carbonization. This makes the current method highly environmental and potentially commercial for processing non-recyclable PET bottles.

Keywords: Carbonization, PET bottles, Active carbon, Plastic waste, Carbon capture

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## Introduction

In 2017, the US had reported only 21% of PET bottle recycling rate. Compared to the US, PET bottle recycling rate in Japan was reported to be 85% (The Council for PET Bottle Recycling, 2017). Although recycling rate seems high in Japan, still 15% of the total PET bottles collected are not recyclable. Here, non-recyclable PET bottles are referred to materials consisting of colored pigment, materials with impurities on surface and materials exposed to long-term UV degradation. These bottles usually lack mechanical strength and thermal stability due to additives and degradation that decrease the purity of polymer (Dutt, et al., 2013; ). They have no value to be recycled into other materials and are still usually processed through thermal treatment. Thermal treatment of plastic materials is the least desired approach in waste management due to environmental and health concerns involving the emission of toxic PAHs (Saha, et al., 2005) and GHGs during the incineration of plastic wastes, especially when climate change is a serious global concern. There is still a need to improve the material value of non-recyclable PET bottles in order to mitigate the dependency on thermal treatment.

From all the above exposed, the aim of this research is to improve the material value of non-recyclable PET bottles. To achieve this, non-recyclable PET bottles were treated into char through carbonization. Carbonization is the thermal degradation of materials in the absence of oxygen to produce solid with high carbon content called char. (Ward, et al., 2014; Silva, et al., 2015) This method is widely used for solid waste treatment due to the temperature range sufficient for sterilization of waste, simplicity of the method, ease for bulk treatment and low energy input compared to thermal recycling. Carbonization of PET has advantages in terms of producing valuable precursor for activated carbon due to the high carbon content and absence of mineral matter. (Correa, et. al., 2017; Han, et al., 2019; Vilota, 2018) The aim of this research is to provide an alternative route to improve the material value of non-recyclable PET bottles for the enhancement of the PET bottle recycling cycle. In particular, we plan to treat the non-recyclable PET bottles into char through carbonization, followed by activation of the carbonized product into activated carbon.

In this study, we had conducted carbonization experiments using commercial PET bottles as model feedstock to give a better understanding on the factors in the carbonization of PET using a bench-scaled batch reactor to obtain high char yield. Current studies include the effects of operating temperature and reaction time on char, wax and gas yield.

## Materials and Experimental Equipment

As shown in Figure 1, an autoclave reactor made of SUS316 with inner volume of 2.0 L was used in this experiment. The reactor was equipped with an inlet for N<sub>2</sub>, an outlet for gaseous products, and a thermocouple to monitor the temperature inside the reactor. The outlet was connected to a heat exchanger followed by a gas-liquid separator, air filter, back pressure regulator (BPR) and finally to a gas bag for collection of gaseous products. φ90 ceramic crucible was placed inside the reactor and approximately 75 g of compressed PET bottles were packed for each experiment. PET bottles were prepared from commercial 500 mL bottles, which were dried overnight with their caps removed. Before each experiment, the reactor was purged with N<sub>2</sub> to remove O<sub>2</sub> from the system to prevent combustion of feedstock. Batch mode runs (Valve 1 and 2 closed) were initiated by heating the reactor from room temperature to set temperature under heating rate of 1°C/min. After reaching the set temperature, the condition was kept constant until the predefined time. Note that reaction time is set to start when temperature reaches the set temperature. Detailed operating parameters are summarized in Table 1.

Char, wax and gaseous products were collected for analyzation. For char, calorific value, proximate and ultimate value were obtained; for wax, GC-MS analysis was used to identify the chemical compounds while HPLC analysis was used to quantify the compounds; for gas, components were quantified through GC-TCD and GC-FID analysis.

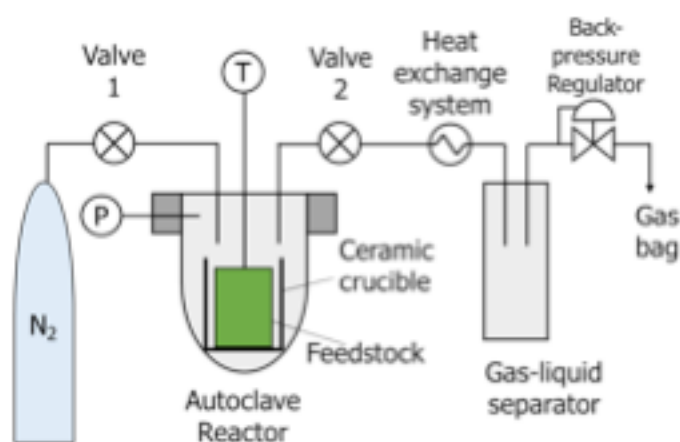


Figure 1: Experimental set-up of carbonization system.

Parameter	Value/Description
Feedstock Type	Clear waste bottle
Feedstock Loading [g]	65-75
Operating Medium	N <sub>2</sub>
Operating Temperature [°C]	320-400, 360-440, 400-480
Operating Pressure [MPa]	0.05
Holding Time [min]	30, 60, 120, 240

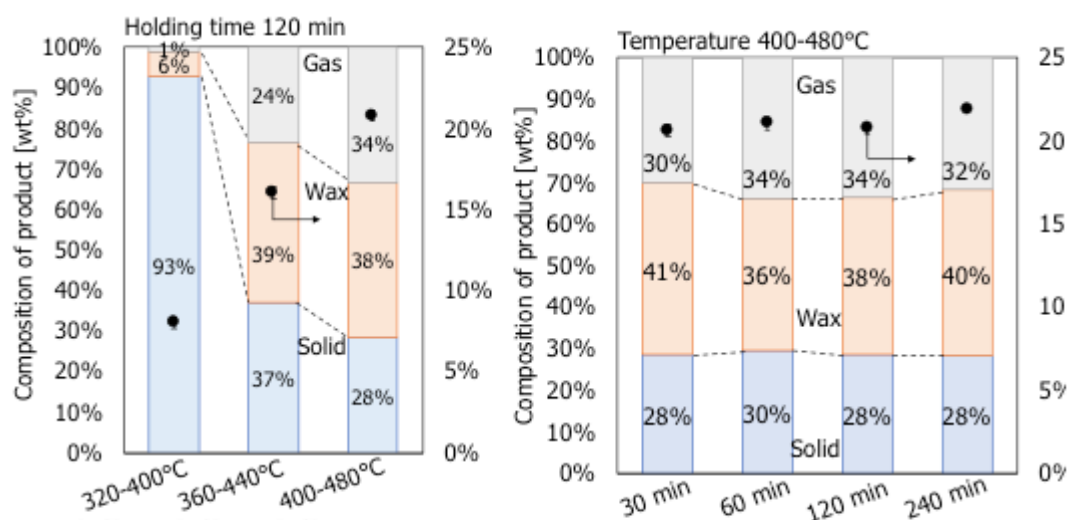
Table 1: Operating parameters of carbonization system.

## Results and Discussion

Figure 2 shows the yield of char, wax and gas and yield of fixed carbon for operations under different temperature at constant holding time of 120 min; and operations under different holding time at constant temperature of 400-480°C.

In a series of temperature difference, char yield ( $y_{char}$ ) was obtained as follows: 93 wt% in operating temperature 320-400°C, 37 wt% in operating temperature 360-440°C, 28 wt% in operating temperature 400-480°C; wax yield was obtained as follows: 6 wt% in operating temperature 320-400°C, 39 wt% in operating temperature 360-440°C, 38 wt% in operating temperature 400-480°C; and gas yield was obtained as follows: 1 wt% in operating temperature 320-400°C, 24 wt% in operating temperature 360-440°C, 34 wt% in operating temperature 400-480°C. Yield of fixed-carbon content increased rapidly compared to the raw PET material to give 12 wt% for Run 320-400°C, 16 wt% for Run 360-440°C and 21 wt% for Run 400-480°C. Although Run 320-400°C produced the highest char yield, further analyzation suggested that most of the char are composed of incompletely carbonized part. This explains the low mass fraction of fixed carbon of Run 320-400°C which was comparable to raw PET. The high fixed carbon of char from Run 400-480°C shows that high temperature is favored for the carbonization of PET to produce char with high fixed carbon yield. As a conclusion, the progression of carbonization was more favored under higher temperature.

On the other hand, in a series of different holding time, char yield was obtained as follows: 28 wt% in holding time 30 min, 30 wt% in holding time 60 min, 28 wt% in holding time 120 min and 28 wt% in holding time 240 min. Also, increasing the reaction time of operation had no significant effect on the fixed-carbon yield. This indicates that carbonization was complete at 30 min and increase of holding time did not affect the composition of product obtained.



**Figure 2:** Yield of char, wax and gas and yield of fixed carbon for (Left) operations under different temperature at constant holding time of 120 min; and (Right) operations under different holding time, at constant temperature of 400-480°C.

Fixed-carbon yield (Nunoura, et al., 2006) was calculated by:

$$y_{fc} = y_{char} \left( \frac{\%Fixed\ Carbon}{100 - \%Feed\ Ash} \right)$$

Figure 3 shows the gas composition, wax composition and CHN composition of char obtained from operations under different temperature at constant holding time of 120 min. Results showed that, for wax composition, wax obtained was mainly composed of benzoic acid. For gas composition, gaseous product obtained was mainly composed of carbon monoxide (37 vol%) and carbon dioxide (43 vol%) with small traces of methane (13 vol%) and other hydrocarbons (7 vol%). For char, the carbon content increased while the oxygen content decreased at high operating temperature. As a summary, the composition of products for all phases are largely affected by the operating temperature.

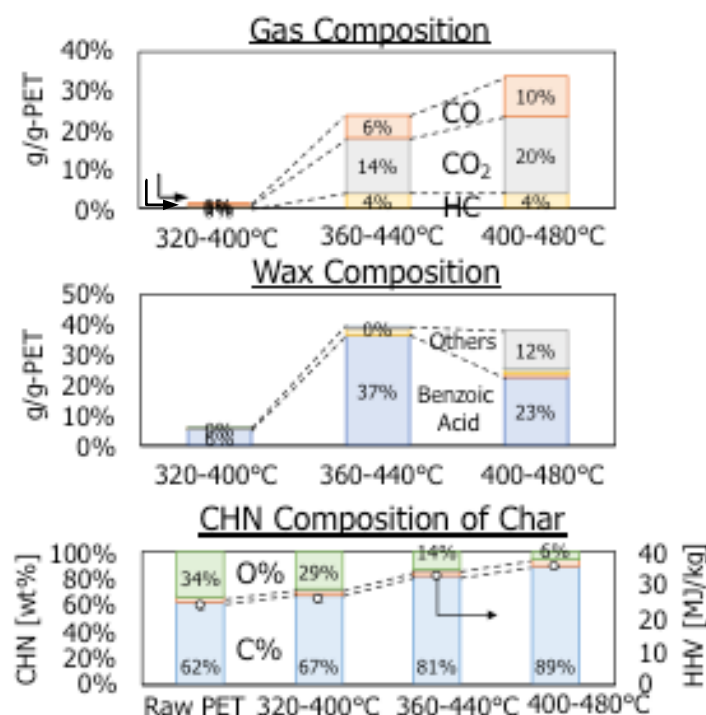


Figure 3: Gas composition, wax composition and CHN composition of char obtained from operations under different temperature at constant holding time of 120 min.

## Conclusions

In this study, char obtained from 400-480°C presents high fixed-carbon yield while only emitting less than 20 wt% of CO<sub>2</sub>. This makes the current method highly environmental (less emission of greenhouse gas) and potentially commercial (achievable at 400-480°C) for processing non-recyclable PET bottles. The carbonization of PET bottles may provide substitute materials for applications such as gas adsorbent. Trapping carbon from plastic waste as char may help reduce greenhouse gas emission and also solve limited landfill problems. Improving the material quality of end product of post-consumed PET bottle may also help enhance the sustainability of the PET bottle cycle.

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## *The Interest of Chinese Citizens in Environmental Issues and Green Activities*

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### **Abstract**

Over the last 30 years, China has experienced rapid economic growth that has resulted in several environmental issues that need to be addressed. Numerous researchers believe that by incorporating the social change ideology of “environmental citizenship”, Chinese citizens’ awareness regarding pollution can play an important role in environmental protection. In this regard, the objective of this study was to investigate Chinese citizens’ awareness regarding environmental issues, pollution in cities, and pro-environmental behavior, and thereafter identify the factor that determines their participation in environmental protection or pollution activities. Using a questionnaire survey, data on aspects such as knowledge of environmental protection laws and garbage sorting rules, awareness of the severity of China’s environmental issues, participation in and prioritization of pro-environmental activities in daily life, were collected. Using factor and regression analyses, the mathematical distributions of these aspects were analyzed. The results showed that a majority of Chinese citizens understand the severity of China’s environmental issues and recognize the need for a change in their activities and opinions. However, only a few them adhere to the environmental protection laws. Presently, the focus of Chinese citizens is shifting from rapid economic development to sustainable development, highlighting the role of the education sector and the national/local government in raising public awareness regarding pro-environmental behavior.

Keywords: Environmental citizenship, pro-environmental behavior, green activities

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## Introduction

Compared with other nations, China has experienced an unprecedented economic growth, and still continues to undergo social change. For a greater portion of the last 60 years, this nation prioritized economic growth over environmental protection (He et al., 2012). Consequently, it is now facing numerous environmental issues that need to be addressed. Many scholars have reported changes in priorities, especially after the 11th Five Year Plan (FYP) that spanned 2006 and 2010 (He et al., 2012). However, the acceleration of industrialization, urbanization, as well as further economic growth continues to place enormous pressure on natural resources in this nation, leading to severe pollution and an excessive demand for resources, which may further hinder economic development and social stability (Wang, 2011). If China maintains its current rapid economic growth rate, and if its economic structure is not fundamentally reoriented, it will sooner, rather than later, reach its resource and environmental limit. Thus, a significant restructuring is necessary with respect to consumption and production modes (He et al., 2012).

Consequently, the Chinese government has had difficulties striking a balance between economic growth and environmental protection. Chinese environmental management is government-regulated, and the environmental policies continue to be executed via a top-down approach (He et al., 2012). Since Environmental Protection Laws (EPLs) were tentatively implemented in 1979, the Chinese government has reformed the production and consumption sectors by amending and re-enacting laws aimed at improving energy consumption efficiency and enhancing environmental protection. In 2018, the EPLs were drastically amended to include environmental regulation and control measures, such as the environmental tax, the environmental impact assessment law, and the emission permit system. Arguably, these administrative initiatives have contributed to the improvement of environmental management to a certain extent. Additionally, there have been indications that the rule of law is now being taken more seriously in the field of environmental protection, owing to China's opening up to global economy and policy (Mol & Carter, 2006). Over the past decades, China's environmental management system has achieved some successes (He et al., 2012).

On the other hand, since the 2000s most especially, environmental destruction has led Chinese citizens to develop grievances and begin environmental discourses, owing to their recognition of the fact that pollution damages their health and material interests (van Rooij, 2010; Yang & Calhoun, 2007).

With growing environmental awareness, Chinese citizens have played an important role in the increased efficient use of natural resources, the adoption of environmentally friendly technologies and cleaner products, the lowering of emissions, and the pressuring of firms into compliance, thereby improving pollution regulation and controlling severe pollution (Mol & Carter, 2006; Rooij, 2010). Many environmental non-government organizations (NGOs) have emerged, resulting in "green-speak" that advocates and promotes a new environmental awareness among citizens (Yang & Calhoun, 2007). Environmentally conscious citizens have a responsibility to work towards a sustainable society, and they embrace all the activities one might normally think of as relating to good environmental citizenship, including recycling, reusing, and conserving (Dobson, 2007).



Numerous researchers believe that through the promotion of the social change ideology of “environmental citizenship”, Chinese citizens’ awareness regarding pollution can play an important role in environmental protection. In this regard, the objective of this study was to investigate the awareness of Chinese citizens with respect to environmental issues, pollution in cities, and environmental protection activities (EPAs). Further, from the results obtained, the goal was to identify the factor that determines their participation in environmental protection or pollution activities, and identify measures that can be put in place to promote environmental protection activities and improve environmental awareness.

## **Methods and Data**

Data collected using questionnaire surveys were used in this study. The questionnaires, which included both open-ended and closed-ended questions, and employed the Likert 7-point scaling system, were distributed to 200 Chinese citizens living in the following cities: Dalian, Shanghai, Amoy, and Shenyang. Data related to the respondents’ basic attributes, environmental awareness and related activities, daily behavior, and psychology, were collected, and finally, a total of 192 valid questionnaires were considered for analyses.

Based on questionnaire-survey data, aspects such as citizens’ knowledge of EPLs, garbage sorting rules, awareness of the severity of China’s environmental issues, participation in EPAs, and prioritization of EPAs in daily life, were analyzed.

## **Results and discussion**

### **Citizens’ Understanding of Environmental Protection Law and Garbage Sorting Rules**

Figures 1-4 show the distribution of responses to questionnaire items regarding citizens’ knowledge of EPLs and garbage sorting rules, as well as their littering and garbage sorting frequency. Only 14.6% of respondents answered “I understand the laws and can explain them to others,” while 74.9% answered “I have heard, but I know nothing about the laws,” and 8% responded “I have not heard of these laws.” Although a majority of the respondents had heard of the EPLs via TV commercials or street advertisements, only a few understood the detailed contents of the laws, indicating that the information regarding EPLs that is made available to citizens by the government and the different municipalities is insufficient to foster autonomous observance of the laws.

On the other hand, a majority of respondents (80%) stated that they understand garbage sorting rules, indicating that knowledge regarding these rules has already infiltrated the society. Garbage bags and publicity posters, which are distributed all over the cities, as well as TV commercials, have been effective in building awareness in this regard. However, 70% of the respondents hardly ever or never sorted their garbage before disposal. Even though they understood the garbage sorting rules, most of them did not voluntarily practice it. Furthermore, approximately 90% of the respondents acknowledged that currently, they do not or they seldom litter, indicating that many Chinese citizens have a revulsion towards littering, and they are committed to keeping their living spaces clean.

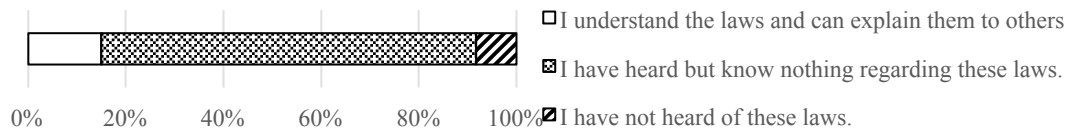


Figure 1: Descriptive statistics of the questionnaire item regarding citizens' understanding of Environmental Protection Laws.

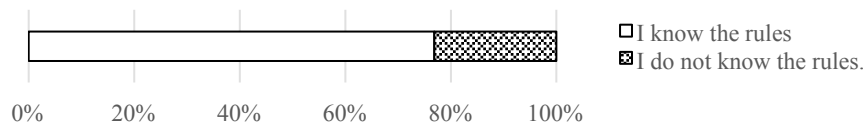


Figure 2: Descriptive statistics of the questionnaire item regarding citizens' knowledge of garbage sorting rules.

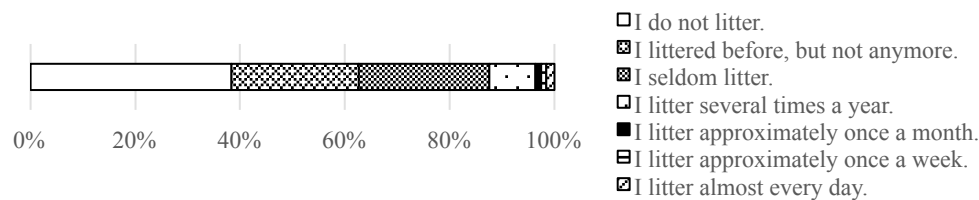


Figure 3: Descriptive statistics of the questionnaire item regarding littering frequency.

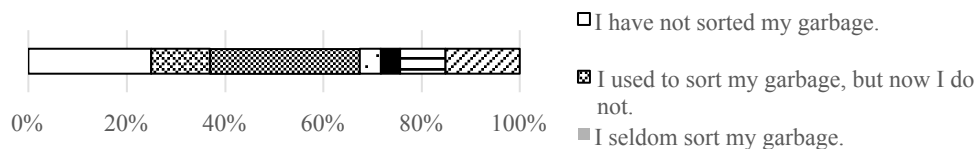


Figure 4: Descriptive statistics of questionnaire items related to garbage sorting frequency.

### Citizens' environmental awareness and related activities

Table 1 presents descriptive statistics of questionnaire items related to respondents' awareness and actions relevant to environmental protection. The different items presented in Table 1 were assigned a score based on the Likert 7-point scale. Taking into consideration the mean scores of all the items, the response "I would like the city I live in to be more hygienic" received the highest score, indicating that of all the environmental problems that affect the daily life of the respondents, cleanliness of living space was of the most important to them. The responses "I think the environmental problems China is facing are very serious" and "I am interested in the environmental problems China is facing" received the next highest mean scores (in that order), indicating that many citizens already feel antipathy towards the current state of environmental pollution in China.

Additionally, the mean scores of "I prioritize maintaining my/our living standard over engaging in energy-saving and garbage weight reduction," and "The top priority for

China is not solving the environmental problem, but further national economic growth” received the lowest scores (in that order). These findings indicate that presently, Chinese citizens value the sustainability of the nation over high-speed economic development and are dedicated to incorporating environmental citizenship, which requires making a commitment to preserving public goods such as the environment (Dobson, 2007).

To extract general factors, all the items were rotated under Promax rotation using maximum likelihood methods. Thereafter, four factors were extracted, and the results of the factor loadings were obtained as presented in Table 1. These four factors were labeled thus: (I) The people around you influence your environmental protection activities, (II) Recognizing the seriousness of environmental problems, (III) Interests in environmental problems, and (IV) Giving priority to national development/improvement of the quality of one’s own life.

	N	Average	Standard deviation	I	II	III	IV
The people around you influence your environmental protection activities.	179	2.056	1.5712	.997			
Your family influences your environmental activities.	176	2.136	1.6540	.698			
I think the environmental problems China is facing are very serious.	186	5.71	1.3917		.949		
I think energy the problems China is facing are very serious.	185	5.303	1.3534		.713		
I have higher eco-awareness than others.	177	4.938	1.3741			.745	
I am interested in the environmental problems that China is facing.	183	5.694	1.3885			.633	
I would like the city in which I live in to be more hygienic.	184	6.5	1.1113			.563	
The top priority for China is not environmental problem-solving, but furthering national economic growth.	181	3.431	1.7863				.999
I prioritize maintaining my/our living standard over engaging in energy-saving and garbage weight reduction.	179	3.838	1.6965				.352

Table 1: Descriptive statistics of questionnaire items related to citizens’ understanding and actions regarding environmental protection.

## **Littering and sorting garbage**

To investigate the impact of citizen's understanding of environmental protection on their garbage sorting and littering behavior, regression analyses were performed. After being weighted via prorating on a 365 days/year basis, garbage sorting and littering frequencies were considered as the dependent variables, while the independent variables included four extracted factors, gender (dummy variable; male = 1), age, education (weighted variable; education years), knowledge of garbage sorting rules (dummy variable; I know the rule = 1), understanding of EPLs (dummy variable; I understand well = 1), and household monthly income (logarithmically converted). The variance inflation factor (VIF) was <3.0 in all the models, and thus, multi-collinearity was avoided.

Table 2 shows the results of the analyses. Statistically, "Recognizing the seriousness of environmental problems" had a negative effect on littering frequency and a positive effect on garbage sorting activities i.e., citizens who valued environmental and energy sustainability in China made efforts to participate in activities that contributed to sustainability. Therefore, if governments could create awareness among citizens regarding the seriousness of the environmental problems China is presently facing, this would encourage their participation in environmental protection activities.

Contrary to our expectations, "Giving priority to national development/improvement of the quality of one's own life" and "Interests in environmental problems" had no direct relationships with littering or garbage sorting. As shown in Table 1, the priority of many Chinese citizens has already shifted from maintaining their life quality and/or national economic development to environmental problem-solving. However, this priority shift did not result in increased frequency of garbage sorting or abstinence from littering. Therefore, Chinese citizens need to be persuaded through education so that they can acquire a more detailed understanding regarding the impact of littering and garbage sorting on environmental problem-solving.

"The people around you influence your environmental protection activities" had a statistically positive effect on littering frequency, but had no effect on garbage sorting frequency, indicating that the citizens placed a high value on others' opinions, which greatly influenced their littering habits. Citizens who prioritize what others think would tend to refrain from littering because this act is generally regarded as illicit and ill-mannered by the society. Contrarily, the opinions of others did not influence garbage sorting, given that it is generally conducted inside houses and is not witnessed by others. Therefore, a measure whereby waste collection staff are able to see the contents of garbage disposed for composting or recycling systems may have an immediate effect on garbage sorting.

Unfortunately, the results showed that "Citizens' knowledge of garbage sorting rules" had no significant effect on either dependent variables, indicating that even though many citizens understand garbage sorting rules (Figure 1), most of them do not properly dispose of their garbage. Therefore, they must be encouraged not only to acquire knowledge regarding garbage sorting, but also to practice garbage sorting activities. Additionally, "Citizens' understanding of Environmental Protection Laws" had a significant effect only on garbage sorting frequency.

Recent studies have shown that younger populations are most likely to engage in pro-environmental behavior, given that they grew up during the period of intense environmental degradation (Chen et al., 2011). Consistent with this finding, this study showed that younger citizens were more likely to refrain from littering compared with older citizens; however, age was unassociated with garbage sorting frequency. Younger citizens expressed greater concern regarding the future environmental sustainability of China. Additionally, they have been educated in schools regarding the problems of modern China; thus, a majority of them are learned and are conscious of the importance of their actions and moral values with respect to maintaining China's sustainability. In cities, scattered garbage and hygiene problems are clearly visible, given that the contribution of garbage sorting to national sustainability is still obscure, and citizens are generally not well educated.

According to previous studies, people with higher levels of education are more likely to engage in pro-environmental behavior. This is because their exposure to more information regarding environmental degradation as well as their schooling have made them more conscious of their responsibility towards the environment (Scott & Willits 1994; Chen et al., 2011). Contrary to these previous studies, this study showed that education and gender are not directly related to littering and garbage sorting. Additionally, it showed that by improving citizens' knowledge regarding law and rules related to environmental protection, education level no longer affected the two dependent variables, meaning that higher levels of education did not strengthen the motivation for environmental sustainability. Therefore, to establish pro-environmental citizen activities, not only the knowledge of law or rules should be imparted, but in addition, education regarding pro-environmental moral values should be provided during elementary education.

Considering that in traditional gender roles, women in China perform more domestic tasks such as garbage sorting and recycling than men, gender may affect environmental protection activities (Chen et al., 2011; Li 2003). However, this custom has been mostly abolished, and women now work. Thus, regardless of gender, it is important that all citizens understand and conform to garbage sorting rules.

	Littering frequency B	Garbage sorting frequency B
Male dummy	.053 (.022)	.055 (.052)
Age	.268*** (.002)	-.076 (.004)
Education	-.043 (.007)	-.037 (.018)
Citizen's knowledge of garbage sorting rules.	-.090 (.042)	.073 (.099)
Citizen's understanding of Environmental Protection Laws.	.072 (.031)	.322*** (.073)
Recognizing the seriousness of environmental problems.	-.187** (.014)	.302*** (.033)
Giving priority to national development/improvement of the	.116 (.011)	-.030 (.027)
Interests in environmental problems.	-.033 (.017)	.159 (.040)
The people around you influence your environmental protection activities	-.245*** (.013)	-.092 (.030)
Businessman dummy.	-.252 (.034)	-.006 (.081)
R-Squared	.184	.229
Adjusted R-Squared	.127	.173
N	153	147

Table 2: Results of regression analyses.  
\*Sig. < .01, \*\*Sig. < .05, \*\*\*Sig. < .01.

## Conclusion

A citizen's high self-efficacy in environmental protection activities would generally promote environmental citizenship. If the atmosphere of the residential area is dirty and surrounding is littered with garbage, citizens will lack the motivation to refrain from littering. Hence, the cleanliness of residential areas helps to foster moral values regarding hygiene. Presently, Chinese citizens cannot fully appraise the extent to which their activities directly contribute towards environmental protection. This could be one of the reasons that suppresses their motivation to engage in environmental protection activities. Therefore, educating citizens on garbage sorting for composting and recycling systems, and explaining how this contributes to environmental protection, may help them feel profitability and reciprocity while practicing garbage sorting.

This study clearly reveals that garbage sorting rules are well-known in China. The dissemination of information by the Chinese government regarding garbage sorting, which is done via television commercials, posters in the city, and the many trash boxes prepared for each sort of garbage, distributed across the different cities, contributes to publicizing the garbage sorting rule. However, this current system does not provide a strong deterrent to negative-environmental activities. The promotion of pro-environmental activities cannot be achieved without radical changes in citizen's understanding and moral values. Shanghai enforced a "compulsory garbage sorting rule" for household waste on July 1, 2019, which requires that individuals who fail to properly sort their garbage will be fined up to 200 yuan. Strict rules can enforce particular behaviors; however, they do not change opinions or understandings. Rather, the understanding of citizen would be effectively changed if they are aware of the observations and judgments of others. Additionally, education, which brings about drastic changes in awareness regarding the environment by fostering a culture that encourages EPAs in China, is now required. At a residential garbage disposal area, if volunteers closely observe trash disposal and sorting, and if residential committee members as well as property management staff are engaged in observing the actions of the neighborhood residents, it is expected that this would encourage citizens to follow the sorting rules.

China, which is a country that has faced international criticism for its domestic environmental policies in the past (Mol & Carter, 2006), is presently shifting its focus from national economic development growth to sustainability. Therefore, the effective implementation of environmental education programs to promote awareness regarding environmental protection may have immediate effects.

This study had some limitations. Firstly, the surveys were conducted only in urban areas. A previous study revealed that the behavioral clusters for urban vs. rural locations are salient (Whitmarsh and O'Neill, 2010). Urban areas may suffer more from substantial environmental threats compared with rural areas (Vitousek et al. 1997; Kalnay & Cai 2003), and larger cities with greater political power and higher employment opportunities can afford to promote pro-environmental behavior (Chen et al., 2011). Therefore, comparing citizens' understanding and awareness with respect to their location i.e., urban and rural, and thereafter, deducing implications based on the approaches employed aimed at improving suitable citizen's pro-environmental activities based on their locations, will be the focus of our next study.

Additionally, the results of this study were contrary to those of previous studies (Scott & Willits 1994; Li 2003; Chen et al., 2011), which showed that citizens who were employed, holding leadership positions, living in larger cities, female, younger, highly educated, single, and have environmentally friendly attitudes, were more likely to participate in pro-environmental behavior. Therefore, a more careful examination is still required to reveal causal relationships among these factors, and to better understand the inconsistencies between the results of this study and those of previous studies.

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## ***Quantifying Risk of Natural Disaster Using Typhoon Damage Cases in Commercial Buildings***

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### **Abstract**

Damages caused by natural disasters are increasing worldwide, and damages are increasing accordingly. Therefore, a number of international public organizations and global insurance companies are actively studying risk modeling models to predict and counter the risks of natural disasters. These organizations are working to increase the sophistication of the model, as it creates a strategy for risk transfer or preparation based on the risk quantification model as the risk of natural disasters increases. Nevertheless, many studies on natural disasters and economic losses have defined the main factors, but there is a lack of comprehensive study on the relationship between risk factors such as natural disaster indicators and building inventory using actual cases. This study examines the risk factors and amount of risk through statistical analysis of damage cases caused by natural disasters. Hence, the purpose of this study is to define the risk indicators and to define the relationship between the risk indicators using actual damage cases of Typhoon Maemi, a representative natural disaster cases in South Korea. Building inventory and natural disaster indicators were used for statistical analysis. The results and framework of this study reflect the vulnerability of the actual damage, vulnerability of the building to natural disasters as well as the vulnerability of the region, so that public agencies and insurance companies will have a practical way to develop natural hazard risk quantification models.

Keywords: Typhoon damage, Vulnerability, Commercial building, Statistical analysis

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## **Introduction**

Recent climate change has led to an increase in the occurrence of severe storms and soaring losses. Many developed countries are adopting insurance as a way to transfer the financial risks of extreme storms. Insurers use natural disaster models and historical loss records to predict and manage potential economic losses for individual buildings, regions and countries. The purpose of this study is to develop a building's local vulnerability function to assess damages caused by typhoons. In order to predict the loss reflecting local vulnerability, we will investigate the relationship based on the importance and significance of the typhoon loss, natural disaster index, and basic building information index, and present the damage function to prepare for future damage prediction and preventive measures. In this study, we used the insurance company's typhoon cicada loss record and limited the scope to residential buildings.

## **Data Collection & Analysis**

In this study, the dependent variable was expressed as loss ratio, which is the insurance payment divided by the total construction cost, and typhoon information and building information were used as independent variables. Typhoon information includes the maximum wind speed and distance from the coastline, and the building information includes the total asset value of the building, the type of building (i.e., reinforced concrete frame, steel frame, wood, and steel roof), number of ground floor, and number of underground. Wind speed is an important indicator of the intensity of a typhoon, causing damage to floods, storms and landslides. The wind speed maps of the damaged buildings were collected based on the date of the accident and the geographic information system (GIS) based on the address information of the typhoon damage record. The distance from the center of the building to the coastline was also collected based on the address information using the geographic information system. The distance between buildings and shoreline correlates with vulnerability to storms (Highfield 2010). Basic building information such as total property value, building type, number of ground floor, and number of underground are also used as vulnerability indicators to suggest typhoon vulnerabilities according to basic building information. The total amount of building property has been confirmed through previous studies on the loss of typhoons that the loss of storms increases as the total amount of assets decreases (Kim 2017). The type of building is an important indicator of the typhoon vulnerability of buildings. In general, building heights are considered vulnerable to typhoons in the order of reinforced concrete, steel, stone, and wood (Khanduri 2003). Building height is also considered an essential indicator of quantification of vulnerability to storms. Building height is statistically correlated with the extent of financial losses. It can be used as a vulnerability index that quantifies the vulnerability of a building to typhoons (De Silva 2008).

## **Discussion**

In the vulnerability function regression analysis for residential buildings, the Adj-R2 value is 0.613, and this model has an explanatory power of 61.3%. The indicators of the vulnerability of typhoon losses were found to be significant in terms of maximum wind speed, distance from shoreline, total property value, and ground floor number. The value of the VIF ranged from 1.031 to 1.210, indicating that there is no problem of multiplicity between variables.

Table 1. Result of regression analysis

Variables	Coef.	Beta Coef.	p > z	VIF
<b>Typhoon Info.</b>				
Distance from coast	-.021	-.238	.000	1.031
Maximum wind speed	.453	.498	.000	1.210
<b>Basic Building Info.</b>				
Underground floors	.019	.015	.689	1.057
Floors	.027	.109	.019	1.052
Construction type	.193	.129	.151	1.088
Total value of property	-2.123E-005	-.321	.000	1.071
Number of Observations		211		
F		46.721		
Adj-R <sup>2</sup>		0.613		

## Conclusion

Typhoons cause severe financial losses, and insurance companies, governments, and municipalities use the typhoon risk assessment model to estimate the level of damage. This study presents a statistical model using the typhoon damage record of insurance companies. The results and framework of this study can provide essential guidance for predicting typhoon losses in insurance and government policies. This study is limited to commercial buildings, but the scope of this study will be extended to residential and industrial buildings. However, the data used in this study are only damage from typhoons, and further studies using various categories of typhoons are required to support the results.

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***An Analysis of the Possibility to Achieve the Specified Indonesian Renewable Energy Development Target: Status and Proposal for the 2020-2024 Medium-Term Development Plan***

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**Abstract**

During the 2015-2019 Medium-Term Development Plan (MTDP), Indonesia's renewable energy showed good growth performances, especially for biofuels. In terms of share, however, there was a large gap between the targets of renewable energy's share and their realizations, due mostly to the growth of fossil fuels which grew higher than expected. The high growth of fossil fuels was caused by large imports of petroleum and LPG and as a result of the "35,000 MW" project implementation. The achievement of developing Indonesia's renewable energy in the next future will not be determined by the sector alone, but also by the growth of other energy sectors, namely oil, natural gas, and coal. For renewable energy to reach its development target in 2020-2024 MTDP (including to achieve 23 percent share by 2025), several strategies and actions were proposed. These include utilizing the increased production of renewable energy to be used to reduce consumption of fossil fuels, linking the development of certain types of renewable energy technologies with development programs and their potential users, establishing a Renewable Energy Development Agency and an Energy Conservation Center, and improving regulations on renewable energy development (particularly on tariff and Renewable Portfolio Standards).

Keywords: Indonesia, renewable energy, energy policy, medium-term development plan

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## Introduction

Indonesia is one of 169 countries in the world which has set its renewable energy development targets (REN21, 2019), driven by various objectives including reducing dependence on fossil fuels, improving the balance of payments and following international agreements on climate change and sustainable development (Purwanto, 2017; Nugroho, 2018a, 2018b). Like many other Asia's developing countries, Indonesia since the early 1970es has put into practice a Five-Year Development Plan in building various sectors of its national life (GoI, 2015; GoI, 2020). Various strategic plans and sectoral policies, for the ease of coordination and achieving their goals, are consolidated in the Five-Year Development Plan document, later known as the Medium-Term Development Plan (MTDP).

A basically fossil fuels country, Indonesia has experienced various developments in its energy policymaking (IEA, 2008, 2014, 2015; Nugroho, 2011, 2018a). The most recent and basic law on national energy policy is Government Regulations in lieu of Laws number 79 of 2014 (Rep. of Indonesia, 2014), which is based on the Energy Law number 30 of 2007 (Rep. of Indonesia, 2007), and which has been translated into Presidential Regulation on National Energy General Plan (GoI, 2017). Included in the core of the long-term national energy policy is the prioritization of renewable energy development.

This paper examines renewable energy development in Indonesia, in the context of national energy policy and medium-term development plans (MTDP). Discussed mainly the achievement of renewable energy development targets in the 2015-2019 MTDP, as well as proposals for renewable energy development for the 2020-2024 MTDP. Several studies estimate that Indonesia's renewable energy development targets are difficult to achieve (Purwanto, 2017; Bappenas, 2017; Bridle, 2018), the paper tried to confirm this, while the proposal is not limited to 2020-2024 MTDP but also efforts to achieve the renewable energy mix target 23 percent in 2025 as stated by the National Energy Policy (NEP).

Our analysis began by studying the data on renewable energy development targets and their achievements in the 2015-2019 MTDP, then looked at the factors that cause differences between target data and their realization. Several previous studies and theories (Boyle, 2004; Tester, 2005; Brown, 2011; Sovacool, 2012, 2013; IRENA, 2014) were studied to explain the causes of these differences. A better understanding of the theories and problems faced in energy development in Indonesia (Bappenas, 2016, 2017a, 2017b, 2018; 2019d; Irsyad, 2017; Nugroho, 2015, 2018a, 2019;) resulted in our proposals for renewable energy development for 2020-2024 MTDP. Besides, we have access to some limited official data and reports (for example Bappenas, 2017a, 2018, 2019) which help conduct this study.

The paper is structured as follows. Section 2 contains the essence of the national energy policy, renewable energy performances during 2015-2019 Medium-Term Development Plan, and some analysis regarding the difference between the target and realization of the renewable energy development during the period. Following analysis, Section 3 contains Indonesia's considerable potential for renewable energy development, and our proposals regarding renewable energy development for the

2020-2024 MTDP that also intended to meet the target of renewable energy share in 2025. Section 4 summarizes and concludes our study.

### Renewable energy performances during 2015-2019 Medium-Term Development Plan

The essence of national energy policy as stated in GR 79 of 2014 covers two main things; first, the estimated total future energy demand or the amount of energy needs to be supplied nationally (divided for electricity and fuel; both until 2050); and the second, the national energy mix, with the direction of increasing the share of renewable energy. The essence of the policy can be summarized as shown in Figure 1.

It can be seen from Figure 1 that the amount of energy that has to be provided will increase from less than 200 MTOE (million tons of oil equivalent) in 2013, to about 400 MTOE by 2025, and to at least 1,000 MTOE by 2050. Given the increasing demand, the share of renewable energy needs to be increased from around 5 percent in 2013 to 23 percent in 2025, and 31 percent by 2050.

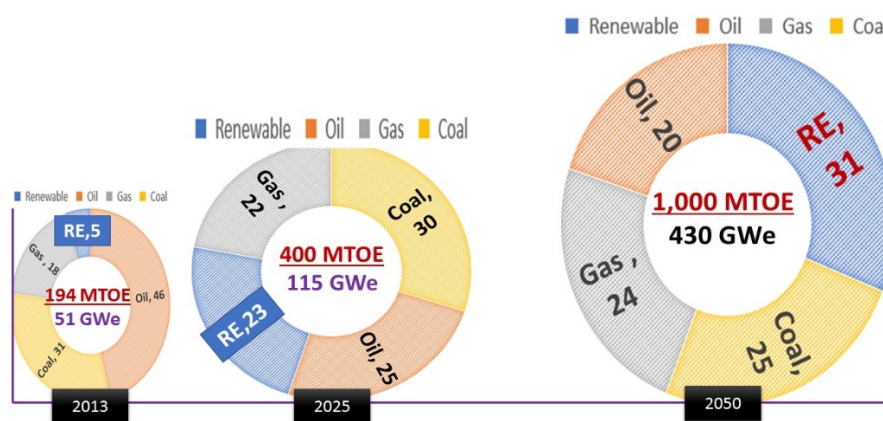


Figure 1: Energy Demand (TPES), Electricity Generation Capacity, and National Energy Mix (according to GR-Law 79/2014)

During the 2015-2019 MTDP, renewable energy showed good growth in production; it was very close to that suggested in the National Energy General Plan (NEGP), which is around 13 percent per year on average. However, this growth was achieved unevenly, and the details differed largely from those predicted in the NEGP. As the Ministry of Energy and Mineral Resources data shows (Dilisuusendi, 2019), the growth of renewable energy-based power plants reached by only 7.1 percent per year on average, far below the targets in NEGP or MTDP.<sup>1</sup> Conversely, the growth of non-electricity renewable energy was very impressive, with liquid biofuels grew by 33

<sup>1</sup> Actually, in the initial 2015-2019 MTDP document there were no quantitative targets for renewable energy development mentioned. The NEGP target for renewable energy development was then adopted by MTDP in the middle implementation of the 2015-2019 MTDP.

percent per year on average, and biogas even higher, at 40 percent per year on average (from 25.2 million cubic meters in 2015 to 95.6 million cubic meters in 2019).

Although the growth of renewable energy in the 2015-2019 MTDP was not poor, its share in the national energy mix was still far lower than expected (Figure 2).

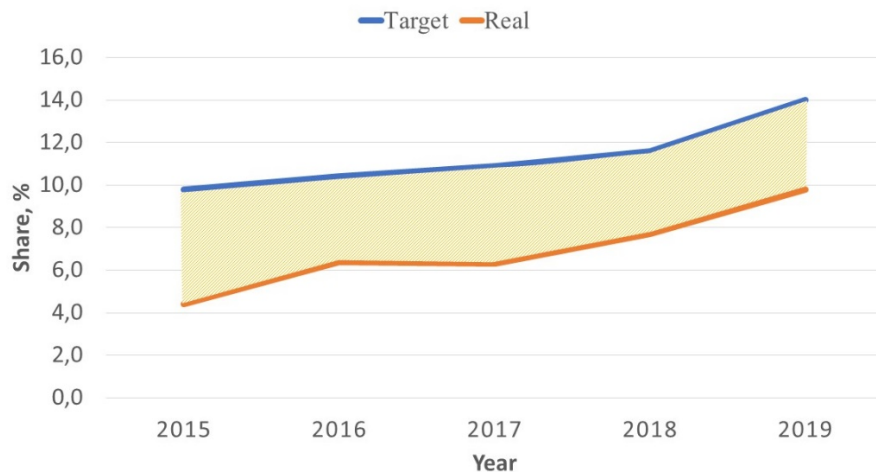


Figure 2: Renewable energy share in national energy mix: targets and realization during the 2015-2019 MTDP

Why did the difference between the share of renewable energy targeted for 2015-2019 MTDP and its realization was quite large?

While many studies focus on barriers/challenges in analyzing Indonesia's renewable energy prospects (Bridle, 2018; IRENA, 2016; Purwanto, 2017), we also consider the development of non-renewable energy, namely oil, natural gas, and coal. Our examination of growth data for all types of energy found that during the 2015-2019 period: (i) oil had grown higher than expected/ the target, (ii) the use of gas grew higher than projected, and (iii) coal even grew very rapidly compared to its projection.

The growths that were above the estimate, can be traced due to the following reasons. First, Indonesia, to some degree, is not successful yet in realizing its old agenda to reduce its large dependence on petroleum as the main source for fulfilling the country's energy needs (IEA, 2007, 2015; Nugroho, 2018; BP, 2019). No longer a net petroleum exporting country, during 2015-2019 MTDP Indonesia met about half of its petroleum needs by importing both crude oil and oil products (MEMR, 2018), be a burden on Indonesia's balance of payments (Bappenas, 2019b). However, the growth of petroleum imports showed a downward trend.

Secondly, as a long impact of Indonesia's energy policy a decade earlier to replace kerosene with LPG for household energy, while its domestic LPG production capacity is limited (Nugroho, 2011), LPG imports continued to increase during the 2015-2019 MTDP (Budiarti, 2019). The high growth of LPG imports during the period (close to 12 percent per year averagely) could partly be a result of the slow development of



Indonesia's natural gas infrastructure, specifically, that serve households (Nugroho, 2018a; Bappenas, 2019c).

Thirdly, the "35,000 MW" program implemented in the 2015-2019 MTDP (GoI, 2015) although only part of it had been built, had led to an increase in domestic coal consumption, specifically for electricity generation (Bappenas, 2016; Tampubolon, 2018). Driven mainly by power generation, coal consumption in that period increased by around 10 percent per year on average (Bappenas, 2019c.)

Within renewable energy itself, we look at the differences in growth that occurs due to the following things. Renewable energy-based power plants that grew by only 7.1 percent on average per year was due to poor tariff policies implemented during the second half of the 2015-2019 MTDP, and this was due particularly to the implementation of Minister of Energy & Mineral Regulation 50 of 2017 (MEMR, 2017; Rahma, 2017).<sup>2</sup>

On the other hand, the impressive growth of non-electric renewable energy is evidence of the effective mandatory policies for the use of biofuels in particular during the period. Taking advantage of its position as the world's largest CPO (crude palm oil) producing country, and in attempt to decrease dependence on fossil fuels, Indonesia since 2008 has developed biodiesel blends and implemented a mandatory use of biodiesel (Rahmanulloh, 2019), the last based on the Minister of Energy and Mineral Resources Regulation No. 12 of 2015 which requires the use of B-20. So far Indonesia's pioneering work in implementing mandatory biodiesel has been quite successful (Hadiyanto, 2018; Rahmanulloh, 2019).

### **Proposals for the 2020-2024 MTDP and to meet the target of renewable energy share in 2025**

Learning from the 2015-2019 MTDP experience, we consider that to achieve the renewable energy share in the future (DEN, 2019; GoI, 2020) two main strategies must be implemented: (i) increasing the capacity of renewable energy development, and (ii) controlling the growth of other types of energy, namely oil, natural gas, and coal. It should also be noted that to achieve the target of 23 percent renewable energy share by 2025, the supply of renewable energy in the 2020-2024 MTDP must grow faster than that in the 2015-2019 MTDP period.

It needs to demonstrate first that Indonesia has enormous renewable energy potential that can be developed (Nugroho, 2014; Bappenas, 2017b; DGNRE&EC, 2019). As Table 1 shows, the development of renewable energy for electricity in Indonesia is still very small compared to its potential. For example, the country, which is currently

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<sup>2</sup> In the middle of the 2015-2019 MTDP, the Minister of Energy & Mineral Resources issued Ministerial Regulation No. 50 of 2017 concerning the use of renewable energy sources for the supply of electricity. The Ministerial Regulation stated that the purchase of electricity from power plants which utilizes renewable energy sources by PLN (The State-Owned Electricity Company) will be determined based on the PLN's Cost of Electricity Supply. Because PLN's costs are considered too low, many prospective electricity providers had withdrawn from the power purchase agreement (Rahma, 2017). It can also be seen that the production of electricity from renewable energy sources, such as geothermal energy, was the result of electricity power purchase agreements made in the previous period, where the principle of "feed in tariff" (Mendonca, 2007) was used in determining electricity purchase agreement.

the world's second-largest producer of electricity from geothermal, has only utilized 7.5 percent of its geothermal potential (NS Energy, 2020; IGA, 2020;). In total, Indonesia has only utilized 2.4 percent of its potential renewable energy sources for electricity utilization. Besides, Indonesia also has a large potential for renewable energy from forests, palm oil, and various other plants that can be utilized as fuel (liquid, solid, or gas), with palm oil being a large source and economically feasible to develop into various types of energy (DGNRE&EC, 2019; Bappenas, 2019d).<sup>3</sup> These renewable energy sources, both for electricity and other uses are unevenly distributed across the archipelago.

<b>RE Resources</b>	<b>Potential</b>	<b>Developed</b>	<b>% (D/P)</b>
Hydro (GW)	75.0	5.3	7.1
Geothermal	25.4	1.9	7.5
Bioenergy (GW)	32.6	1.8	5.5
Solar (GWp)	207.8	0.1	0.0
Wind (GW)	60.6	1.1	1.8
Ocean (GW)	17.9	0.0	0.0
<b>Total</b>	<b>419.3</b>	<b>10.2</b>	<b>2.4</b>

Table 1: Indonesia's renewable energy for electricity: potential and developed (2019)

Learning from the 2015-2019 MTDP experience, we consider that to achieve the renewable energy share in the future (DEN, 2019; GoI, 2020) two main strategies must be implemented: (i) increasing the capacity of renewable energy development, and (ii) controlling the growth of other types of energy, namely oil, natural gas, and coal. It should also be noted that to achieve the target of 23 percent renewable energy share by 2025, the supply of renewable energy in the 2020-2024 MTDP must grow faster than that in the 2015-2019 MTDP period.

We propose that a portion of the additional renewable energy production can be used to replace fossil fuels (oil, natural gas, and coal) in a number of applications (Boyle, 2004; Tester, 2005; Sovacool, 2013).

The growth of coal consumption can be reduced (though not much) by implementing a co-firing program, where coal is blended with pellets resulted from the rehabilitation of palm oil plantation, energy forests, city waste, etc. As the technology is ready (IEA-ETSAP & IRENA, 2013), and negotiation with the state-owned electricity company is in good progress, the co-firing program could be deployed once the pricing system is encouraging (Husaini, 2019; KESDM, 2017). Another one is to develop renewable energy to reduce the use of natural gas and LPG imports by expanding the application of biogas that has been developed so far, for example, that by the BIRU program (FAO, 2014), and adding to it by developing new programs, for instance, the Bio-CNG (compressed natural gas) one (GGGI, 2019). There are grasses, reeds and bushes in Indonesia that potentially could be developed into methane or biogas programs (Supriyanto, 2016; DGNRE&EC, 2019).

<sup>3</sup> Since 2006, Indonesia has been the world's largest producer of crude palm oil, produced 43 million tons of CPO (crude palm oil) in 2018 (GAPKI, 2019). There are also fuel potentials from forests, plantation, paddy field, etc. that can be developed in Indonesia (DGNRE&EC, 2019).

Developing renewable energy to reduce fossil-based fuel will be the main program for the development of non-electric renewable energy. Indonesia's previous success in developing the B-10 biodiesel program needs to be increased by developing the B-20 program and so on (KESDM, 2019). In addition to the biodiesel program which has proven successful, the development of the Green-Fuel program that is being initiated is important to be supported.<sup>4</sup> The success of the two programs later will greatly contribute to the success of the renewable energy development program, in terms of increasing renewable energy production, reducing the growth of fuel (fossil-base) consumption and improving Indonesia's balance of payments.

We also propose that renewable energy development, especially for electricity, to be more focused on linking the types of electricity generation with development programs and potential users that are specific to the 2020-2024 MTDP. The hydropower plant must be given priority to meeting the demand for electricity by industrial estates that are built nearby (Bappenas, 2018) by not immediately building coal-fired power plants because of its low cost or easier to construct, for example. It will also important to continue the development of small hydro to meet rural villages' demand (Bappenas, 2017b). Because many of the islands in eastern Indonesia are still experiencing shortages of electricity supply (PT PLN, 2019), while the geothermal potential is located on some of these islands (Bappenas, 2014; Nugroho, 2015), it is appropriate to build (small-scale) geothermal power plants to increase electricity supply on these small islands.

The huge biomass potential in Indonesia can be developed by planting energy forests whose products can be used for cooking fuel, even electricity generation. Development of biomass for electricity potentially could be carried out in plantation areas (especially oil palm plantations) and, in addition to for own use, its utilization can be connected to the surrounding community (Bappenas, 2019d). The use of solar power in tropical countries Indonesia which has been too low (Table 1) needs to be expanded by installing photovoltaic units in remote areas, as much as possible to reduce the use of diesel fuel. Conversely, urban areas also need to develop regulations that require the use of solar power by luxury housing/apartments (including by building rooftop solar power), government offices, and commercial buildings to meet the NEGP targets (GoI, 2017; Burke, 2019).

Beyond the technical matters as previously described, we also propose about institutions and regulations to be established during the 20120-2024 MTDP period. This is considering that the development of renewable energy in Indonesia will continue going forward, therefore a strong institutional and regulatory foundation needs to be established to sustain this large work. Regulations, institutions and tariff policies that support the development of renewable energy need to be strengthened or in place (IEA, 2015; Nugroho, 2018b; Burke, 2019; Purwanto, 2017).

Government organizations responsible for developing renewable energy must be strengthened with greater expertise and ability to carry out their duties, including

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<sup>4</sup> Green fuel refers to fuels that are processed in a refinery with treated crude palm oil, called refined bleached deodorized palm oil (RBDPO) through a treatment called coprocessing. There are three types of green fuel, namely gasoline, diesel, and aviation turbine oil. The processing method is different from a 20 percent biodiesel blend, where the CPO material called FAME (fatty acid methyl ester) is blended only after the crude oil becomes fuel (KESDM, 2019).

strengthening cooperation between the central and regional governments on these matters (Nugroho, 2018b). Not only stop at strengthening renewable energy organizations within the government but also forming state-owned enterprises doing renewable energy business, equivalent to those already established for the oil, natural gas, and coal industries. IREDA (Indian Renewable Energy Development Agency) of India and the country's several State-Owned Enterprises engaged in the field of renewable energy are worth emulating to accelerate the development of Indonesia's renewable energy (Burke, 2018; IESR, 2018; IREDA, 2019, Nugroho, 2011, 2018a).

Another proposal on the institution is to establish an Energy Conservation Center. Influencing the growth of oil, natural gas and coal so that they are not too far above the projections as in case of the 2015-2019 MTDP could be carried out partly for example by developing public transportation in major cities of Indonesia, and so on (Bappenas, 2019a; Nugroho, 2018a). However, we consider that the establishment of an Energy Conservation Center could encourage more programmatic and massive efforts to conserve energy consumption, which will have a major impact on conserving fossil fuel consumption. The proposal that the Energy Conservation Center be immediately formed in MTDP 205-2019 also after studying several previous reports which stated that Indonesia's energy conservation potential is quite large in various sectors (IEA, 2015, 2017). However, until now there has been no agency having the responsibility to do jobs such as energy audits, provide soft credit as an incentive to undertake energy conservation projects, or foster the growth of energy management/service companies as the agency's main tasks (Nugroho, 2018a). The model we propose to emulate is the Japanese Energy Conservation Center, whose development has been imitated, for example, by Thailand (Nugroho, 2012; ECCJ, 2018).

On regulation, we support to continue the regulation regarding the mandatory use of biodiesel which is mixed with diesel fuel from petroleum, even developing the regulations for higher biodiesel content, to B-30 or even B-40 if its technology and economic development can be achieved during the 2020-2024 MTDP. This is the case for biodiesel developed from FAME process. For green fuels project made from RBDPO (Refined, Bleached, and Deodorized Palm Oil) we suggest that once the development is successful, regulations that oblige their use in the country are immediately issued, similar to that of FAME biodiesel (KESDM, 2015).

We also propose that in the 2020-2024 MTDP period the government issues regulations regarding the "Renewable Portfolio Standards" (Martin, 2009; Nugroho, 2018b), intended for the first time for state electricity companies, to fulfill the obligation to develop renewable energy in various working areas of the company. This is important as the state electricity company is a major player in the supply of electricity in all regions of Indonesia (IEA, 2015; ADB, 2016) while the renewable energy share in the company's power mix in 2019 is only around 12 percent, contributed mainly by hydro and geothermal power (PT PLN, 2019). The final regulatory support we propose is regarding tariffs for purchasing electricity generated by renewable energy sources, by re-implementing the "feed-in tariff" policy that was enacted in the previous period and proven to stimulate renewable energy development. Our overall proposal for renewable energy development to meet its goals in the 2020-2024 MTDP including to support the 23 percent renewable energy share in 2025 is summarized as shown in Table 2. Our preliminary simulations show that by

implementing the proposal described above, it will not difficult to meet such targets of renewable energy development as mandated in the NEGP and 2020-2024 MTDP documents (GoI, 2017, 2020).

<b>1. Renewable energy to replace/reduce fossil fuels consumption</b>	
Program	Action
1.1 Reduce coal consumption in power plants	Co-firing, blending coal with biomass pellets.
1.2 Reduce LPG imports	Continue biogas program; implement Bio-CNG.
1.3 Reduce the growth of oil consumption and petroleum imports	Expand the B-20 with B-30 (FAME), implement the green fuels program.
<b>2. Linking renewable energy (RE) technology with development program and potential users</b>	
Type of RE technology	Action
2.1 Hydropower	Hydropower to meet industrial estates demand and small hydro for rural villages.
2.2 Geothermal	Small geothermal for Eastern Indonesia's islands.
2.3 Biomass	Biomass for plantation and local community.
2.4 Solar power	Photovoltaic for rural villages and urban's luxury houses.
<b>3. Energy institution</b>	
Coverage	Action
3.1 Renewable energy	Establish a Renewable Energy Development Agency.
3.2 Conservation Center	Establish an Energy Conservation Center.
<b>4. Regulation</b>	
Topic	Action
4.1 Biofuels	Continue mandatory for biodiesel, issue the one for green fuels
4.2 Renewable Portfolio Standards	Establish RPS for the state-owned energy companies
4.3 Renewable Energy Prices	Re-implement the FIT (feed-in-tariff) approach.

Table 2: Summary of proposals

## **Summary and conclusion**

During the 2015-2019 MTDP, Indonesia's renewable energy showed a good growth performance as it was very close to that suggested in the National Energy General Plan (NEGP). However, in terms of share in the national energy mix, there was a large gap between the targets of renewable energy's share for 2015-2019 MTDP and their realizations. The gap was caused more by the growths of fossil fuels (oil, natural gas and LPG, and coal) which grew higher than expected. The growth of fossil fuels was caused by large imports of petroleum and LPG and as a result of the implementation of the "35,000 MW" projects. The growth of renewable energy for electricity was much lower than the growth of renewable energy used for fuel, especially for biodiesel and biogas.

The Indonesian archipelago has enormous renewable energy potential that can be developed both as electricity as well as fuels. However, the achievement of the development of renewable energy in the future will not be determined by this sector alone, but also by the growth of other energy sectors, namely oil, natural gas, and coal, that also must be controlled.

In order for renewable energy development to reach its development target in 2020-2024 MTDP (including achieving a 23 percent share of renewable energy by 2025), we propose a number of strategies and actions to be taken. These include utilizing the increased production of renewable energy to be used to reduce consumption of fossil fuels, linking the development of certain types of renewable energy technologies with their potential users, establishing a Renewable Energy Development Agency and an Energy Conservation Center, and improving regulations on renewable energy development (particularly on tariff and Renewable Portfolio Standards).

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***Fostering Sustainability through Renewable Energy Resource Development: The  
Law and Policy in Nigeria***

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**Abstract**

Renewable energy sources (RES) exploitation and utilization is the hallmark of sustainable development in any country around the globe. The need to decarbonize Nigeria's energy base through the utilization of RES to ensure sustainability cannot be overemphasized. In the last two decades, the Nigerian Government has shown keen interest in renewable energy resource development by evolving a plethora of policies and plans which articulates certain visions, goals, objectives, targets, and strategies. This paper critically examined these policies with a view to ascertain their efficacy. It was found that the policies are ineffective and inadequate. The paper further revealed that legislation is a pivotal tool to accompaniment and advance policies, but at present, the absence of a legislative framework pose a major challenge to RES exploitation and utilization in Nigeria. The author recommends, among other things, the urgent need to enact a coherent and comprehensive legislative and regulatory framework to drive RES development and deployment in the country.

Keywords: sustainable development, renewable energy, law, policy, Nigeria

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## Introduction

Nigeria's energy supply is largely based on fossil fuels (Okposin, 2019: 138). Currently, 80% of total energy consumption in Nigeria is derivable from petroleum (oil and gas) (Akorede, et al 2017: 196). In contrast, Nigeria generates a small amount of energy from renewable sources such as hydro power, solar, wind and biomass. Oil and gas are main components of fossil fuels which are finite. Nigeria's reliance on the consumption of fossil fuel resources cannot continue indefinitely. Over reliance on fossil fuels has been a bane of underdevelopment in Nigeria, and if the trend continues, sustainable development will be an illusion (Atsegbua, 2019: 2). Nigeria currently suffers from energy poverty (Dioha, 2017). Fossil fuels are insufficient to sustain the ever increasing demand for energy in Nigeria due to population increase and continuous quest for improved living standards by the citizens<sup>1</sup>.

Fossil fuels are also environmentally unfriendly. Its exploration and production is known to be a major anthropogenic activity contributing to climate change<sup>2</sup>. There is growing consensus on the need to abdicate fossil fuels combustion in order to reduce emissions, seek RES utilization to foster sustainability. The need to decarbonize Nigeria's energy base through the utilization of RES to ensure sustainability cannot be overemphasized. A plethora of policies have been evolved and a target of 30% RES utilization by 2030 has been set by government<sup>3</sup>.

This paper critically examines these policies to ascertain their efficacy. In the paper, the author argues that the policies are ineffective and inadequate. In doing so, the author employs a doctrinal research methodology relying heavily on primary and secondary sources. Apart from the introduction section, the rest of the paper is segmented seriatim: conceptual clarification; sources of energy in Nigeria; renewable energy as a tool for sustainability; critical review of renewable energy policies in Nigeria; challenges and barriers to renewable energy resource development in Nigeria; recommendations; and lastly, conclusion.

## Conceptual Clarifications

A conceptual clarification of two key terms is deemed necessary to ensure that the paper is put in proper perspective. The essence is to elucidate their meaning within the context of the paper, rather than to embark on a detailed analysis of these terms or concepts. In the paper, "renewable energy" simply means energy generated from renewable resources through natural process that are infinite on the earth surface and

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<sup>1</sup> According to British Petroleum, "population and income are the key drivers behind growing demand for energy". See British Petroleum. (2016). *Energy Outlook 2016*. London: British Petroleum. 11. Nigeria's population is currently the 7th largest in the world, and is projected to become the 3rd most populous country in the world by 2050 with an estimated population of 410.638 million. See United Nations Department of Economic and Social Affairs, Population Division. (2017). *World Population Prospects: The 2017 Revision: Key Findings and Advance Tables. ESA/P/WP/248*. New York: United Nations. 5, 26.

<sup>2</sup> Intergovernmental Panel on Climate Change (IPCC). (2013). *Fifth Assessment Report (AR5 WG1). Summary for Policymakers, 4*

<sup>3</sup> This target is the focus of the National Renewable Energy and Energy Efficiency Policy (NREEEP), 2015. See Energy Commission of Nigeria & Federal Ministry of Science and Technology. (2014). *National renewable energy and energy efficiency policy*. Abuja: Federal Republic of Nigeria.

continuously replenished on a human time scale, such as hydro, solar, wind, rain, tides, waves, ocean energy, geothermal heat, fuel cell, biomass, bio gas, and hydrogen derived from renewable resources (Olawuyi, 2015: 324-327). They are widely accepted to be environmentally friendly and promote sustainable development (Atsegbua, 2008: 5). They are distinct from fossil fuels (a category of non-renewable energy) which are finite resources created by time and pressure compressing organic matter such as the remains of plants and animals into large rocks formations. "Sustainable development" as used in the paper refers to "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"<sup>4</sup>. The term "sustainability" is used interchangeably with the concept of "sustainable development". Closely related to the concept of "sustainable development" is "the concept of sustainable utilization of natural resources" which connotes the proper, efficient and effective use of natural resources in a manner that will promote sustainability (Atsegbua & Daudu, 2019: 7).

### Sources of Energy in Nigeria

There are two sources of energy in Nigeria, namely: renewable and non-renewable. Renewable energy sources that are predominant in Nigeria are hydro, solar, wind, biomass and the use of firewood (Atsegbua et al, 2010: 296). There is also prospect of geothermal sources. Hydropower has been in use since the late 1950s for electricity generation; and developments in solar and wind energy are on the increase due to their high potentials and government support arising from recent energy policies and initiatives (Aliyu, Madu & Tan, 2018).

The installed capacity for hydropower has remains stagnant for many years, while the output power has continued to decline due to lack of maintenance and fluctuation in volume of water flowing into reservoirs (Akorede et al, 2017: 204). Solar power as one of the emerging renewable energy in the country has exciting possibilities, and the northern part has the highest potential for solar energy (Aliyu, Dada, & Adam, 2015). Wind power is presently of limited use but showing promising prospects (Adekoya & Adewale, 1992; Adaramola & Oyewola, 2011; Oyedepo, 2012a). The technology for biomass is at its infancy in Nigeria<sup>5</sup>. In 2007, the National Bio-fuel Policy and Incentives was made to facilitate the development and promotion of domestic ethanol fuel. Firewood which is a component of biomass is abundantly used in the rural communities, and its use has an enormous environmental cost (Atsegbua et al, 2010). Geothermal power is unexploited but research shows some Basins have high geothermal gradient potentials (Ikeagwuani, Agbidi & Bamisele, 2015: 731).

Non-renewable energy in Nigeria mainly consists of crude oil, and natural gas. Nigeria currently has an estimated oil reserve of 37.45 billion barrels, 5,627 billion cubic meters of natural gas, and 2.75 billion tonnes of coal and lignite.<sup>6</sup> Oil is the

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<sup>4</sup> World Commission on Environment and Development. (1987). *Our Common Future*. Oxford: Oxford University Press. (Endorsed by the United Nations General Assembly Resolution 42/187).

<sup>5</sup> NNPC News. (May 2006) 28(5).

<sup>6</sup> Organization of the Petroleum Exporting Countries (OPEC). (2018). *Annual Statistical Bulletin 2018*. [https://www.opec.org/opec\\_web/en/press\\_room/5027.htm](https://www.opec.org/opec_web/en/press_room/5027.htm). Retrieved February 24, 2019; British Petroleum. (2018). *Statistical review of world energy 2018*. London: British Petroleum; United States Energy Information Administration. (2019). *International energy statistics, 2019*. Washington DC: United States Energy Information Administration; Energy Commission of Nigeria. (2013). *National energy policy* (Draft Revised ed.) , 9, 17.

most widely used fossil fuel in Nigeria (Osueke & Ezugwu, 2011: 1). Daily average production had grown since its first commercial discovery at Oloibiri, (now in present day Bayelsa State) in 1956 to around 2.5 million barrels per day in 2012 (Douglas-Abubakar, Muhammed & Salau, 2019). Dirty coal was hitherto harnessed. There is also potentials for shale hydrocarbons in Nigeria Frontiers and it's Inland Basins (Omorieg, 2017: 82). The environmental degradation arising from crude oil exploration and production in Nigeria cannot be overemphasized. Spills are common and gas flaring is perpetual (Ajugwo, 2013: 6-7), thereby exacerbating land, water, and atmospheric pollution especially in the Niger Delta region; and immensely contributing to climate change. Faring of gas has also led to great economic and biodiversity loss.

### **Renewable Energy as a Tool for Sustainability**

There is inextricable link between energy and sustainable development, and it is evident that energy sustainability is important in order to achieve sustainable development (Oyedepo, 2012b). In light of the above, the United Nations obligates its member states to transit to cleaner and affordable sources of energy<sup>7</sup>. Renewable energy is often referred to as 'clean energy'. All RES are regarded as the 'greenest energy source', it has gained universal acceptance, and favoured as a replacement for fossil fuels energy<sup>8</sup>. Renewable energy sources (RES) exploitation and utilization is the hallmark of sustainable development in any country around the globe. Renewable energy is indeed a tool for sustainability. Its rapid deployment results in significant energy security, climate change mitigation and economic benefit (Bradbrook, 2008: 109-112). If renewable energy resources are effectively and appropriately developed in Nigeria, commercial activities will be boosted, green jobs will create wealth especially for the rural communities, energy security will be assured, and there will be lesser environmental impacts.

### **Critical Review of Renewable Energy Policies in Nigeria**

In the last two decades, the Nigerian Government has shown keen interest in renewable energy resource development by evolving a plethora of policies which articulates certain visions, goals, objectives, targets, and strategies (Omorieg, 2019: 304). These policies include:

#### **National Electric Power Policy (NEPP), 2001**

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<sup>7</sup> See United Nations Development Programme, "2030 Agenda for Sustainable Development". Adopted 25th September, 2015, New York, United States of America. <http://un.org/sustainabledevelopment/sustainable-development-goals/>. Goal 7 of the Sustainable Development Goals enhance international cooperation to facilitate access to clean energy. <http://www.unenivonment.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-7>, Retrieved November 9, 2019.

<sup>8</sup> See the Paris Accord which was adopted on December 12, 2015 at COP21 under the UNFCCC; applicable to all the 198 parties to it (entered into force on November 4th, 2016 and has been ratified by 187 parties as of November 2019), including European Union. See UNFCCC COP21 Session Paris Decision, December 12, 2015/FCCC/CP/2015/L.9/Paras 1-5, at 2. See also Encyclopaedia Britannica, "Paris Agreement: International Treaty (2015)". <https://www.britannica.com/topic/Paris-Agreement-2015#accordion-article-history>. Retrieved December 18, 2019. The accord seek to ensure transformative change in the global energy sector by evolving decarbonization agenda which promotes the use of renewable and energy efficiency.



This policy marks the first step to reform the power sector in Nigeria. It was created in March 2001 and has three main goals, namely: the privatization of the National Electric Power Authority (NEPA) and introduction of the Integrated Power Producers (IPPs) of electricity; encouragement of market competition amongst participants by gradual removal of subsidy; and liberalization of the electricity market. No emphasis was laid on the utilization of renewable energy to generate electricity power (Atsegbua & Erhagbe, 2019: 311).

### **National Energy Policy (NEP), 2003, 2006, and 2013**

It is the first comprehensive energy policy in the Nigeria. This policy document which first came into effect in 2003 has been reviewed severally. The main goal of the policy is to ensure energy security. It serves as a blueprint to foster a robust energy supply mix through the principle of energy diversification (Atsegbua & Erhagbe, 2019: 312). Paradoxically, it endorses the optimal utilization of fossil fuels, and seeks to pursue the development and deployment of renewable energy. Its provision clearly shows weaknesses to effectively transit to clean and affordable energy.

### **National Economic Empowerment and Development Strategy (NEEDS), 2004**

The need to tackle poverty and facilitate national development necessitated the launching of this policy by the Olusegun Obasanjo government in 2004. NEEDS<sup>9</sup> encapsulates national goals such as employment generation, wealth creation, re-orientation of values, and human resource development, and sustainable natural resource development to meet the nation's economic needs. The development and deployment of renewable energy technologies was aptly considered. However, the policy was marred with poor fiscal policy implementation, lack of transparency, leadership problem, and macroeconomic challenges.

### **Renewable Electricity Policy Guidelines (REPG), 2006**

The policy was developed by the Federal Ministry of Power and Steel in December 2006 to facilitate the expansion of electricity generation from renewable energy sources. It contained lofty objectives for promoting renewable energy in the power sector. Government has however failed in its implementation.

### **National Bio-fuel Policy and Incentives (NBPI), 2007**

It was initiated by the Nigerian National Petroleum Corporation (NNPC). Its main thrust is the utilization of biomass resources mainly agricultural produce to improve the quality of fossil fuel in Nigeria. It establishes the Bio-fuel Energy Commission and a Bio-fuel Research Agency to conduct researches for optimal production of bio-fuels<sup>10</sup>. A key component of the policy is the provision of incentives for investors. A major limitation of the policy is its failure to identify means of technological transfer. Another limitation is lack of implementation as the commission it seeks to establish

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<sup>9</sup> National Planning Commission. (2004). *National economic empowerment and development strategies*. Abuja: Federal Republic of Nigeria.

<sup>10</sup> See Federal Republic of Nigeria. (2007). *Official gazette of the Nigerian bio-fuel policy and incentives*. Abuja: Federal Republic of Nigeria.

has yet been established. The Energy Commission of Nigeria seems to have taken up its role.

### **Renewable Energy Master Plan (REMP), 2005 and 2012**

The Renewable Energy Master Plan was developed by the Energy Commission of Nigeria (ECN) in collaboration with the United Nations Development Programme ((UNDP). The policy is implemented by the Ministry of Environment. The document articulates Nigeria's vision for achieving sustainable development. It places premium on renewable energy as a tool to achieve sustainable development. It provides a road map for achieving the renewable energy policy thrust in the NEP 2003. The revised 2012 version contains different programmes of different renewable energy resource exploration; and identifies key issues relating to investment and technology required to drive renewable energy. It articulates strategies to transit from use of fossil fuels to clean, reliable, secure energy supply in Nigeria by integrating 20% of renewable electricity generation into the national grid by 2020, and 10% of Nigeria total energy consumption by 2025<sup>11</sup>. However, it remains a toothless bulldog in the absence of a specific legislation that can engender its enforcement.

### **National Renewable Energy and Energy Efficiency Policy (NREEEP), 2015**

This policy recognizes the importance of renewable energy to reduce the adverse impact of fossil fuels on the environment. It sets target to increase Nigeria's power generating capacity to 40,000MW; and to integrate renewable energy sources into energy generation in the country. It set a target of achieving 2,438MW in the short term (2013-2015); 8,188MW in the medium term (2016-2020); and 23,134.8MW in the long term (2021-2030) from renewable energy generation and utilization representing a target of 30% RES utilization by 2030<sup>12</sup>. It addresses several issues including renewable energy pricing and financing, energy efficiency and conservation, project implementation, research and development, amongst others. The realization of the target set has been hampered by lack of implementation and financial constraints. If the policy is properly implemented, it would facilitate the rapid development and deployment of renewable energy to transit from dirty fossil fuel.

### **Rural Electrification Strategy and Implementation Plan (RESIP), 2016**

This plan was first initiated as Nigeria Rural Electrification Programme in 1981 by the Federal Ministry of Power and Steel, and executed by the scrapped NEPA. The Power Sector Reform Team noting some shortcomings prepared the Rural Electrification Strategy and Implementation Plan in 2006. This was however reviewed and redrafted by a committee in 2014. The initial policy thrust was the extension of the national grid to rural communities in realization that fewer than 20% of rural household have access to electricity. The RESIP now focuses on the expansion of access in clean and affordable manner, thereby encouraging the use of on-grid and off-grid means of electricity supply. If government pursue sustainable utilization of natural resources in the country including the abundant renewable resources in the

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<sup>11</sup> Energy Commission of Nigeria & United Nations Development Programme. (2005). *Renewable energy master plan*. Abuja: ECN & UNDP.

<sup>12</sup> Energy Commission of Nigeria & Federal Ministry of Science and Technology. (2014). *National renewable energy and energy efficiency policy*. Abuja: Federal Republic of Nigeria.

rural communities in Nigeria, energy poverty will become a thing of the past (Sambo, 2005; Atsegbua & Erhagbe, 2019).

A common thread of incoherence runs through the key provisions of these policies. They contain observable gaps and are marred with several challenges and barriers. Implementation is poor and ineffective. Overlap and duplication of some activities exist amongst the institutions created. Alignment and harmonization of the various policies is deemed imperative to coordinate several policy issues (Atsegbua & Erhagbe, 2019: 319). It is noteworthy that at present, there is no direct legislative framework on renewable energy in Nigeria (Ladan, 2009: 94; Oyedepo, 2012c: 11; Okonkwo, 2013: 738; Oniemola, 2015: 85; Okposin, 2019: 163). The Energy Commission of Nigeria (ECN) Act, Cap. E10, LFN, 2004, and the Electric Power Sector Reform (ESPRA) Act, 2005 do not make specific provisions on the development and utilization of renewable energy in the country. An appropriate legislative framework on renewable energy is a prerequisite for maximizing investment opportunities in the sector (Ladan, 2009: 95; Oniemola, 2011: 5; Chineke, et al, 2015)

### **Challenges and Barriers to Renewable Energy Resource Development in Nigeria**

Identifiable challenges and barriers to renewable energy resource development in Nigeria include:

#### **Inadequate Policies and Lack of a legislative framework**

Regulation of renewable energy in Nigeria is largely done at policy level. The existing renewable policies are inadequate and do not provide for legal or fiscal instruments that would attract investment. There are no laws specifically enacted to govern activities and bind government, institutions and stakeholders in in the energy sector in relation to renewable energy (Ladan, 2009: 94; Olawuyi, 2013b; Oniemola, 2015: 85; Mbajiorgu, 2016: 250; Okposin, 2019: 163).

#### **Weak institutional framework, implementation gaps and overlap of roles**

Many of the institutions are not productive. Governance is characterized by instability. Thus many of the existing policies poorly implemented. Different government articulates different policies. Furthermore the institutions created have overlap of functions. Poor implementation creates distortions (Emodi & Ebele, 2016: 10).

#### **High cost, insufficient funding and financial constraints**

This is another major challenge. It endangers implementation. No stringent measures exist to provide needed funding renewable energy development. Renewable energy technologies are capital intensive, it is imperative that financial and investment barriers be removed otherwise, the price for a developing country like Nigeria becomes enormous (Efurumibe, 2013; Ladan, 2014: 466 - 477; Okposin, 2019:157).

### **Lack of technological know-how and inefficient technology transfer measures**

The Nigeria law on technological transfer- the National office for Technology Acquisition and Promotion Act of 1979 (NOTAP ACT) is inadequate mainly due to its narrow scope. Its technology classification does not include modern day environmentally sustainable technologies (ETS). Secondly, the procedure of transfer of technology are unclear and cumbersome, thirdly, issues of sustainability is not prioritize nor considered. (Olawuyi, 2013a: 7 - 10; Atsegbua et al, 2010: 294).

### **Absence of adequate Research and Development (R&D)**

Public initiatives to drive Research and Development (R&D) is grossly inadequate in the country. There is need for government to invest in R&D activities to enhance technological innovation. Private sector participation is also very important (Efurumibe, 2013; Olawuyi, 2015).

### **Corruption and poverty**

Corruption constitutes a major hindrance to effective implementation of initiatives and projects articulated in the policies. The diversion of public funds is a common occurrence in Nigeria. There is lack of accountability both from government and established institutions (Emodi & Ebele, 2016: 10). Poverty on the other hand, poses a major threat to national development, and hampers sustainable development. Nigeria ranks amongst the poorest countries in the world.

### **Lack of information, poor public awareness and ineffective standards**

The inadequacies of regulatory agencies to provide sufficient information, create public awareness, and ensure standards and quality control constitute another set of significant factors that hamper the development of renewable energy in the country (Emodi & Ebele, 2016). The consequence is the creation of market gap resulting in high risk perception for renewable energy projects and initiatives.

### **Social-cultural barrier**

This is intrinsically linked to societal and personal values and norms affecting perception and acceptance of renewable energy. In this regard, participation in decision making becomes relevant (Igbinovia, 2014).

### **The challenge of variability**

Otherwise referred to as "intermittency problem" is mostly associated with wind and solar resources making it difficult to plan satisfactory in balancing supply with demand. The solution lies in efficient storage and technical balancing to meet heat or power demand changes (Okposin, 2019: 155 - 157).

## **Recommendations**

An urgent enactment of a coherent and comprehensive legislative and regulatory framework to drive renewable energy resource development and deployment in Nigeria is recommended.

The proposed legislation should directly encompass the renewable energy policies that have been put in place, ipso facto, accompany them, reflect government commitment to ensuring sustainable development of its natural resources through an increased investment on renewable energy and guarantee investor's assurances.

The proposed legislation should establish a distinct institution to regulate and implement its provisions to avoid overlap of roles with other agencies.

The proposed legislation should provide for mandatory connection of RES to the national grid, and oblige IPPs to generate power from RES.

The proposed legislation should make provisions for fiscal regulation and incentives to attract investors; and promote private sector participation.

There is need for government to also provide effective measures to enhance technological transfer, generate funds, combat corruption, create educational initiatives to promote RES awareness, promote Research and Development (R&D) and address the challenge of poverty.

## **Conclusion**

This paper critically examined the various renewable energy policies in Nigeria. The challenges and barriers inherent therein were discussed. It is evident from the preceding discussion that through the enactment of a coherent and comprehensive legislative and regulatory framework to drive renewable energy resource development and deployment, the various policies on renewable energy would be strengthened, fossil fuel dependence would be reduced, and sustainability would be enhanced in Nigeria.

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## *Prospects for Nuclear Energy Policy in Australia*

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### **Abstract**

During the May 2019 national election campaign, Prime Minister Scott Morrison denied his Liberal-National Party (LNP) government had any intention to pursue nuclear power for Australia. An official ban on nuclear power remains in place, but following the election, a parliamentary inquiry into nuclear energy was announced, and its report delivered in December 2019. This inquiry restarted a long-running debate on nuclear policy in Australia. Under the Liberal-Country Party government in the 1950s, Australia hosted the UK's atomic weapons testing, and considered developing Australia's own nuclear weapons arsenal. However, after the election of a Labor Party government in 1972, Australia ratified the Non-Proliferation Treaty (NPT), and has relied on the extended deterrence protection of its US ally ever since. Australia has nevertheless been a major exporter of uranium, and has maintained a small research reactor. In 2006, the LNP government of John Howard commissioned a report into nuclear power, which found it was uneconomic, given Australia's preponderance of coal-fired energy. A Royal Commission held by the South Australian state Labor government in 2016 found nuclear power would still be uneconomic, compared to renewable energy sources. Nuclear power advocates argue that small modular reactors (SMRs) could deliver baseload energy for Australia, while reducing carbon emissions. The opposition Labor Party remains against nuclear power though, particularly over where to site power plants, and disposal of nuclear waste. Any future Australian nuclear power industry is therefore a very long-term prospect, as renewable energy becomes more widespread, efficient, and affordable.

Keywords: Nuclear Power, Australian Politics, Energy Policy

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## **Introduction**

Since the onset of the atomic age, whether to have nuclear power has been a long-running policy debate in Australian politics. Despite possessing large amounts of uranium, Australia has so far not pursued the option to develop nuclear energy. This has been due to its relative economic disadvantage, compared to the abundance of established coal and gas-fuelled electric power, and public concerns over the safety of nuclear reactors and disposal of radioactive waste. An overall bipartisan political consensus has therefore been maintained among Australia's main political parties, to uphold a moratorium prohibiting nuclear energy, although some politicians from the conservative parties have occasionally advocated its adoption.

Promoters of the nuclear option, including representatives of the mining industry, have therefore attempted to keep the issue on the public agenda. Debate over policy addressing climate change has given these nuclear power advocates renewed opportunity to argue that it will enable Australia to secure baseload electric power, while reducing carbon emissions. The most recent parliamentary inquiry into the issue, following the 2019 federal election, has argued that new nuclear technologies may be a future option to supplement Australia's energy sources. However, rather than bringing a resolution, this recommendation has only perpetrated the political dispute over this highly controversial issue.

## **The Background of Australian Nuclear Policy**

Australian involvement in the nuclear power cycle has its origins in the discovery of radium, first extracted in Australia in 1906. Further exploration confirmed that Australia possessed up to 40% of the world's uranium ore deposits. The Australian government first mined uranium in 1944, to help supply the USA's Manhattan Project to develop the atomic bomb. Commercial mining of uranium began in 1954, at the Rum Jungle mine in the Northern Territory (NT), and the Radium Hill mine in South Australia (SA). Uranium exports would go on to supply markets in the USA, Europe, Japan and South Korea, and eventually China and India. (Ian Lambert, Jaireth, McKay & Mieztis, 2005).

Australia was also directly involved in the development of nuclear weapons during the Cold War. The Liberal-Country Party (LCP) Coalition government of Prime Minister Robert Menzies demonstrated its ongoing loyalty to the declining post-war British Empire, by offering to host the United Kingdom's atomic weapons testing program. The first atmospheric test took place at the Monte Bello Islands off the coast of Western Australia (WA) in 1952, and further open-air tests were conducted in WA and at Maralinga in SA, until October 1957. These test sites were left highly contaminated, particularly Maralinga. Thousands of Australian Defence Force personnel who assisted in the tests later suffered adverse health effects as a result. These personnel, and the traditional indigenous owners of the lands subject to the test had to endure a long legal battle against both the UK and Australian governments. They did not receive any kind of recognition or compensation, until a Royal Commission was held in 1985 (Firth, 1999, pp.120-122).

Australia also took its first minor, but significant steps towards developing nuclear science during the Menzies government. The Atomic Energy Act of 1953 established

the Australian Atomic Energy Commission (AAEC), a statutory government authority. The AAEC supervised the construction of the small 10MW High Flux Australian Reactor (HIFAR) at Lucas Heights, in the southern suburbs of Sydney, which became operational from 1958. Another small graphite research reactor (MOATA) was operated from 1958 to 1995. The AAEC was renamed the Australian Nuclear Science and Technology Organisation (ANSTO) in 1987. Used for nuclear science research, and production of materials for nuclear medicine, HIFAR was replaced by the Open Pool Australian light-water (OPAL) reactor in 2007 (ANSTO, 2020).

### **Australia Considers Nuclear Weapons and Nuclear Power**

The Cold War experience of hosting British nuclear testing prompted a push within various members of the Menzies government, and the Australian military, for Australia to acquire its own nuclear weapons capability. In 1956, Minister for Air Athol Townley, proposed the Royal Australian Air Force (RAAF) acquire free-fall nuclear bombs. The Defence Committee of Cabinet then recommended the Australian Defence Forces acquire tactical nuclear weapons from the UK. However, Menzies was not enthusiastic, and by 1958, had confirmed his preference to continue to rely on the extended deterrence protection of the USA. The RAAF nevertheless from 1963 still acquired American F-111 strike aircraft, which could carry nuclear weapons. John Gorton, who became Liberal Prime Minister in 1968, was more keen for Australia to domestically produce its own nuclear weapons, particularly since Communist China tested its own weapons from 1964. However, by then Australia was under diplomatic and political pressure to sign the Nuclear Non-Proliferation Treaty (NPT); Gorton's government reluctantly did so in February 1970 (Walsh, 1997, pp.3-12).

Boosted by persistent lobbying from AAEC chairman Phillip Baxter, Gorton still proceeded to authorize the development of a British-designed nuclear power plant at Jervis Bay, the section of the Australian Capital Territory on the south coast of New South Wales (NSW). As well as generating electricity, the project was overtly designed towards providing Australia with its own potential nuclear weapons production capability, should its strategic position in the region deteriorate, as was feared during the later stages of the Vietnam War. However, Gorton's successor as Liberal Prime Minister in 1971, William McMahon, was less amenable to the proposal, and halted preliminary construction (McLaren, 2019).

### **The Three Mines Policy & the Nuclear Power Moratorium**

The LCP government meanwhile delayed Australia's ratification of the NPT, which had to wait until after the election of the Australian Labor Party (ALP) government of Gough Whitlam in December 1972. The Whitlam government also suspended all contracts for uranium ore exports, pending a number of official inquiries into uranium mining. Allowing the export of uranium had become a hotly contested policy issue within Labor. The ALP's Left faction opposed it, a position energetically supported by the environmental and nuclear disarmament movements, which had emerged by the 1970s to conduct vigorous anti-uranium campaigns, including mass public rallies, instigating strikes, and direct protest action (Branagan, 2014, pp.1-2). Uranium mining was supported by the Right faction of the ALP, and its various affiliated unions in the mining sector. By 1975, Labor declared its 'Three Named Uranium

Mines Policy’, which only allowed three uranium mines to be in operation at any one time. However, a moratorium against nuclear power was effectively in place in Australia, a prohibition that has endured to the present (Vestergaard, 2015, pp.24-25).

Even before signing the NPT, Australian governments have maintained Australia’s role in the nuclear warfighting network of its US military ally. This has been principally done through hosting an American Signals Intelligence base at Pine Gap in central Australia. The highly-classified defence satellite and communications ‘Joint Defence Space Research Facility’, has been in operation since 1969 (Ball, 1980, pp.58-59). Australia also recently refused to sign the Treaty on the Prohibition of Nuclear Weapons at the United Nations in 2017 (as did mutual US ally Japan), citing the necessity of remaining under the protection of the USA’s extended nuclear deterrence (IHRC, 2018).

After the dismissal of the Whitlam Labor government in November 1975, the Liberal-National Party (LNP) government under Prime Minister Malcom Fraser allowed new mining of uranium ore to export for use in nuclear power plants, which commenced in 1976, at the Mary Kathleen mine in Queensland (Lambert et al, 2005). After more rancorous debate at ALP policy conferences, the next Labor government of Bob Hawke continued the three mines policy from 1983. The LNP Coalition led by John Howard overturned the policy after it won government from 1996; but, no more than three mines have ever become operational at any one time, which has left the convention of the restriction unofficially still in effect (Firth, 1999, p.122). The long-running political moratorium on nuclear power was given further legal force though, with the passage in the Federal Parliament of the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*; a wide-ranging piece of legislation, its section s140A expressly prohibits nuclear power generation (Commonwealth of Australia, 1999).

### **The Switkowski and Australia Institute Reports**

As a long, lucrative mining boom continued during the fortunate tenure of the Howard government, there was persistent lobbying from the mining industry and other advocates for a nascent Australian nuclear industry. This led in June 2006 to an official inquiry, the Report into Uranium Mining, Processing and Nuclear Energy, chaired by nuclear physicist Dr Ziggy Switkowski (BBC, 2006).<sup>1</sup> After receiving over 230 submissions, the Switkowski Report was released in November 2006. It concluded nuclear power was a possible option for Australia’s energy mix, which could potentially deliver electricity to the national grid within 10 to 15 years. 25 reactors could possibly supply up to a third of Australia’s electricity by 2050, and reduce carbon emissions by 8 to 17% (DPM&C, p.xii).

However, the Report also concluded that nuclear energy would be 20 to 50 per cent more expensive compared to coal and gas generated power, particularly if there was no price placed on carbon emissions. There would also be considerable obstacles to Australia entering the foreign-dominated market for uranium enrichment (DPM&C, p.45). The Report also neglected to address the rather important issues of feasible

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<sup>1</sup> Switkowski had been the CEO of Telstra, Australia’s largest telecommunications company; he was later appointed chair of ANTSO, and would go on to chair the National Broadband Network Company.

locations for power plants, and the disposal of nuclear waste. The Howard government used the Switkowski Report to sidestep any commitment to nuclear power. The Labor Party, now led by Kevin Rudd, continued its traditional policy of maintaining the moratorium on nuclear energy, which continued throughout the Labor governments of Rudd (2007-2010, 2013), and then Julia Gillard (2010-13) (Crowe, 2006).

Following the Switkowski Report, the Australia Institute (AI) public policy think tank released its own report in January 2007, examining where nuclear power plants could be realistically located in Australia, should nuclear energy ever proceed. It identified 19 possible locations for nuclear power plants, based on proximity to power grids of major energy markets, and access to large provisions of water. These criteria meant the most likely sites would have to be along the populated east coast of Australia, ranging along the coasts of Queensland, NSW, Victoria and SA. The AI report also referred to opinion polls, where only 35% of Australians supported nuclear power, and only 25% would support a nuclear power plant being built in their local area (Macintosh, 2007, pp.1-4).

The results of both the Switkowski and AI Reports reinforced the general bipartisan opposition to nuclear energy well into the next decade. After coming to office in 2013, the LNP government of Tony Abbott (a climate science sceptic) issued an Energy Green Paper in 2014, which considered there was potential for Australia to pursue Small Modular Reactors (SMRs), or thorium reactors in future, as Australia possesses 8% of the world's thorium deposits. However, the Green Paper also noted both these emerging technologies were still in development stage. Skills shortages, the relative low cost of alternative energy sources, and adverse community sentiment, particularly after the Fukushima disaster in Japan in 2011, were also significant barriers to Australia developing nuclear energy (DoI, 2014, pp.61, 71).

Abbott, and then Foreign Minister Julie Bishop, still favoured allowing nuclear power, if it was economically feasible, and did not require any government subsidies. After being deposed from the Liberal Party leadership by rival Malcolm Turnbull in 2015, Abbott called for the legal prohibitions on nuclear power to be lifted, something he had failed to even attempt while in office (Brown, 2017). Nuclear energy supporters now admit a pricing mechanism for Australia's carbon emissions needs to be reintroduced, to allow a nuclear power industry to ever become feasible (Quiggan, 2019). Such a carbon pricing system had been established by the Gillard Labor government in 2011; but, it was abolished in 2014 under Abbott's government (which incorrectly called it a 'carbon tax'), in favour of a taxpayer-funded 'Direct Action' policy, largely based on a bureaucracy-directed Emissions Reductions Fund (ERF) to subsidise polluting industries. This regulatory policy approach continued under the LNP Coalition governments of Turnbull, and then of Scott Morrison, which renamed the ERF as the 'climate solutions' fund in February 2019 (Holden & Dixon, 2019).<sup>2</sup>

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<sup>2</sup> Morrison replaced Turnbull as Liberal Party leader and Prime Minister after a party room challenge in August 2018, after Turnbull failed to implement legislation for stronger emissions reduction (Sengupta, 2018).

## **The Australian Nuclear Association**

Supporters in the LNP, some academics and scientists, the Australian Workers Union, and industry lobby groups have still continued to defend nuclear energy in public debate. Since its formation in 1983, the key organization promoting nuclear power in Australia has been the Australian Nuclear Association (ANA). It describes itself as:

an independent incorporated scientific institution which promotes the knowledge and practice of the peaceful, safe and effective use of nuclear science and technology to benefit people, science and the environment....ANA strongly supports the use of nuclear power for Australia as reliable, affordable and low carbon generator of electricity and as a low carbon source of heat for industry...The ANA supports the removal of Federal and State legislative nuclear prohibitions so that nuclear power can be considered on its merits (ANA, 2020a).

The ANA holds public lectures and biannual conferences extolling nuclear power; its 2019 conference in Sydney was opened by Deputy Premier and NSW National Party Leader John Barilaro, with the conference theme of ‘Nuclear for a Low Carbon Future’ (ANA, 2019). It has extensive links with international lobby groups for the nuclear industry, such as the American Nuclear Society and the World Nuclear Association. Significantly, one of the ANA’s members include the very wealthy and influential Minerals Council of Australia (MCA).<sup>3</sup> The peak body for the mining industry, within the ANA the MCA represents the interests of uranium miners, principally the large multinational companies BHP Billiton, Rio Tinto, and Paladin Energy (ANA, 2020b).<sup>4</sup>

These connections indicate the considerable interest overseas nuclear energy corporations have in exploiting a potential Australian market. According to the 2015 GenCost Report from Australia’s science agency, the CSIRO, renewable energy was projected to reach similar costs with coal by 2030, and become the cheapest form of energy by 2050. Meanwhile, nuclear power would continue to be the most expensive form of power generation, even with a carbon price. Any future nuclear power industry in Australia would therefore inevitably be heavily reliant on foreign investment, supported by lucrative government subsidies, and an extensive level of bureaucratic supervision and regulation (Graham, 2015).

## **The SA Royal Commission and SMRs**

The ANA was hence one of the interested parties who made over 250 submissions to the Nuclear Fuel Cycle Royal Commission, announced by the South Australian Labor government in March 2015. After nearly 40 public hearings, and testimony from 132 witnesses at Expert Advisory Panels, the final report was delivered in May 2016 (ABC, 2016). As the state most closely tied to uranium mining, the purpose of the Royal Commission was criticized by environmental campaigners as providing justification for further expansion of nuclear related industries (Long, 2016).

These fears from anti-nuclear critics turned out to be well-founded, as the key

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<sup>3</sup> The MCA donated \$146,730 to political parties in FY2018-2019 (AEC, 2020).

<sup>4</sup> The three mines currently in operation are: Ranger in the NT, and Olympic Dam and Four Mile in SA. A total of 7798 tonnes of U3O8 ore was produced in 2019. (World Nuclear Association, 2020).



recommendations of the Royal Commission included: further encouragement of uranium mining; local processing of ore; and most controversially, the establishment of a facility for storage and disposal of nuclear waste. While the Royal Commission's report also recommended that federal prohibitions on energy generation by nuclear power be removed, a nuclear power plant would not be economically viable in South Australia (DP&C, 2016, pp.xiv-xv).

The section of the Report which dealt with nuclear energy included an examination of SMRs, the next-generation technology being heavily promoted by enthusiasts such as the ANA. SMRs are compact light water reactors, with a generating capacity of 300 MWe or less; most large-scale reactors in current operation generate around 1GWe. They are designed to be assembled from various components, making SMRs readily transportable. While their development is being promoted by a number of overseas corporations, including from the US, UK, China, South Korea, India and Russia, SMRs are not yet commercially operational (Gothe-Snape, 2019). Since their investment costs, timescales of introduction, and security risks are all still unknown and unproven, the Royal Commission Report concluded that SMRs were not economically viable, having a lower thermal efficiency than traditional larger fixed-location reactors (DP&C, 2016, pp.202-203).

### **The 2019 Election & Parliamentary Inquiry**

Although the LNP remained consistently behind in opinion polls into 2019, on April 10, Prime Minister Scott Morrison announced a general election for May 18, hoping to take advantage of continuing positive growth in the economy, and the relative unpopularity of Labor's Opposition Leader Bill Shorten ("Australian Prime Minister", 2019). In the first week following the start of the campaign, Morrison was forced to backtrack on suggestions he was potentially open to nuclear-sourced energy, which saw the Labor Party swiftly accuse the government of preparing to lift the moratorium. Seeking to suppress this political controversy early in the campaign, Morrison made a clearer statement, that there were no plans by the government to change the laws prohibiting nuclear power (Ferguson, 2019).

Despite these denials during the election, less than three months after the LNP's generally unexpected victory (two seats were gained, for a still-narrow majority of 78 in the 151-seat Lower House of Representatives), Energy Minister Angus Taylor announced on August 2 that the House Standing Committee on Environment and Energy of the Federal Parliament would conduct an inquiry into the feasibility of nuclear energy.<sup>5</sup> This came at the prompting of nuclear power enthusiasts in the LNP Coalition, who were emboldened by their election win (Macmillan, 2019).

The inquiry took three months, during which 11 public hearings were held, and 309 submissions received. The LNP-majority-dominated committee delivered its Report to Parliament on December 13, 2019. The committee chair, LNP MP Ted O'Brien,

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<sup>5</sup> Australian Electoral Commission data later revealed the fossil fuel industry made \$1,894,024 in political donations the year preceding the election: \$1,147,376 to the Coalition, and \$725,448 to Labor. Gas company Woodside, and coal company Adani were among the largest donors. The United Australian Party, led by Clive Palmer, received \$83.7 million in donations from Mineralogy, Palmer's own mining company. The UAP received 3.4% of the vote, and did not win a single seat (Stayner, 2020).

cited the need to reduce greenhouse gas emissions, in recommending a partial lifting on the restriction on nuclear technology for Australia's energy mix. Only new technology such as SMRs should be considered, and only with public consultation and consent, including for any associated nuclear waste disposal facilities (hence the title of the report) (DHR, 2019).

In their dissenting minority reports, the opposition committee members from Labor and the Independents argued against lifting the current restrictions on nuclear energy. They cited the lack of any clear economic case for nuclear power, including for the as-yet unproven technology of SMRs, amid the overall global decline of the nuclear power industry; the Labor report stated that global gross nuclear power generation had peaked at 17.46% in 1996, and had declined to 10.5% by 2018. The dissenters also raised the potential safety dangers of nuclear power and waste storage (SCEE, 2019, pp.55-73, 75-93). Responding to the report while attending the COP25 summit in Madrid, Energy Minister Taylor said there were "no plans" for the government to end the prohibition of nuclear power, which could not proceed without community and bipartisan political support (Foley, 2019).

Even before the conclusion of the inquiry, movement towards a permanent nuclear waste disposal facility took another step further in November, when the South Australian town of Kimba voted in a referendum held by the Australian Electoral Commission in favour of hosting a 'National Radioactive Waste Management Facility', by 61.58%, to 38.42% opposed. Local indigenous Native Title Holders claimed they had been excluded from the ballot, and planned a challenge in the Federal Court, supported by environmental groups also opposed to any facility (Smith, 2019). In a following ballot in December, the town of Hawker, also in regional SA, voted 52% against hosting a nuclear waste dump ("Residents vote against", 2019).

While neither of these ballots were legally binding on the federal government, in February 2020, the former Resources Minister Matt Canavan announced the federal government's approval for a nuclear waste dump at the rural property of Napandee, near Kimba. It is expected to concentrate the storage of low-level medical-origin radioactive waste, which is presently stored on-site at over 100 locations around Australia. Environmental groups such as the Australian Conservation Foundation (ACF) and local residents opposed to the dump are already planning to continue protests against such a facility going ahead ("South Australian farming property", 2020).

The ACF was also critical of a plan by mining company Boss Resources to re-open the Honeymoon uranium mine in SA; while it is one of only four mines in Australia with a currently valid export licence, it has not been in production since 2013. The company claimed new processing technology would make the mine viable again, once uranium prices recovered from their current slump on international markets. The ACF countered this optimistic assessment, pointing to the major company Rio Tinto's closure in 2012 of one of its main pits at its Ranger mine in the Northern Territory, due to lack of demand (Gooch & Tomevska, 2020).<sup>6</sup>

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<sup>6</sup> As of February 10, 2020, uranium was trading on the New York Mercantile Exchange at US\$24.55/lbs; the market peak was US\$140, on June 1, 2007 (Trading Economics, 2020).

## **Conclusions – the Climate Crisis Debate and the Fate of Australian Nuclear Policy**

The unprecedented bushfire crisis that Australia endured during the summer of 2019-20, which commanded global attention, intensified public calls for stronger action to reduce Australia's carbon emissions. There was widespread awareness, supported by scientific opinion, that the likelihood of such extreme bushfires had been aggravated by drier conditions and higher temperatures caused by global warming (Gramling, 2020). Nuclear power advocates did not shirk this opportunity to re-enter the debate; while bushfires were still burning, the ANA invited a nuclear science professor from the Massachusetts Institute of Technology to spruik nuclear power, urging its necessity in order for Australia to eventually reach zero carbon emissions (Borschmann, 2020).<sup>7</sup>

The nuclear debate thus remains active in federal politics. On the first day of parliamentary sessions for 2020, former National Party leader (and outspoken nuclear power advocate) Barnaby Joyce launched a failed party room challenge to reclaim the leadership of the Nationals from Deputy Prime Minister Michael McCormack. At the first joint LNP party room meeting for 2020 held the same day, in a divisive debate over climate policy, backbench Liberal MPs Trent Zimmerman and Tim Wilson advocated adoption of nuclear power to reduce carbon emissions; National MPs such as Joyce argued for more coal-fired power stations, subsidised by the government if necessary. This demonstrates the ongoing policy tensions within the Coalition between 'moderates' willing to take action on climate change, and sceptics who deny the science altogether (Martin, 2020).

Following a cabinet reshuffle after Joyce's failed leadership bid, Nationals MP Keith Pitt was appointed Resources Minister, replacing Matt Canavan. Pitt was the MP mainly responsible for instigating the parliamentary inquiry into nuclear energy, as an advocate for lifting the moratorium. Amidst this latest political turmoil within the Coalition, Morrison maintained there were still no plans by the government to lift the long-standing ban on nuclear power (Coughlan, 2020).

Despite ongoing overseas investment in SMRs, this technology is still far from commercial realization, not expected until the 2030s at the very least. Even if the legal prohibition was overturned in the near future, a nuclear power industry in Australia would be unlikely to be established and viable until the 2050s, at the earliest. There would be substantial risks of cost blowouts, and requirements for extensive regulation and subsidies of foreign investment and operation, since there is no domestic experience and expertise for operating commercial nuclear power plants. The financial argument against nuclear energy is further reinforced by the latest updated CSIRO-AMEO Gencost 2019-20 study; it reconfirms earlier findings that renewable energy, principally solar and wind, will continue to be cheaper than coal and gas, while nuclear remains the most expensive option (Parkinson, 2020).

Future proposals for nuclear power by any Australian government are certain to be highly contested. Labor's policy remains firmly opposed to nuclear power; the ALP

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<sup>7</sup> The bushfire crisis largely eased in February, due to another extreme weather event – the heaviest rainfall for 30 years along the east coast of Australia, which caused local flooding (BBC, 2020).

would therefore be sure to politically exploit any hint of its proposal towards the next national election, due in 2022. Meanwhile, Scott Morrison's LNP government faces growing internal divisions, and widespread discontent among the electorate over its lacklustre climate policy (Bongiorno, 2020). Decisions over where to site power plants, and disposal of nuclear waste would remain highly controversial issues. Any Australian nuclear power industry is therefore a very long-term prospect, if ever, as less risky renewable energy becomes more widespread, efficient, and affordable.

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***Application of Google Street View Application for Footpaths' Inspection in  
Nakhonratchasima City Municipality, Thailand***

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**Abstract**

Walking is one way to increase physical activity regardless of whether the purpose for walking is for transportation or leisure. Therefore, this paper aims to inspect urban footpaths in term of infrastructures and facilities based on data of Footpath Standard Inspection (FSI) from Ministry of Transport (MOT). This study selected 5 routes of Nakhonratchasima City Municipality (NCM) that were reported as a quality footpaths along public transport routes from The Study of Traffic Management and Public Transport Development Master Plan in Nakhon Ratchasima Urban Area. Moreover, Google Street View (GSV) was used for footpaths' investigation in NCM. GSV was implemented to help with prior inspecting process by allowing prospective researches to take a virtual tour before visiting. The results showed that all inspected 5 routes above-based GSV still were lacked of curb ramp and obstacles arrangement. These results are consistent with the currently true ground. Moreover, footways are now not provided facilities for disables such as protective rails and braille block. Consequently, the results of footpaths' inspection in NCM will be able to take action for planning and improving footpaths in NCM toward health and wellbeing further

Keywords: Health and wellbeing, Footpath, Google Street View

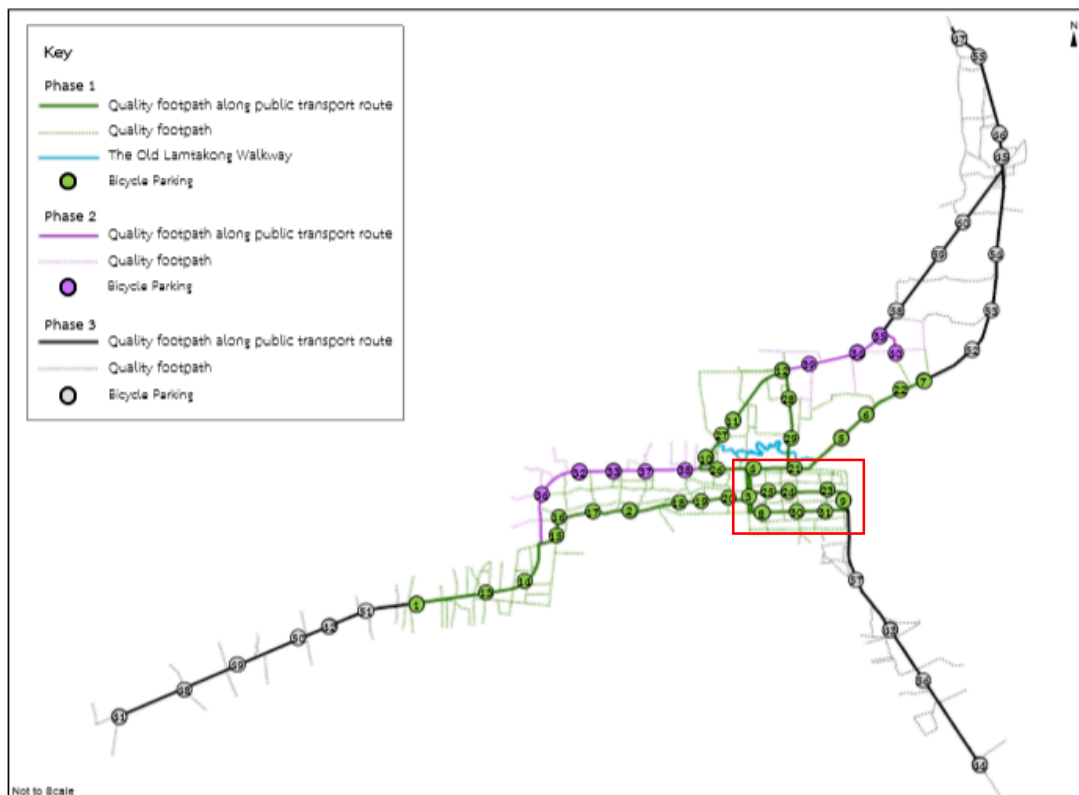
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## Introduction

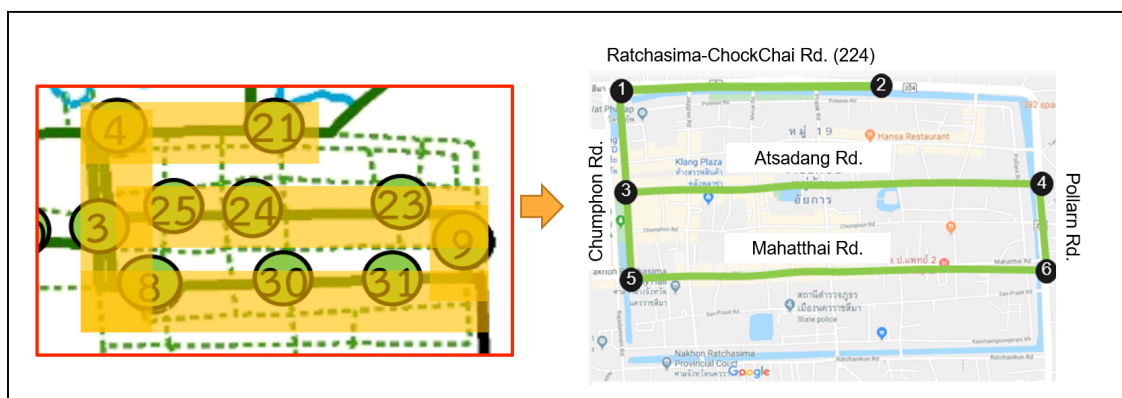
Walking is the easiest and cheapest and cheapest way to develop a healthy lifestyle. There are many health benefits for people who walk regularly, including improving medical conditions like diabetes; preventing cancer, heart attacks, and stroke; contributing to a longer life, and boosting overall well-being (Kyu et al. 2016). To encourage walking activities in an urban area, footpaths must comply with the following best practice standards of safety and support for all users. In developed countries realize the importance of sustainable traveling in the cities by maintaining the condition of the footway. The footpath is a vital roadside element as it facilitates pedestrian movement and enhances overall connectivity. Accessible, safe, comfortable and well-maintained footpaths enhance the walking experience and promote walking as a mode of transport for short-distance commuting.

The research uses secondary data for selecting the research footpath routes. The Study of Traffic Management and Public Transport Development Master Plan in Nakhon Ratchasima Urban Areas (2017) has reported that the traditional center (city moat areas) is an urgent place urban are to be developed in terms of traffic and public transport. There were 5 routes around the traditional center (city moat areas) to be inspected. The selected routes were reported as a quality footpath along public transport routes from as shown in the red circle in figure 1.



Source: office of Transport and Traffic Police and Planning Ministry of Transport  
Figure1: Park and Ride, Interchange/Mode Change and appropriate Access Points for Phase 1, Phase 2 and Phase 3

The researcher use Google map to define the name road. Also the researcher have create the point of origin and ending point of each route for inspecting as show in figure 2.



Source: office of Transport and Traffic Police and Planning Ministry of Transport  
Figure2: the study routes

The research is using Footpath Standard Inspection (FSI) from the Ministry of Transport, Thailand (MOT) to measure footpath in urban. There are three main elements to measure such as Walkway, Protective Rails/ Barrier and Protruding Objects. First, the pedestrian path width is not less than 1.5 meters; the pavement must be smooth, not slippery, and not rough; it should be provided ramps from sidewalks to roads, road crossing, connected building or section of different levels in order to safely and conveniently. Second, protective rails should be provided in dangerous areas to prevent slipping of the wheelchair. Third, protruding objects should be arranged to have enough sidewalk the same as standard if any necessary protruding object, there should not be more than 100 mm. and not installed less than 700 mm. height from the floor.

Google Street View application (GSV) is used to be as a tool for investigation. The image database of Google Street View is a network of adjacent 360° high-resolution panorama images, which are divided into quadratic tiles. Those images are intended to be accessed via the Google Maps static application programming interface (API) (Zamir and Shah, 2010). It helps enable people everywhere to virtually explore the world. This research implemented GSV to help with the prior inspecting process by allowing prospective researches to take a virtual. However, this application has a limitation in terms of data, it only provides the imagery from the part so the data in this research was in July 2018. Moreover, GSV has no function for distance measurement. Therefore, footpaths width cannot be inspected in this research.

After virtually investigating the footpath tour by GSV in each study routes in forward and backward as presented in Table 1.

Table 1: Footpath inspection checking list

Footpaths Route (Origin to End)	Walkway		Protective Rails/ Barrier	Protruding Objects
	Smooth Pavement	Ramps Providing	Protective Rail	Obstacles arrangement
1 to 2	✓	✓	✗	✗
3 to 4	✓	✓	✗	✗
4 to 3	✓	✓	✗	✗
5 to 6	✓	✓	✗	✗
6 to 5	✓	✓	✗	✗
1 to 5	✗	✓	✗	✗
4 to 6	✓	✓	✗	✗

Source: The researcher

It found that all inspected 5 routes were lacked of obstacles arrangement. There were many shops on the footpath. Moreover, there were some motorcycle parked on the footpath as well as a show in the sample figure 3.



Source: Google Street View

Figure3: Lack of protruding objects arrangement sample pictures.  
Moreover, footways are not protective rails for disables people as show in Figure 4.



Source: Google Street View  
Figure3: Lack of protective rail for footpath.

## Conclusions

After inspection footpath by using GSV, it showed that footpath 5 routes around the traditional center (city moat areas) in Nakhonratchasima City Municipality were lack of protruding objects arrangement and there were no facilities for disables such as protective rails. The results of footpaths' inspection in NCM will be able to take action for planning and improving footpaths in NCM toward health and wellbeing future. The research methodology is able to implement in other area.

## Acknowledgements

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***Healing Village: Implementing Biomimicry and Natural Architecture to Promote  
Sustainability in Healthcare***

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The IAFOR International Conference on Sustainability, Energy & the Environment  
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**Abstract**

Sustainability in healthcare is essential to have many beneficial outcomes. Healing Village is a healthcare project in Tehran, Iran which is designed not only for the patients to have better healing experience, but also for all people living in the surrounding community. Healing Village aims to spread long-term health and well-being through biomimicry and sustainable natural architecture. In this redesign process, the researchers present a new healthcare center completely adaptive with its surrounding environment. This center would produce and consume based on its resources and needs. Analyses of the surrounding neighborhoods and the climate reveal challenging issues like air pollution, as well as other characteristics the project such as its limitations, weaknesses, and strengths. The function of the hospital in the Healing Village is considered as a prospective example of biomimetic architecture operating similar to natural organisms that create a living structure which is transforming, breathable, and self-cleaning to protect the indoor building and help users reach better outcomes. The biomimicry and natural architecture methods make Healing Village a good example of well-being for the city of Tehran and could be used as a model for other polluted cities in the world.

Keywords: Sustainability, natural architecture, biomimicry, healthcare architecture, well-being

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## **Introduction**

Healing Village is a sustainable design project in healthcare that seeks to provide long-term health and well-being among neighbors, reduce the surrounding neighborhood carbon footprint, and provide people with opportunities to be healthier. Healing Village is designed as a green space inside a busy city to create a feeling of being in nature to improve occupants' health and well-being. Thus, Healing Village is a concept that obtains to proactively encourage a healthy lifestyle before people become sick. Sustainability is a lens to analyze neighborhood issues and climate change. To achieve Healing Village's goals, this research is divided into three categories: well-being neighborhood, building a hospital with sustainability and efficiency design strategies, and produce energy.

## **Research Significance**

This project will be beneficial for the people and have four levels of impact with different scales including city, district, neighborhood, and site. In the largest level of impact, Healing Village would be connected to agriculture schools of the city to share research and educational aspects of planting on the site. In the scale of city, this project would encourage other hospital owners to implement sustainable strategies such as using renewable energies. On the district scale, it would encourage people to use electric cars as well as bicycles. Incorporating a charging station on the site can encourage people to use electric cars and decrease the level of air pollution. Since electric cars need a considerable time to recharge, people can spend their time on the site or even in the surrounding areas while their vehicles are charged. Turning to neighborhood, the project's goals are purifying air, generating electricity, minimizing the possibility of power outage during the high usage season (summer), and attracting people for social and healthy activities. Finally, on the fourth level, site, Healing Village aims to improve staff satisfaction and efficiency, decrease the length of hospitalization, and encourage people to walk and have better lifestyles and fresh food.

## **Research Question**

What design solutions could be incorporated to make Healing Village sustainable? To answer this question, this research looks at the project site and climate issues to identify the site's strengths, weaknesses, and limitations to provide better natural architecture and biomimicry solutions that fit this particular site.

## **Term**

Biomimicry is learning from and then emulating nature's forms, processes, and ecosystems to create more sustainable designs (biomimicry.net). Biomimicry offers a deep understanding of how living things work and learn strategies to react to surrounding problems. These strategies can be used to solve design challenges in sustainability (biomimicry.org).



## Analyses

### Climate and Precipitation

The weather in Tehran is extremely different between summer and winter. The summer is hot and arid, while the winter is cold and dry. The summer lasts for 3.6 months (average high of 97°F and low of 77°F). The winter lasts for 3.5 months (average low of 34°F and high of 47°F) (“Average Weather in Tehran”, 2019).

The wind comes from three directions: west, south, and north. It comes from the west for four months with a peak percentage of 37% on April 18. It comes from the south for 4.8 months with a peak percentage of 49% on July 23. It comes from the north for 2.2 months, with a peak percentage of 32% on January 1 (Average Weather in Tehran, 2019).

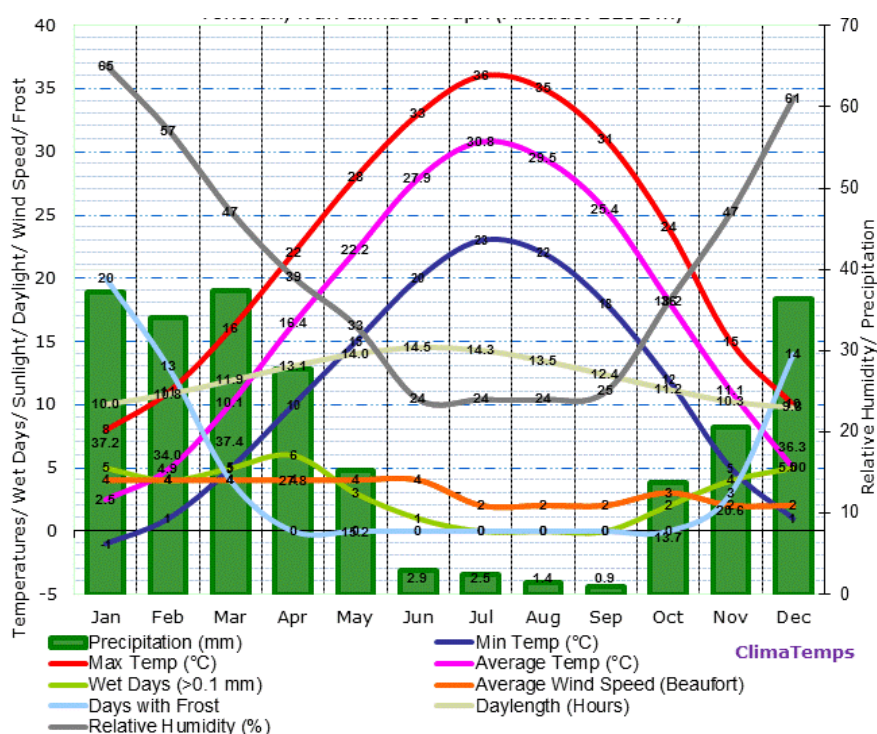


Figure 1. Climate in Tehran, Iran in 2019 (Average Weather in Tehran, 2019)

The city of Tehran is exposed to the sun for a long time. On the longest day, the sun lasts for 14.5 hours, while on the shortest day, for 9.5 hours (“Relative Humidity in Tehran, Iran”, 2019). "The average annual relative humidity is 40.2% and average monthly relative humidity ranges from 24% in June to 65% in January" (“Relative Humidity in Tehran, Iran”, 2019).



Figure 2. The site analysis shows the different wind directions, different sun altitudes between summer and winter, and the directions of the most noise and polluted streets.

### Site Issues

The project is located in Tehran, Iran. Tehran is the capital of Iran which is the most populated city of the country with over nine million people. The site of the project has strengths, weaknesses, and limitations, all of which were considered throughout the project. Site area, underground water, wind, and sunlight (as lighting and energy source) were considered as the main strengths of the site and were implemented to enhance the environmental quality and sustainability. Tehran faces many problems due to overcrowding; consequently, the main weaknesses of the site are air pollution, noise pollution, and traffic. Also, there are not enough fresh food markets for the people living in the neighborhood. It is important to consider some strategies in this project to address these problems. There are also some natural limitations that need to be considered including limited water sources, dry weather, changing temperature (hot and cold), and sunlight (as heating source during summer). Design strategies that were implemented for this project directly and indirectly address these issues.

Table 1: Research finding

Strength	Weakness	Limitation
- site area	- air pollution	- water source
- wind	- noise pollution	- dry weather
- sunlight (as lighting and energy source)	- visual pollution	- changing temperature (hot & cold)
	- traffic	- sunlight (as heating source in summer)

### Well-being Neighborhood

The overall design of Healing Village was inspired by Persian culture and Persian garden elements such as water fountain, dome, and sunken courtyard. The Healing Village design addresses the neighborhood's problems since the site would produce and consume based on finding resources and demands. It would include space for gardening on site (5) and indoor center with the hydroponic system (4) to use in the hospital and for community needs. It also would consider neighbors' activities as a part of the content of the project (2, 3, 12). Neighbors could learn a healthy lifestyle and participate in the Healing Village activities such as gardening (5), exercising (12), and cooking in healthy ways (2). The design of the site has areas for participants to walk and gather for social events and activities (3, 12) as well as walking paths for Healing Village workers (8). Healing Village encourages users to use bicycles (6) or use electric cars and provides a charging station in the parking lot. The site's contoured topography helps to design a hidden parking lot (7). The energy generators, solar panels and cells (11,12), wind turbines (10), and carbon engineering system (9), would be visible to show neighbors Healing Village's ways to generate its energy and educate them about alternative ways to consume available natural resources.



Figure 3. Redesigned site plan

### **Efficient Hospital Building**

Hospitals are not sustainable; large amounts of energy are consumed 24 hours a day, seven days a week (CBECS, 2012). According to CBECS, hospitals use the most energy on heating the building, air conditioning (HVAC) systems, lighting as well as many other energy-intensive activities that occur. Through the design of Healing Village project, natural architecture and biomimicry were considered to find solutions to reduce the usage of the energy in these systems and make the building more efficient. Efficient design considerations are divided into natural ventilation approaches and daylight solutions.

### **Natural Ventilation Approach**

Healing Village looks at the natural ventilation strategies that work well in the site. Findings reveal that using wind tower, sunken yard, and debulking façade will help to maximize the natural airflow indoors and reduce the use of HVAC systems during certain times of the year (see Figure 6). However, because the site suffers from pollution, these strategies need to be supported by filtration systems, and other strategies, which were inspired by biomimicry.

### ***The First Approach: Green Façade***

One of the design solutions for this project to address some of the weaknesses and limitations is the Green façade system. In this system, polluted air passes the green surface while being purified and cooled and is then diverted into the building via a fan. While this system could be efficient in warm seasons, by closing the vents in cold seasons, energy waste could be prevented. The water needed for this system is circulated, which makes the system more efficient and uses less water. Finally, this element on the façade will prevent direct sunlight from penetrating into the building during summer.

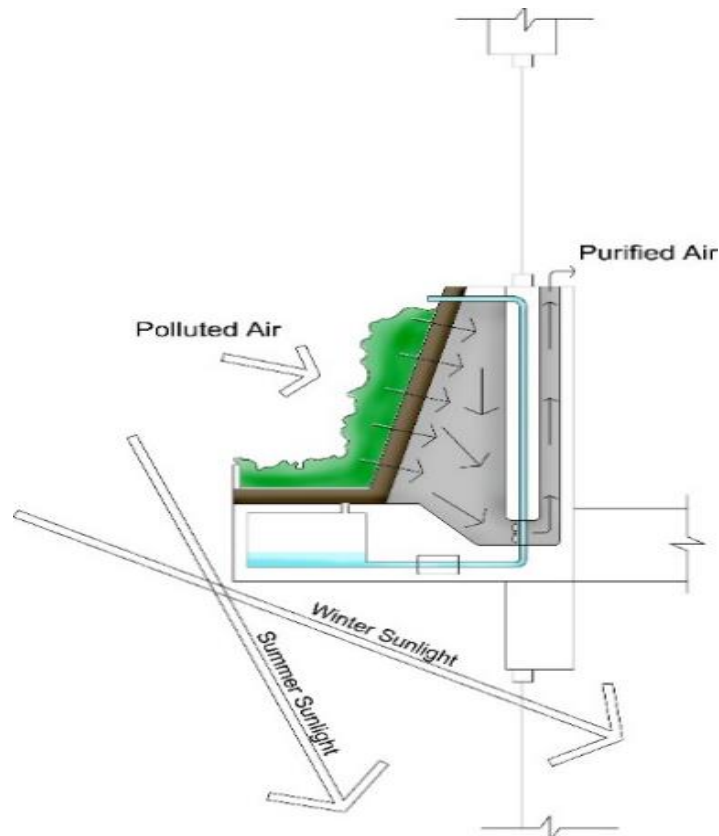


Figure 4. Green façade

### ***The Second Approach: Biosystem (Breathing)***

An evaporative cooling system, Biosystem, would be located between the double skin façade and the original façade in the south and west sides of the building. This system works in hot and dry climates, and it is inspired by four natural systems (biomimicry): stoma of plants, pinecones, hair around eyes in the desert, and human skin (Minsolmaz Yeler & Yeler, 2017). The Biosystem would use the stoma of plants concept to address osmotic pressure changes and control openings for evaporation and use pinecone concept to address relative humidity changes. The hair around eyes (eyelashes) concept would apply to protect against small particles (dust and sand). Finally, the human skin concept would apply to latent heat transfer– cooling through evaporation.

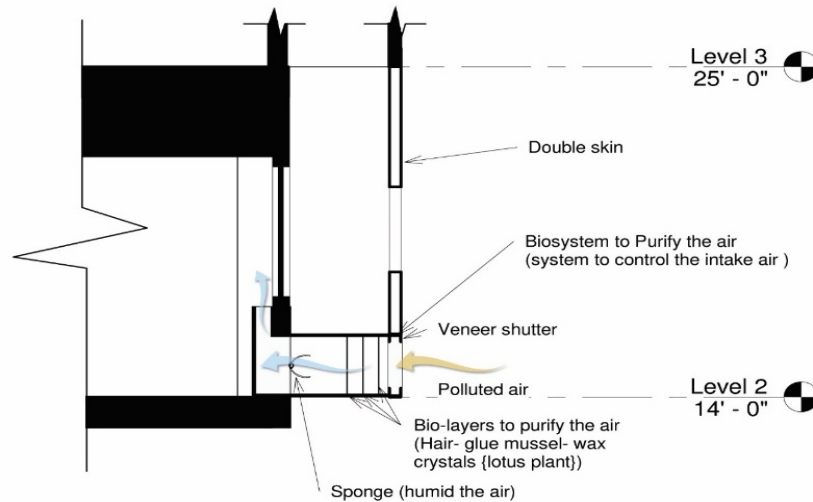


Figure 5. The section shows the Biosystem layers and functions

This system would allow fresh air to penetrate patient rooms and exam rooms. The system would have a veneer shutter to control internal airflow. In addition, it has three different layers to catch dust and small germs. Finally, after purifying the air, the system has a sponge to make the air humid to become cooler. This system would have the ability to control opening and closing, depending on individuals' needs.

***The Third Approach: Decrease Pollution and Self-Cleaning***

This strategy is used in the design to purify the air before it comes into the interior spaces using two biomimicry strategies (decrease pollution and self-cleaning) to catch dust and pollution. The first layer in this system would have the potential to catch small germs and infection. Mussels have strong water-based glue that cleans their surfaces (biomimicrybe.org). Inspired by this sanitary bond, the first layer would have

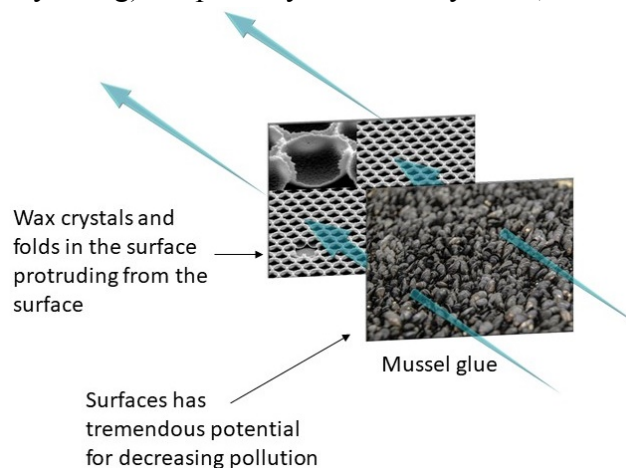


Figure 6. The drawing shows the two layers: decrease pollution and

mussel glue to decrease pollution at Healing Village. The second layer would contain wax crystals folded in to the surface to catch dirt, like in a lotus plant (a dirt-free plant) (AskNature Team, 2002).

### ***The Fourth Approach: Transformer***

The building would have the capability to change its color, adjusting to the surrounding temperature. The concept of this approach is inspired by changing colors in chameleons; chameleons have the ability to reflect different wavelengths of light and change their color to protect themselves (lauranadineolivier, 2016). In the building design, this strategy would be applied in the façade using Thermochromic, a “heat-sensitive paint contain[ing] pigments” (Ashish, 2018). These pigments change the color of the applied surface according to changes in the surrounding temperature: the color of the building façade turns white during hot temperatures to reflect the sunlight (protect the indoors from heat), while the color turns darker (dark brown) during the cold temperatures to absorb the heat from the sun. As the main goal, this strategy would help the building reduce energy usage.

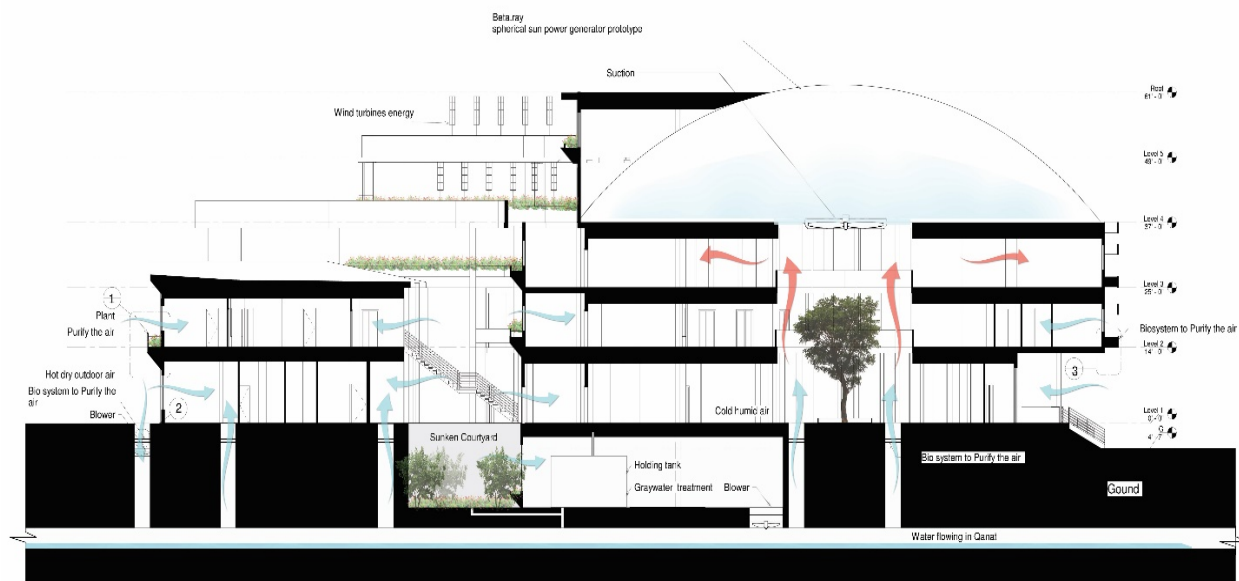


Figure 7. This section shows the natural ventilation strategies to purify and cool the air (2) to bring it to the indoor spaces. All patient rooms are located on the side of the building to access purified and cool air either purifying the air via Green Façade in north and east (1) or purifying the air via Biosystem in the west and south (3).

### **Daylight Solutions**

The nature of healthcare facilities’ layout and physical space requirements causes many limitations to provide indoor spaces with natural lighting. Due to the huge area needed for every healthcare facility and other limitations of building shape, it is almost impossible to provide natural lighting for all indoor spaces. On the other hand, natural lighting has many benefits for the users and the building. To overcome this problem, some natural strategies were implemented on this project to maximize natural lighting in indoor spaces.

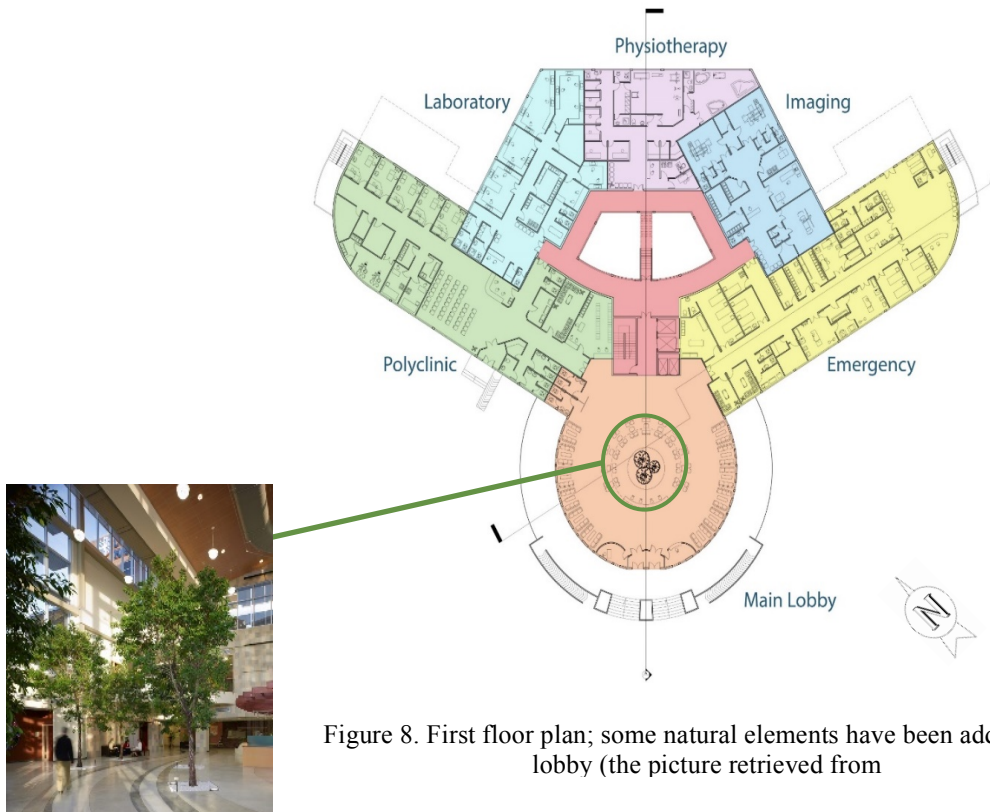


Figure 8. First floor plan; some natural elements have been added to the lobby (the picture retrieved from



Figure 9. Second floor plan; some minor design changes bring natural lighting to the corridor (the picture retrieved from





Figure 10. Basement floor plan; some change on the floorplan design and considering sunken courtyard bring natural lighting and natural ventilation for support departments (the picture retrieved from <https://irandoostan.com/ir/iran-tour/tours-to-iran-civilization-persa->

## Produce Energy

The aforementioned solutions would allow Healing Village to be more efficient and reduce energy usage. However, the site needs energy to function; therefore, the design takes advantage of the site's strengths to produce solar and wind energy for Healing Village's use. Another potential source of energy would be the pollution from the site vehicles, known as Carbon Engineering.

## Solar Energy

### Spherical Sun Power Generator Prototype (Beta.ray)

Spherical sun power generator prototype (Beta.ray) was established by German Architect Andre Broessel. This technology has a spherical geometric shape to take advantage of its principles; it provides twice the output of a traditional solar panel in a smaller area ("The Spherical", 2015). Healing Village would have a dome in the hospital building (inspired from the surrounding culture) using the Beta.ray method to produce a significant amount of energy to cover the building demands.

### Solar Panel (Inspired by Lotus Plant)

The site would have numerous solar panels with a special coating (inspired from the Lotus Plant) developed by the Oak Ridge National Laboratory. The panel has "new water-repelling, anti-reflective glass coating that could increase the efficiency of solar panels by up to 6%" (Dana, 2015) and helps the panel last longer. This coating resists high temperatures and benefits the panel through self-cleaning, similar to the Lotus

Plant. These solar panels would be located in various locations: pergolas, parking lot, and walking path.

### **Wind Energy (Wind Turbine Parks - Biomimicry)**

Wind Turbine Parks is a wind energy generator inspired by the concept of fish swimming in shoals, using small water vortexes that allow them to swim faster using less energy (Rovalo, Dwyer, & Dorfman, 2017). This method increases the turbine productivity because each turbine catches more wind. These turbines would be located on top of the building and have less noise, are safe for birds, and fit better in the natural landscape compared to traditional turbines.

### **Carbon Engineering (Air to fuel & Air purifying)**

Due to many reasons such as population density, traffic, industrial factories, poor quality of gasoline, and inadequate transportation systems, Tehran is among the most polluted cities of the world. Therefore, air pollution is one of the main challenges of designing Healing Village. Carbon Engineering Ltd is a Canadian-based clean energy company that works on practical ways of reducing carbon dioxide from the air or even converting it to other forms of energy. By using this system on the site, the polluted air will be absorbed using gigantic fans and purified by advanced systems and filters; these systems can absorb existing carbon dioxide in the air and convert it to solid and clean fuels to be used in transportation systems. Having this technology on the project site not only provides people living on surrounding area with clean or at least less-polluted air, but it can also produce clean and environmentally-friendly fuel for transportation systems.

### **Conclusion**

This paper presents a research project that considers the neighborhood and climate issues to reduce neighborhood problems and enhance well-being through designing a sustainable hospital. Healing Village is designed to produce strategies and systems from natural architecture and biomimicry to address air quality, lighting, gardening, and energy. In designing this type of hospital, the researches consider the social and environmental impacts of the building on people in the surrounding neighborhood with aims to reduce harmful practices on the environment and improve neighbors' well-being and health. The considered design strategies could be valuable to other dry climate and polluted cities. This paper presented some product strategies on the market as well as the authors' efforts to bring suggested solutions to the site design. Many aspects may need to be considered for future research; one potential experiment may be the use of transformer strategy and how it can help reduce energy usage. Moreover, the research could examine Biosystem strategies to find solutions to bring fresh air indoors in polluted climates. Future research might look at sustainability in healthcare climate to decrease carbon and pollution footprint, increase hospital's building efficiency, and improve well-being. Research should expand people's understanding of living things' functions to obtain better biomimicry solutions to develop new strategies to help designer and architecture practices.

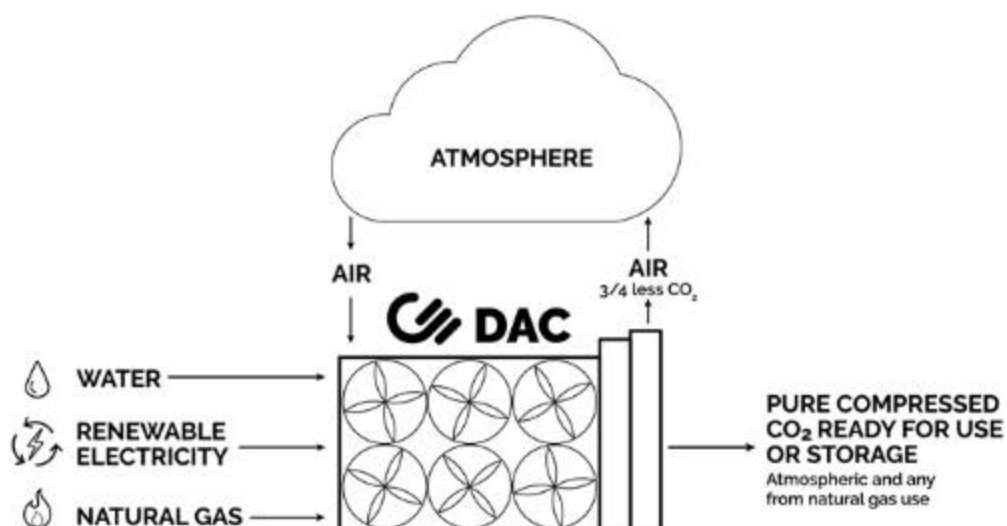


Figure 11. How Carbon Engineering system can purify the air and convert carbon dioxide to other forms of energy (retrieved from <https://carbonengineering.com/our-technology/>)

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***A Comparative Study of three Mathematical Models for Predicting the Indoor  
Environment Quality (IEQ) in Research Office***

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**Abstract**

Indoor environment quality is considered as an important indicator of sustainable development of structures, and it can be used to reflect the occupants' comfort level in buildings. However, it is difficult to evaluate the impact of physical parameters on the occupants' comfort in individual level because of the coexistence of parameters and their interactions with each inhabitant. The objective of this research is to find out the most suitable mathematical model to predict the occupants' comfort in research office by comparing three different IEQ models: Iordache's IEQ model, Wong's multivariate-logistic model and Ncube's IEQ model. The data were collected by combining physical measurement with subjective survey. The entire experiment was carried out in a research office in Japan Advanced Institute of Science and Technology, with a sample of 12 participants (6 sub-groups). And data were collected twice a week for each sub-group during the three-week experiment. The relevant physical environment parameters from the collected data were brought into three mathematical models to calculate the corresponding thermal index, indoor air quality (IAQ) index, acoustic index and visual index. Meanwhile, Actual Mean Votes and Actual Percentage of Satisfaction (APS) were calculated by analyzing the questionnaire from subjective survey. By comparing the calculated indexes and the corresponding APS through the SPSS, the results showed that Iordache's IEQ model is best-fit comfort prediction for the research office.

Keywords: Indoor environment quality, Wong's multivariate-logistic model, Iordache's IEQ model, Ncube's IEQ model

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## Background

Indoor environment quality is considered as an important indicator of sustainable development of structures, and it can be used to reflect the occupants' comfort level in buildings. Comfort is a composite mental response of occupants to indoor physical environment based on their physiological and psychological state (Wong L.T., Mui K.W., & Hui P.S., 2008). Comfort can be divided into many parts, among which the four basic components are thermal comfort, IAQ comfort, acoustic comfort and visual comfort. Mui et al. point out that the occupants' comfort in buildings depends on many environment parameters, like air temperature and relative humidity (K.W. Mui, W.T. Chan, & J. Burnett, 1999). In addition, relevant literature shows that indoor environment has a direct impact on occupants' health and work productivity, such as bad indoor environment can cause long-term health problems, reduce happiness index, and reduce their work efficiency (Alhorr Y. et al., 2016), (Feige A. et al., 2013), (Kridlova Burdova E., Vilcekova S., & Meciarova L., 2016).

According to the statistical data from ASHRAE, researchers need to spend 80% to 90% of their research time in the research office (ASHRAE, 2012). Burdova et al. (2016) pointed out that good indoor environment can improve researchers' comfort and their research performance. Therefore, it is important that indoor environment must meet the requirements of comfort.

However, in the actual environment, it is difficult to evaluate the impact of individual physical environment parameters on the occupants' comfort separately. This is mainly due to the coexistence of many of these parameters and their interaction with each inhabitant (Budaiova Z. & Vilcekova S., 2015). Therefore, relevant comprehensive mathematical models are proposed, such as Wong's multivariate-logistic model, Iordache's IEQ model and Ncube's IEQ model (Wong L.T. et al., 2008), (Mihai T. & Iordache V., 2015), (Ncube M. & Riffat S., 2012). These mathematical models are used to comprehensively evaluate the co-effects of multiple physical environment parameters on the occupants' comfort in buildings.

There is still some imperfection of those models, where the impact of building use is not considered. Some studies have shown that the weight of related environmental parameters is different among buildings with different uses (Lee Y.S. & Guerin D.A., 2010), (Malmqvist T., 2008). Studies have shown that acoustic parameters are the most important factors to affect comfort in research environment (Wong L.T. et al., 2008), (Lee M.C. et al., 2012). Since the above mathematical models are based on data from office and residential buildings, their applicability in the research facilities has not been fully tested.

## Research Objective

In this research, physical measurement and subjective survey are used to collect the data from the participants. After the data collection, three different comprehensive mathematical models are compared to achieve the following objectives:

- a. Find out the most suitable mathematic model that best predict the IEQ for the research facilities.
- b. Find the inner correlation between thermal, IAQ, visual and acoustic indexes.



## Mathematical Model

Three different mathematical models were examined in this research, which are Wong's multivariate-logistic model, Iordache's IEQ model and Ncube's IEQ model (Wong et al., 2008), (Mihai T. & Iordache V., 2015), (Ncube M. & Riffat S., 2012).

### A. Wong's multivariate-logistic model

Wong's multivariate-logistic model is developed based on the subjective evaluation about indoor environmental condition from 293 occupants in a typical air-conditioned office in Hong Kong. The equation of Wong's multivariate-logistic model is listed from Eq.1 to Eq. 5:

$$\text{Thermal Index: } \phi_1 = 1 - \frac{PPD}{100} \quad (\text{Eq. 1})$$

$$\text{IAQ Index: } \phi_2 = 1 - \frac{1}{2} \left( \frac{1}{1 + \exp(3.118 - 0.00215\zeta_2)} - \frac{1}{1 + \exp(3.230 - 0.00117\zeta_2)} \right), 500 \leq \zeta_2 \leq 1800 \text{ ppm} \quad (\text{Eq. 2})$$

$$\text{Visual Index: } \phi_4 = 1 - \frac{1}{1 + \exp(-1.018 + 0.00558\zeta_4)}, 200 \leq \zeta_4 \leq 1600 \text{ lux} \quad (\text{Eq. 3})$$

$$\text{Acoustic Index: } \phi_3 = 1 - \frac{1}{1 + \exp(9.540 - 0.134\zeta_3)}, 45 \leq \zeta_3 \leq 72 \text{ dBA} \quad (\text{Eq. 4})$$

$$\text{Overall IEQ: } \theta = 1 - \frac{1}{1 + \exp(-15.02 + \sum_{i=1}^4 K_i \phi_i)}, K_1 = 6.09, K_2 = 4.88, K_3 = 4.74, K_4 = 3.70 \quad (\text{Eq. 5})$$

### B. Iordache's IEQ model

Iordache's IEQ model is a multiple non-linear regression models developed based on the data from university classroom and professors' office in Romania. The equation of Iordache's IEQ model is listed from Eq.6 to Eq. 10:

$$\text{Thermal Index: } I_{th} = \begin{cases} 28.57\theta_o - 514, & \theta_o \leq 21.5 \\ -28.57\theta_o + 800, & \theta_o \geq 24.5 \end{cases} \quad (\text{Eq. 6})$$

$$\text{IAQ Index: } I_{IAQ} = 3.125Q_{air} - 12.5 \quad (\text{Eq. 7})$$

$$\text{Visual Index: } I_v = 0.33E_{av} \quad (\text{Eq. 8})$$

$$\text{Acoustic Index: } I_a = -3.33L_{pi} + 200 \quad (\text{Eq. 9})$$

$$\text{Overall IEQ: } I_{IEQ} = \frac{1}{4}(I_{th} + I_a + I_v + I_{IAQ}) \quad (\text{Eq. 10})$$

### C. Ncube's IEQ model

Ncube's IEQ model is a multiple regression model developed based on the surveyed input data from 68 occupants in two selected office buildings in UK. It is used to quick assess the environmental performance of the air-conditioned office alongside energy performance. The Equation of Ncube's IEQ Model is from Eq. 11 to Eq. 15.

$$\text{Thermal Index: } TC_{index} = 100 - PPD \quad (\text{Eq. 11})$$

$$\text{IAQ Index: } IAQ_{index} = 100 - PD_{IAQ}, \text{ where } PD_{IAQ} = 395 \times \exp(-15.15 \times C_{CO_2}^{-0.25}) \quad (\text{Eq. 12})$$

$$\text{Visual Index: } L_{index} = -176.16x^2 + 738.4x - 690.29, x = \ln(\ln(\ln(\text{illumminance}))) \quad (\text{Eq. 13})$$

$$\begin{aligned}
 \text{Acoustic Index: } AC_{index} &= 100 - PD_{ACC}, \text{ where } PD_{ACC} \\
 &= 2 \times (\text{Actual}_{\text{SoundPressureLevel}} \\
 &\quad - \text{Design}_{\text{SoundPressureLevel}}) \quad (\text{Eq. 14})
 \end{aligned}$$

$$IEQ_{index} = 0.30TC_{index} + 0.36IAQ_{index} + 0.18AC_{index} + 0.16L_{index} \quad (\text{Eq. 15})$$

## Research Methodology

### A. Introduction of controlled office

In this research, physical measurement and subjective survey were used to collect the data from the participants in a controlled office environment at Japan Advanced Institute of Science and Technology in Japan. The total floor area of the controlled office is 36m<sup>2</sup>, with the clear ceiling height of 2.17m. The envelop of this controlled office is constructed using heat-insulating materials, and covered by sound insulation board. In addition, the window shadings are also installed to avoid the interference of the nature light. One set of air conditioner with ventilation function is installed at the center of the ceiling to provide constant thermal and IAQ condition for the office. The illumination condition is controlled by six sets of LED lights on the ceiling, together with two desk lamps. The acoustic condition is adjusted by playing the video of discussion with related topic to the participants. The plan view of the controlled office is in Figure 1.

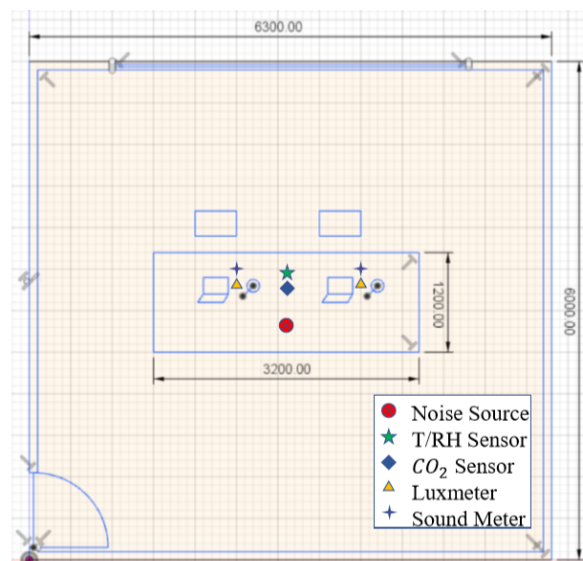


Figure 1: Plan View of the Controlled Office

### B. Experiment Process

In this experiment, the independent variable is the indoor air temperature (22°C, 24°C, 26°C), illumination level (300lux, 550lux) and background noise level (40dBA, 70dBA). 12 researchers are recruited and divided into 6 sub-groups, where the researchers in each sub-group are in the similar research area. For each sub-group, the participants need to attend three sets of experiment and each last for 130 minutes to prevent the influence of the fatigue. During each set of experiment, the office condition is changed for 4 times and the temperature remains constant. Each participant needs to conduct their own research work during the 2-hour experiment. The participants can communicate with each other about their research during the

noisy condition, while they need to keep quiet during the quiet condition. The flow chart of each set of experiment is listed in Figure 2.

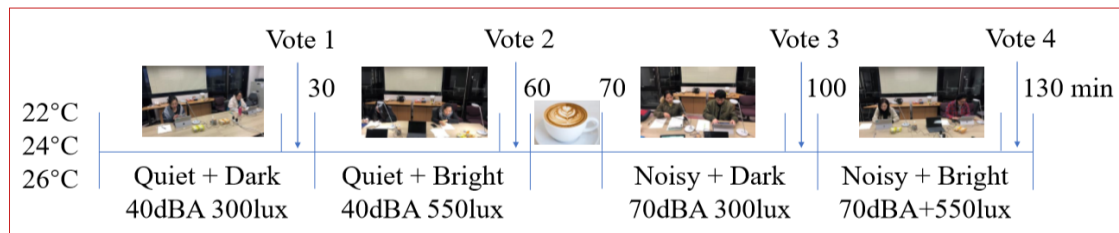


Figure 2: Experiment Procedure for each set of Experiment

### C. Physical Measurement and Questionnaire

Several physical environment parameters are recorded in the experiment process. For thermal comfort, indoor air temperature, relative humidity and air velocity are recorded. For IAQ part, the concentration of indoor carbon dioxide is recorded. For acoustic comfort part, average background noise level and reverberation time are recorded. And for visual comfort part, luminance of office desk is recorded.

A specially designed questionnaire is distributed to the sample population in order to assess their comfort level about the office. It includes three sections: general information, environment preference and environment sensation & satisfaction. 7-point ASHRAE scale is used for rating the occupants' sensation and satisfaction, while 3-point McIntyre scale is adopted for choosing the preference about the environment (Zomorodian Z.S., Tahsidoost M., Hafezi M., 2016). Check list is also used in the questionnaire for selecting the clothing insulation and recording their activity.

### D. Comparative Study

After data acquisition, the relevant environmental parameters are brought into three mathematical models to obtain the corresponding thermal index, IAQ index, acoustic index and visual index.

Meanwhile, Actual Mean Votes and Actual Percentage of Satisfaction (APs) are calculated by analyzing the questionnaire from subjective survey, where the APS value is used to represent the actual occupants' comfort. The comparative analysis is conducted with the help of the SPSS. Through comparing the calculated indexes and the corresponding APS value, the optimal mathematical model for research office is found out.

## Results and Discussion

### A. Physical Environment Parameters

Table 1 shows all the measured physical environment parameters for each environment condition, which includes the indoor air temperature, relative humidity, concentration of indoor carbon dioxide, illuminance level at the office desk and average background noise level. Because of the heat-insulating materials around the walls and window shading, no direct solar radiation was inputted and thus the mean

radiation temperature can be approximately equal to the indoor air temperature measured in the controlled office.

	Air Temperature (°C)	Relative Humidity (%)	CO2 (ppm)	Illuminance (lux)	Noise (dBA)
22+Dark+Quiet	21.8	20.3	680	289	43.3
22+Bright+Quiet	21.7	20.4	700	534	43.5
22+Dark+Noisy	21.8	20.3	693	295	72.1
22+Bright+Noisy	21.8	20.5	715	530	70.6
24+Dark+Quiet	24.5	21.5	743	301	42.3
24+Bright+Quiet	24.3	20.2	750	551	41
24+Dark+Noisy	24.3	20.1	770	303	70.8
24+Bright+Noisy	24.3	20.2	765	557	69.5
26+Dark+Quiet	25.8	19.3	690	288	40.8
26+Bright+Quiet	25.9	19.1	687	520	42.5
26+Dark+Noisy	26.2	19.2	715	293	68.9
26+Bright+Noisy	26.2	19.1	721	505	71.3

Table 1: Summary of Measured Physical Environment Parameters

### B. Factor Analysis of actual Satisfaction

The thermal satisfaction vote, IAQ satisfaction vote, visual satisfaction vote and acoustic satisfaction vote were used for factor analysis using SPSS, in order to calculate the weight coefficient of each IEQ index for actual results.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.623
Bartlett's Test of Sphericity	Approx. Chi-Square	50.389
	df	6
	Sig.	.000

Table 2: KMO and Bartlett's Test of Actual Satisfaction

The KMO value is 0.623, which falls into the range between 0.6 to 0.7. The significance value from Bartlett's test of sphericity is 0.000, less than 0.01, which means that the sample data is normally distributed. From the results of KMO and Bartlett's test, the entire sample set is appropriate for factor analysis and there exists a meaningful relationship among thermal, IAQ, visual and acoustic indexes.

From the communalities list, the extracted variance of four components are all above 0.4. This indicates that it is acceptable conduct factor analysis and majority information can be remained with acceptable loss.

According to Total Variance Explained List, it can be found that only one initial eigenvalue is larger than 1. Even though the first component only contributes to 43.374% to total variance, it is used to explain the entire data information.

	Initial	Extraction
Thermal_Satisfaction	1.000	.456
Visual_Satisfaction	1.000	.529
Acoustic_Satisfaction	1.000	.496
IAQ_Satisfaction	1.000	.658

Extraction Method: Principal Component Analysis.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.739	43.474	43.474	1.739	43.474	43.474
2	.968	24.201	67.674			
3	.698	17.439	85.113			
4	.595	14.887	100.000			

Extraction Method: Principal Component Analysis.

Table 3: Communalities List and Total Variance Explained List

The component score coefficient is obtained by normalization of the component matrix. And the weight of four indexes are obtained by unifying the component score coefficient (Table 4). Therefore, The weight coefficient for thermal index is 0.227, for visual index is 0.249, for acoustic index is 0.239 and for IAQ index is 0.284. Therefore, the actual IEQ equation is as Eq.16:

$$\begin{aligned}
 \text{Actual IEQ} = & 0.227 \times \text{Thermal Satisfaction} + 0.249 \times \text{Visual Satisfaction} \\
 & + 0.239 \times \text{Acoustic Satisfaction} \\
 & + 0.284 \times \text{IAQ satisfaction} \quad (\text{Eq. 16})
 \end{aligned}$$

	component matrix	component score coefficient	weight of index
Thermal	0.597	0.453	0.227
Visual	0.655	0.497	0.249
Acoustic	0.629	0.477	0.239
IAQ	0.747	0.566	0.284

Table 4: Component Matrix, Component Score Matrix and Weight of Indexes

### C. Comparison among Three Mathematical Models

According to the results in Table 5, it indicates that all three models are not accurate for the prediction of thermal satisfaction at low temperature. This is because the thermal satisfaction index in Wong's and Ncube's IEQ Model is developed according to Fanger's Thermal Comfort Model, without considering the influence of actual outdoor temperature on thermal satisfaction. In addition, Iordache's Model does not consider the effect of relative humidity on thermal satisfaction.

As for the prediction of the visual satisfaction, Iordache's IEQ model simulates well under low illuminance condition, while Ncube's IEQ model and Wong's IEQ model provide better simulation under high illuminance condition.

In the prediction of acoustic satisfaction, the deviation between the predicted results of Iordache's IEQ model and the actual results is small, while the other two IEQ models predict much higher satisfaction rate than the actual results.

For IAQ comfort, the experiment results indicate that all three models are not accurate in predicting the IAQ satisfaction. This is because none of the three models consider the influence of other variables on IAQ satisfaction. The results show that the participants give lower IAQ scores under high temperature and high noise conditions.

	Thermal				IAQ				Acoustic				Visual			
	Actual	Wong	Iordache	Ncube	Actual	Wong	Iordache	Ncube	Actual	Wong	Iordache	Ncube	Actual	Wong	Iordache	Ncube
22+Dark+Quiet	33.33	93.00	100.00	93.00	83.33	96.01	70.19	79.67	58.33	97.67	55.81	83.40	41.67	64.47	47.685	60.50
22+Bright+Quiet	41.67	92.00	100.00	92.00	83.33	95.81	70.19	79.23	58.33	97.61	55.15	83.00	66.67	87.68	88.11	71.73
22+Dark+Noisy	58.33	93.00	100.00	93.00	75.00	95.88	70.19	79.38	8.33	46.97	10.64	25.80	58.33	65.23	48.675	60.96
22+Bright+Noisy	66.67	93.00	100.00	93.00	66.67	95.65	70.19	78.90	16.67	51.99	15.63	28.80	66.67	87.44	87.45	71.62
24+Dark+Quiet	83.33	93.00	100.00	93.00	75.00	95.34	70.19	78.30	50.00	97.96	59.14	85.40	66.67	65.98	49.665	61.40
24+Bright+Quiet	83.33	94.00	100.00	94.00	75.00	95.26	70.19	78.16	66.67	98.28	63.47	88.00	66.67	88.67	90.915	72.17
24+Dark+Noisy	83.33	94.00	100.00	94.00	66.67	95.03	70.19	77.74	8.33	51.32	14.97	28.40	66.67	66.23	49.995	61.54
24+Bright+Noisy	91.67	94.00	100.00	94.00	75.00	95.09	70.19	77.84	16.67	55.65	19.29	31.00	66.67	89.00	91.905	72.33
26+Dark+Quiet	66.67	88.00	62.89	88.00	58.33	95.91	70.19	79.45	66.67	98.33	64.14	88.40	66.67	64.34	47.52	60.42
26+Bright+Quiet	58.33	87.00	60.04	87.00	66.67	95.94	70.19	79.52	66.67	97.91	58.48	85.00	75.00	86.81	85.8	71.34
26+Dark+Noisy	66.67	85.00	51.47	85.00	58.33	95.65	70.19	78.90	16.67	57.63	21.29	32.20	58.33	64.97	48.345	60.80
26+Bright+Noisy	66.67	85.00	51.47	85.00	58.33	95.58	70.19	78.77	16.67	49.65	13.30	27.40	66.67	85.83	83.325	70.90

Table 5: Summary of the Satisfaction of Actual Results and 3 IEQ Models

According to the T-test comparison (Table 6), there is no statistical difference between the prediction by Iordache’s Model and the actual IAQ satisfaction, acoustic satisfaction and visual satisfaction. However, there is statistical difference between the prediction of thermal satisfaction and the actual statistical results, and the prediction of IEQ is affected.

The results also showed that Iordache’s IEQ Model is best-fit comfort prediction for research office by comparing the calculated indexes and the corresponding APS. However, Iordache’s IEQ Model still needs to be adjusted. First of all, the equation of each comfort index only consider the physical environmental parameters in its own aspects, without considering the impart of other variables. Secondly, the weight of all four comfort indexes should be adjusted according to different types of room usages.

	t	df	Sig. (2-tailed)	IEQ				
				Actual	Wong	Iordache	Ncube	
Actual_Thermal - Iordache_Thermal	-2.445	11	0.033	55.55	91.25	68.42	80.34	
Actual_IAQ - Iordache_IAQ	-0.020	11	0.985	63.67	95.81	78.36	81.33	
Actual_Acoustic - Iordache_Acoustic	-0.075	11	0.941	51.06	49.06	57.37	69.54	
Actual_Visual - Iordache_Visual	-0.860	11	0.408	54.65	73.32	68.32	71.45	
Actual_IEQ - Iordache_IEQ	-3.119	11	0.010	68.77	91.54	69.75	82.16	
				24+Bright+Quiet	72.75	96.42	81.14	83.41
				24+Dark+Noisy	56.44	55.61	58.79	71.29
				24+Bright+Noisy	62.69	78.18	70.35	72.37
				26+Dark+Quiet	64.23	88.70	61.18	73.06
				26+Bright+Quiet	66.78	94.34	68.62	72.17
				26+Dark+Noisy	50.21	48.99	47.82	59.91
				26+Bright+Noisy	52.28	58.66	54.57	58.74

\* Correlation is significant at 0.05 level (2-tailed)

Table 6: Comparison Result between Iordache’s IEQ Model and Actual Result

#### D. Correlation Analysis

In the questionnaire, thermal satisfaction, IAQ satisfaction, acoustic satisfaction and visual satisfaction are scored from 1 to 7, where 1 represents total dissatisfaction and 7 represents total satisfaction. For the correlation analysis, the thermal satisfaction vote, IAQ satisfaction vote, visual satisfaction vote and acoustic satisfaction vote are analyzed using SPSS and the total sample size is 144. The results are shown in Table 7 and Table 8.

	Mean	Std. Deviation	N
Thermal_Satisfaction	3.94	1.102	144
IAQ_Satisfaction	4.14	1.227	144
Visual_Satisfaction	4.04	1.384	144
Acoustic_Satisfaction	3.30	1.449	144

Table 7: Average Mean Vote for Thermal, IAQ, Visual and Acoustic Satisfaction

		Thermal_Satisfaction	IAQ_Satisfaction	Visual_Satisfaction	Acoustic_Satisfaction
Thermal_Satisfaction	Pearson Correlation	1	.223**	.300**	.124
	Sig. (2-tailed)		.007	.000	.047
	N	144	144	144	144
IAQ_Satisfaction	Pearson Correlation	.223**	1	.273**	.382**
	Sig. (2-tailed)	.007		.001	.000
	N	144	144	144	144
Visual_Satisfaction	Pearson Correlation	.300**	.273**	1	.161
	Sig. (2-tailed)	.000	.001		.034
	N	144	144	144	144
Acoustic_Satisfaction	Pearson Correlation	.124	.382**	.161	1
	Sig. (2-tailed)	.047	.000	.034	
	N	144	144	144	144

\*\* Correlation is significant at the 0.01 level (2-tailed).

Table 8: Correlation Analysis among Thermal, IAQ, Visual and Acoustic Satisfaction

According to Table 7, the mean value of thermal satisfaction vote is 3.94 with standard derivation of 1.102. For IAQ comfort, the mean value of IAQ satisfaction vote is 4.14 with standard derivation of 1.227. As for Visual comfort, the mean value of visual satisfaction is 4.04 with standard derivation of 1.384. And for acoustic comfort, the mean value of acoustic satisfaction is 3.30 with standard derivation of 1.449.

The result of correlation analysis is listed in Table 8. The results showed that the Pearson correlation factor between thermal and IAQ satisfaction is 0.223, between thermal and acoustic satisfaction is 0.124, between IAQ and visual satisfaction is 0.273 and between visual and acoustic satisfaction is 0.161, which all fall into the range of 0.1 to 0.3. The significance value of the above four pairs are all below 0.05. Therefore, there is weak correlation for the above four pairs under 95% confidence level and correlation is positive.

As for the pair of thermal and visual comfort, the Pearson correlation factor is 0.300. For the pair of IAQ and acoustic comfort, the Pearson correlation factor is 0.382. They both fall into the range of 0.3 to 0.5. Both significance value are less than 0.05, which means the correlation between IAQ and acoustic as well as between IAQ and acoustic are moderate and positive under 95% confidence level.

From the results of correlation analysis, there is positive correlation among thermal satisfaction, IAQ satisfaction, visual satisfaction and acoustic satisfaction. The correlation is from weak to moderate. This shows that when developing the mathematical model for individual index, it needs to consider the influence of all physical environment parameters from all four aspects. This is also an important reason why the three mathematical model has deviation from the actual results.

## Conclusion

The results indicated that there is positive inner relationship among thermal, IAQ, visual and acoustic satisfaction. However, the correlation is from weak moderate. The results also showed that Iordache's IEQ Model is best-fit comfort prediction model for research office by comparing the calculated indexes and the corresponding APS through the SPSS. However, Iordache's IEQ Model still needs to be adjusted. First of all, the equation of each comfort index only considers the physical environment parameters in its own aspect, without considering the impart of other variables.

Secondly, the weight of all four comfort indexes should be adjusted according to different types of room usages.



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## *Communicating Sustainability*

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### **Abstract**

This paper examines contemporary mediated communication on sustainability, encompassing strategic messaging and news. Using case study analysis, it explores how information about sustainability is being communicated by a range of actors—from environmental non-profits to Fortune 500 companies—and how those messages and stories flow through mainstream and social media. Situated in a political climate where tweets that cast doubt compete with science, how do citizens and consumers navigate this information, and what is its potential impact? The concept of sustainability guiding this work draws from the UN document, Our Common Future, which defines it as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs.” Adopted by myriad organizations, the concept of sustainability extends beyond development to include a range of practices—from natural resource stewardship to supporting human health and economic vitality.

Keywords: sustainability communication, framing, influencers, corporate social responsibility, plant-based, climate change

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## Introduction

When *Time* magazine named climate activist Greta Thunberg its 2019 Person of the Year, mediated communication surrounding the announcement spread swiftly, far beyond sustainability circles. News organizations worldwide—from the Associated Press to *Zeit*—covered the story, along with Thunberg’s appearance at the COP25 summit in Madrid, where she castigated world leaders for their inaction to address climate change (Jordans, 2019; Zeit, 2019). On social media, Donald Trump wasted no time tweeting criticism of the 16-year-old, calling the *Time* award “ridiculous,” and saying, “Greta must work on her Anger Management problem,” should “chill” and see a movie with a friend (Trump, 2019).

With her acerbic wit, Thunberg mocked Trump by updating her Twitter profile, “@GretaThunberg A teenager working on her anger management problem. Currently chilling and watching a good old fashioned movie with a friend” (Thunberg, 2019). The sparring jumped from Twitter to mainstream news and entertainment media, and even attracted Michelle Obama’s support for Thunberg: “@GretaThunberg, don’t let anyone dim your light” (Obama, 2019).

This example illustrates contemporary mediated message flow. Tweets and headlines, videos and photos—flowing from mainstream to social media, and then back again. The stories can start with one person’s activism—like Thunberg’s—but can also begin on a corporate website with strategic messaging setting the agenda. Situated in a political climate where tweets that cast doubt compete with science, how do citizens and consumers navigate this information, and what is its potential impact?

This paper explores these questions through a two-phase study, beginning with an examination of corporate sustainability messaging. The concept of framing and the role of influencers guide the research, exploring how messages and stories about sustainability flow through mainstream and social media. The future of food emerges as a significant area of concern, and the second phase of the study addresses mediated messaging in this realm.

## Background

The concept of sustainability guiding this work draws from the UN document, *Our Common Future*, which defines it as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 1987). Adopted by myriad organizations, this definition extends beyond development to include a range of practices—from natural resource stewardship to supporting human health and economic vitality. Among those institutions are global companies.

Often termed as corporate social responsibility (CSR), Reilly and Larya (2018) note that CSR is closely related to sustainability and that the concepts are frequently used interchangeably. Ott, Wang, and Bortree (2016) analyzed 300 corporate, nonprofit, and

university websites for sustainability content and found more than half of the corporations included a sustainability landing page on their sites. Communicating a commitment to sustainability can enhance a company's image (Parguel, Benoit-Moreau, and Larceneux, F. (2011) and reputation (Herzig and Schaltegger, 2011). It can also fuel sales and drive growth, as Kronthal-Sacco and Whelan found in their review of consumer purchasing from 2013 to 2018. "Products marketed as sustainable are driving not only product but also total category/market growth" (2019, p. 4). The presence of sustainability messaging on corporate websites and in mainstream and social media merits further examination and is addressed in this study.

## **Framing**

From network news coverage of old-growth forests (Liebler and Bendix, 1996) to polar bears as icons for climate change (Born, 2019), framing has guided decades of research concerning communication and the environment. Defined for the present study, framing concerns "...variations in how a given piece of information is being presented..." (Scheufele and Iyengar 2014, 1). As Entman expressed, "Frames call attention to some aspects of reality while obscuring other elements, which might lead audiences to have different reactions" (1993, 55).

Reports of environmental and climate disasters are often framed through the lens of sensationalism and despair. In late fall of 2019, Sydney, Australia braced for "unprecedented and catastrophic fire danger," as flooding in Venice brought the city "to its knees" (Rabe, Clun, and Chrysanthos, 2019; Povoledo, 2019). In the same week, an "Arctic blast" shattered hundreds of temperature records across the United States (Holcombe and Yan, 2019).

Inflammatory language and photos illustrating the devastation can convey a sense of hopelessness against out-of-control forces. In recent years, public perception of the importance of climate change has intensified. Nine in ten Americans now "think the earth is experiencing climate change in some way" (DePinto, Backus, and Salvanto, 2019). Growing numbers consider climate change to be a crisis, and they increasingly want the government to take action—from 59 percent in 2015 to 76 percent in 2019 (Washington Post-Kaiser, 2019).

According to Pan and Kosicki (1993), "Choices of words and their organization into news stories are not trivial matters. They hold great power in setting the context for debate, defining issues under consideration, summoning a variety of mental representations, and providing the basic tools to discuss the issues at hand" (70). Framing can relate to our perceptions of issues, such as the severity of the problem and whom to blame. It can also help identify solutions, and motivate action. Feldman and Hart (2018) found that news stories that included information about actions to address climate change "...increased hope, while decreasing fear, relative to a story that only discussed climate impacts" (p. 598). Readers reported feeling less negative after reading news containing an effective solution to a social problem (McIntyre, 2019).

Yet, conflict frames are prevalent in news stories. And journalists appear to play a role in that framing. Bartholomé, Lecheler, and de Vreese found that “Journalists do not merely disseminate conflict frames put forward by political actors, but actively shape when and how conflict appears in the news” (2015, p. 451). Parks identified a focus on negativity in more than a century of journalism textbooks, reconstructing their emphasis and rationalization of bad news and conflict (2019).

Gain and loss frames are also evident in mediated communication. A meta-analysis of more than 30 years of literature on these frames found gain frames related to positive emotions and loss frames, negative emotions (Nabi, Walter, Oshidary, Endacott, Love-Nichols, Lew, and Aune, 2019).

Fear and hope have also been studied with regard to climate change and advocacy behavior. Evoking fear, followed by hope, “had the strongest positive influence on advocacy behavior” (Nabi, Gustafson, & Jensen, 2018, p. 460).

Messaging surrounding sustainability can create doubt, whether unintentionally, or purposefully. In January 2018, when much of the United States suffered record low temperatures and winter storms, Donald Trump tweeted, “Amazing how big this system is. Wouldn’t be bad to have a little of that good old fashioned Global Warming right now!” (2018). In *Merchants of Doubt*, historians Naomi Oreskes and Erik Conway detail efforts to discredit science and create doubt—from the tobacco industry and smoking to fossil fuel and climate change (McKie, 2010).

## **Influencers**

The influence of celebrities on public perceptions and behavior has long been a staple of promotional messaging (Mowen and Brown, 1981). From athletes to film stars, the attractive and admired have endorsed products in ads and addressed social issues of choice. This continues today with online media, magnified through social networks and augmented by additional influencers outside the mainstream media spotlight. Business publication, *Inc.*, published a prediction that a major impact on consumer and employee expectations for businesses would follow *Time* magazine naming Greta Thunberg person of the year (Kline, 2019).

A growing body of research examines social media influencers and corporate messaging, from developing models for maximizing influence (More and Lingam, 2019), to celebrity endorsement of veganism (Phua, Jin, and Kim, 2019). For this study, influencers include celebrities in sports and entertainment, as well as activists, such as Greta Thunberg, with a presence on social media.

## **Methods**

The first phase of the current study examined sustainability content on company websites for the top 100 corporations of the 2019 Fortune 500 (Fortune, 2019). How, and where, did they position sustainability on their websites? Was it showcased or easily navigated

from a tab or link on the landing page? Was it found under “values” or “responsibility,” or only evident if searched for? This approach builds on Ott, Wang, and Bortree (2016), who analyzed 300 corporate, nonprofit, and university websites for sustainability content.

Companies that showcased sustainability on their websites were then further analyzed using a qualitative approach. What was being promoted, and how was it presented, both on the corporate website and on social media? How were news media covering the companies and their promoted sustainability initiatives, as well as other potentially negative news about the companies? Finally, this phase identified further cases for analysis. A focus on food and sustainability emerged—in particular, alternative protein.

Informed by Phase 1 and the focus on food and sustainability that emerged, Phase 2 brought in additional companies for analysis—Beyond Meat and Impossible Foods. It examined message content and flow for these businesses vis-à-vis framing and influencers. Specific frames included gain, fear, conflict, and doubt. Corporate messaging, news coverage, and social media were assessed during 2019. The tool, twXplorer (2013), was used to make a random selection of tweets using search terms that reflected various frames—“plant-based meat” and “fake meat.” Google News was used to find additional news articles containing the search terms.

### Findings and discussion

The Phase 1 analysis of the top 100 corporations in the 2019 Fortune 500 found that 93 percent included sustainability content on their websites, as noted in Figure 1, below. More than half made that content easily accessible, either through a readily visible tab or a link on the main page. About ten percent showcased sustainability as the first thing a visitor encounters when opening the site, along with full-screen photos and engaging text. Of those, a third are food-related companies. The others, by the nature of their business, are inherently related to a potentially negative impact on the environment including contributing to climate change. They include fossil fuels, auto manufacturing, online retail shipping, chemicals, and a bank that funds these industries.

Phase 1 findings	
Sustainability content	Percent of sites
Showcased on main page	09
Tab, link on main page	14
Under other tab directly Corporate responsibility, Our values	31
Under other tab indirectly	20
Not evident, searchable	19
Not found	07

Figure 1

One might surmise that the companies placing sustainability messaging in a prominent or an easy-to-access location on their site have achieved goals or have specific programs in place to combat climate change. Another possibility is offering an antidote to negative news about the company.

ExxonMobil's corporate site opened to a full-screen visual of a tree, blue sky and green grass—front and center—with text reading, “Pushing forward on advanced Carbon Capture research.” Clicking on a bright red box linked to a press release announcing the partnership with FuelCell Energy, Inc., and noting “ExxonMobil exploring opportunities to deploy technology within its operations” (2019).

In addition to its news release, the company was running ads on NPR at that time, promoting the technology. Journalist Alexander Kaufman (2019) raised a red flag about the ads, and wrote, “As someone who, uh, consumes a lot of journalism, the uptick in ad buys is glaring. Can't help but think it's a response to mounting litigation and climate protests.” Economic anthropologist Jason Hickel called the ads “denialism” in his tweet, adding, “The solution to climate breakdown is to delete fossil fuel companies like Exxon” (2019).

Around the same time, Exxon was in court in New York, fighting a climate change lawsuit. Massachusetts had also just filed suit against the company for deceiving the public through its media messaging (Malo, 2019). *Axios* reported this as “Oil industry to Trump: Carbon capture needs way more subsidies” (Harder, 2019).

DuPont also showcased its sustainability efforts prominently, albeit with ambiguous language touting innovative contributions: “Through our science, our people and our communities, DuPont pledges to constantly improve and innovate more sustainable ways of contributing” (2019). The background photo of a cityscape included a river in the scene, which may have been ill-fated, considering that at the time the company was under fire for water contamination. Note, however, that a new photo soon replaced the city scene, instead featuring happy children at play in a living room setting (DuPont, 2020).

At the time of this analysis, the film, *Dark Waters*, was playing in U.S. theaters. The movie centers on a chemical contamination lawsuit against DuPont (Rosa, 2019). The chemical, perfluorooctanoic acid (PFOA) had been used in DuPont's coatings for decades, including the non-stick cookware coating Teflon (American Cancer Society, 2016). According to the Centers for Disease Control (CDC), PFOA has been found in bodies of water and persists in the environment. The CDC reports that human exposure is widespread, and that the chemical “can remain in the body for long periods of time” (2017).

Amidst the lawsuits and attention from the film, the company announced its merger with International Flavors and Fragrances, IFF, a \$26 billion deal that “bets on meatless future” (Meyer, Rocco, and Beesley, 2019). CNBC reported that the merger would benefit meat alternatives. “DuPont produces the plant-based proteins used in meatless alternatives, while IFF creates the flavors and colors” (Lucas, 2019).



Food and sustainability appear prominently on another Fortune 100 website, Pepsico (2019). Known for soft drinks and chips, this snack food giant showcases a verdant field on its landing page. A man wearing jeans and a polo shirt (perhaps a potato farmer) is standing front and center holding up a bag of Lays classic chips. Text highlights the company's 2018 Sustainability Report, with easy navigation to the details. A second picture pane shows beverage packaging, with their 2025 goal of reducing virgin plastic and single-use bottles by 35 percent.

The most popular video on Pepsico's YouTube page is a joint effort with the nonprofit CARE, called "Closing the Crop Gap" (Pepsico, 2019a). Lauded by PRNEWS with a Platinum PR Award, for bringing "global attention to the issue of gender inequality in farming while also increasing awareness of the brand's involvement with sustainable agriculture and commitment to empowering women" (PRNEWS, 2019).

Two other food companies in Fortune's top 100 showcase sustainability on their websites, both with alternative protein. From a plant-based burger photo on Archer Daniels Midland's (2019) page, to the term "sustainable protein" on poultry producer Tyson's (2019) site, companies are highlighting the role of plants in meeting sustainability goals. This emphasis on alternative protein in sustainability for both food and non-food companies merits further exploration, and leads to Phase 2 of this research.

### **Additional background for Phase 2: Animal agriculture, resource use, and climate change**

During the 2019 U.N. Climate Summit in Madrid, a group of scientists published a call to action in *The Lancet Planetary Health* to reduce livestock production worldwide. "If the livestock sector were to continue with business as usual, this sector alone would account for 49% of the emissions budget for 1.5°C by 2030..." (Harwatt, Ripple, Chaudhary, Betts, and Hayek, 2019). The previous year, the World Resources Institute linked food production to climate change in its report, "Creating a Sustainable Food Future," recommending reducing meat consumption among its proposed solutions (Searchinger, Waite, Hanson, and Ranganathan, 2018).

Nearly a year later, as Donald Trump moved the United States closer to withdrawing from the Paris Agreement, The World Resources Institute and its experts continued to be cited in major news media. In its story, "Are my hamburgers hurting the planet?" *The Washington Post* referenced the WRI report, writing, "Beef requires about twice as much land per gram of protein as chicken and pork, and 20 times as much land as the equivalent amount of protein from beans (Kaplan, 2019).

Informed by the emphasis of alternative protein in both food, and non-food corporations in Phase 1, the Phase 2 analysis focused on the major plant-based meat companies Beyond Meat and Impossible Foods. In 2019, Beyond Meat went public, and its stock soared. Its products are now in more than 58,000 grocery stores, restaurants, and other locations (Beyond Meat, 2019). The company displays its mission prominently on its website with visual icons for each value. "By shifting from animal to plant-based meat,

we can address four growing global issues: human health, climate change, constraints on natural resources, and animal welfare” (Beyond Meat, 2019). It also cites a University of Michigan study that measured the environmental impact of a quarter-pound beef burger to the Beyond Burger. It reports “99% less water,” “93% less land,” “90% fewer GHGE” (Greenhouse Gas Emissions), and “46% less energy” (Beyond Meat, 2019).

The mission stated on Impossible Foods’ website is to “...make the global food system truly sustainable by eliminating the need to make food from animals. Why? Animal agriculture uses a tremendous amount of the world's natural resources” (Impossible Foods, 2019).

Both mission statements employ a gain frame, weaving a sustainable food future into company values. The alternative meat products are presented as the solution—conserving resources, heading off climate change, and addressing human health and animal welfare. The gain frame flows through mainstream and social media, with stories and posts conveying those values as well as another gain—investment and profit.

Framing gain was evident in financial news as well as mainstream and social media in spring 2019, with Beyond Meat’s public stock offering. The win for investors and businesses was conveyed in headlines, such as *CNN*’s “Beyond Meat soars 163% in market debut” (Wiener-Bronner, 2019), and, “Investors Find More Reasons To Back Plant-Based Meat Brands,” in *Forbes* (Forgrieve, 2019).

The media framed another gain in their messaging surrounding these alternative meat companies—addressing climate change. A story in *The New Yorker* referenced the WRI report, “Creating a Sustainable Food Future,” quoting its author, who said, “Giving up all beef would be the most effective thing we could do for the planet.” But even a three-fourths reduction, he calculated, would reduce greenhouse gases globally by about 20 percent” (Friend, 2019).

Conserving resources is yet another gain frame communicated in mediated messages about alternative meat. A story on NPR’s website notes that, “Beef production uses about 20 times the land and emits 20 times the emissions compared to producing beans, per gram of protein” (Aubrey, 2019).

Resonating with the values set forth on Beyond Meat’s website, animal welfare is framed as a gain in stories and social media posts about meat alternatives like Beyond and Impossible burgers. The *Veg News* story “Popularity of Impossible Foods and Beyond Meat is saving 250,000 animals annually” includes a photo of a wide-eyed calf looking into the camera (Starostinetskaya, 2019).

The language associated with stories about these products appears related to story frame. For example, consider the terms “plant-based” versus “fake meat.” A story reported by *The Christian Science Monitor* used “plant-based” in its headline and conveyed a tone that tended to normalize meat substitutes: “Beyond vegans: Plant-based ‘meat’ goes mainstream from KFC to Dunkin’” (Belsie, 2019).

To further explore this concept, the research tool, twXplorer (2013), was used to capture a random snapshot of 500 tweets using the search term “plant-based meat,” on December 27, 2019. The animal welfare story noted above appeared among the results, as well as a piece about reducing emissions to benefit the planet with plant-based meals (One Green Planet, 2019).

Conversely, the term “fake meat” produced stories and tweets conveying fear rather than gain. For example, the headline, “Doctor: Burger King’s Impossible Burger has 18-million times more estrogen than regular Whopper,” claiming it “may cause men to grow breasts” (Pappert, 2019). Researching the source revealed, however, that the doctor cited was actually a veterinarian writing for *Tri-State Livestock News* (Stangle, 2019). Also note that the headline was subsequently changed, but that the claims remained in the article and the hyperlink verbiage (Pappert, 2020).

Searching for “fake meat” on Google News returned alarmist ads created by a PR group supported by the meat industry—the Center for Consumer Freedom. Its fear frame plays on chemicals in processed food and likens the product to dog food (2019).

The search term “fake meat” also returned stories driven by conflict—pitting the beef industry against alternatives—as can be seen in this *Wall Street Journal* piece, “America’s Cattle Ranchers are Fighting Back Against Fake Meat” (Bunge and Haddon, 2019). A federal judge recently blocked an Arkansas law that would have restricted the word “meat” in plant-based packaging (ACLU, 2019). However, the fight continues, as a U.S. senator introduced a bill called the Real Meat Act, to restrict labeling of plant-based meat (Fischer, 2019).

A *Politico* story reports that only two U.S. studies on agriculture and climate change have been conducted since Trump took office—both positive to the beef industry (Bottemiller Evich, 2019). The National Cattlemen's Beef Association funded one of them, further research reveals (NCBA, 2019).

The conflict frame is also evident in a *Today Show* story, “There’s a growing backlash against the rise of fake meat—here’s why” (Jackson, 2019). The story raises concerns about health and nutrition of Beyond and Impossible burgers. The “backlash” approach is also seen in this *Vox* story that addresses the processed nature of alternative meat (Piper, 2019). But, instead of using a critical tone, the piece presents evidence to debunk the critics’ arguments against the plant-based products.

However, conflict frames can introduce doubt—as we see in this story from *The New York Times*: “Fake Meat vs. Real Meat. Millennials are gobbling down plant-based burgers, prompting meat producers to question the health benefits of “ultra-processed imitations” (O’Connor, 2019). The conflict presented in the story includes describing, and linking to, the ads from the Center for Consumer Freedom discussed above, with the term “ultra processed imitations.” Impossible Foods is quoted in the story, calling the campaign “fear mongering.” While the piece includes responses to the attacks, its construction places the criticism first, which introduces a doubt-thread that flows

throughout the text. The beef industry's claims and other criticism are addressed via nutritional comparisons with raw beef patties, a Harvard doctor's perspective, and lawmakers' attempts to restrict labeling plant-based products as "meat." Transitions in the writing also reflect doubt: "But are plant-based meats really better for you than meat?" and "Patients of his told him they were confused about the health benefits of plant-based beef substitutes..." (O'Connor, 2019).

### **Influencers and plant-based meat**

Amidst the fear, conflict, and doubt, a number of influencers have entered the space with support for a plant-based lifestyle. Beyond Meat's Twitter and YouTube channels feature rapper Snoop Dogg serving up Beyond Sausage sandwiches at Dunkin' Donuts (Beyond Meat, 2019a). Beyond Meat's website highlights the documentary, "The Game Changers," noting, "Elite athletes are a testament to the power of a plant-based lifestyle. The Game Changers is a revolutionary new film about meat, protein, and strength" (Beyond Meat, 2019).

HipHop artists Wutang eat Impossible sliders in the most-watched video posted on Impossible's YouTube channel (Impossible YouTube, 2019). Other celebrities supporting plant-based living include Beyoncé and Jay-Z. They wrote, in the introduction to the book, *Greenprint*, "We want to challenge you, as we challenge ourselves, to move toward plant-based foods. We all have a responsibility to stand up for our health and the health of the planet" (2019, p. 9).

Ellen DeGeneres urged people to eat less meat in a video with nearly 5-million views on her Instagram. "It's a great idea for the planet, it's a great idea for your health, it's a great idea for the animals' health—so eat less meat" (2019).

### **Conclusions**

This two-phase study found that 93 percent of the top 100 companies of the 2019 Fortune 500 included sustainability content on their websites. Of the nine that showcased sustainability on their front pages, at least two were concurrently involved in legal action or negative news about their companies and the environment, with public and media perception calling into question their messaging.

A focus on food and alternative protein emerged among companies that promoted sustainability prominently on their websites. This emphasis led to additional analysis in Phase 2, examining two major plant-based meat companies, Beyond Meat and Impossible Foods. This qualitative look identified the gain frame in messaging on company websites, mainstream news, and social media. Use of the term "fake meat" appeared related to conflict, fear, and doubt. That included messaging disguised as consumer freedom that readily flows through social and news platforms. Conversely, the term "plant-based meat" aligned with solutions and optimism. Influencers were found to be fueling the plant-based message, which has made its way from corporations to consumers.

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***Public Perceptions about Waste and Recycling: “Don’t Consume Less, Just Recycle More.”***

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**Abstract**

As waste generation increases around the world, associated sustainability challenges with waste management are also escalating (Kaza et al., 2018). What do Americans think are effective personal strategies they can take to reduce waste, and what perceptions do they have about the systems in place for managing waste, in particular the recycling system? In a national online survey, 863 participants reported their perceptions about waste behaviors and the recycling system. When asked about what they and other Americans could do to reduce landfill waste, most participants cited disposal behaviors (e.g., recycling) rather than source reduction behaviors (e.g., buying less). This contrasts with EPA and UN waste management recommendations to minimize impact of waste focusing on reduced waste generation as a primary strategy. However, when thinking about reducing plastic waste in the ocean, participants aligned their recommendations with experts by citing source reduction behaviors more frequently than disposal actions. Addressing our global waste problem will require a dual approach focusing on significant reduction in waste generation (i.e., the production and consumption of many material goods) while simultaneously improving circular recycling strategies. The misperceptions revealed in this research indicates the need for better public understanding about what happens to waste after it is thrown away and an increased emphasis on waste reduction strategies.

Keywords: sustainable consumption, waste, recycling, perceptions, heuristics

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## Introduction

As global material consumption keeps increasing beyond sustainable levels, humans are generating more waste than ever before and yet recycling less (Ellen MacArthur Foundation, 2019; Kaza et al., 2018). Waste generation and disposal has severe upstream and downstream consequences. Producing goods that are then thrown away is resource and climate intensive, from the environmental and social degradation of sites where virgin materials are extracted to the energy used in production and transport of those goods (Ellen MacArthur Foundation, 2019; Hossain et al., 2016; US EPA, 2013a). When those goods become waste and are disposed, different waste management solutions such as simply landfilling or converting the waste-to-energy have various negative downstream effects (US EPA, 2016). Evidence of our waste crisis abounds – from predictions that plastic will outnumber fish in the oceans by 2050 (World Economic Forum & Ellen MacArthur Foundation, 2016), evidence that humans are consuming tens of thousands of microplastic particles every year with unknown health outcomes (Cox et al., 2019), and the acceleration of climate change (Ackerman, 2000). Given these widespread problems associated with waste, what do people think are effective personal actions they can take to reduce waste?

Experts recommend minimizing waste by focusing on source reduction and reuse (Hyman et al., 2015; US EPA, 2015); however, popular efforts have focused primarily on the third ‘R’ – recycling – rather than reduce or reuse as a sustainable waste management strategy (Jaeger, 2018). Despite the widespread acceptance that recycling has as an environmentally friendly option and its advantages when compared to other disposal strategies (e.g., landfilling, incinerating), recycling as currently practiced has several problems. Global recycling rates are low – an estimated 9% of all plastics ever produced have been recycled (Geyer et al., 2017) and the U.S. recycled only 25% of all municipal solid waste generated in 2017 (US EPA, 2017). Not all materials (most notably, plastic) can be recycled in perpetuity and often require addition of virgin materials in the recycling process (Sedeghat, 2018). In the U.S., recycling programs vary considerably across the country. This lack of standardization combined with individuals’ lack of knowledge and motivation leads to high rates of contamination (i.e., non-recyclable items being put in the recycling stream; Bell, 2018). Further complicating the recycling landscape in the U.S. and many other developed countries, in 2018 China passed a new policy strictly limiting the amount of recyclable materials they would import. As the U.S. used to send more recyclable materials to China than anywhere else (National Waste and Recycling Association, 2019; Semuels, 2019), this change has resulted in several municipalities increasing costs of recycling programs, shutting programs down, reducing the list of acceptable items, and incinerating and landfilling recyclables (Corkery, 2019; Lieber, 2019; Semuels, 2019).

Addressing our global waste problem will require a dual approach focusing on significant reduction in waste generation (i.e., the production and consumption of many material goods) while simultaneously improving circular strategies to recycle items for multiple additional uses of their materials. Inspired by Attari et al. (2010)’s examination of public perceptions of energy consumption and savings and Attari (2014)’s study on perceptions of water use, this research examines how people perceive waste generation and disposal. When thinking about reducing waste, do people think about disposal strategies (e.g., recycling, composting) or expert-

recommended reduction strategies (e.g., buying less, reuse)? As poor recycling behaviors inhibit high rates of resource recovery when generated waste is being disposed, what misperceptions do people have about the recycling system? In studying water (Attari, 2014) and energy (Attari et al., 2010), the authors found various misperceptions the public has about those respective systems. Similarly, we expected participants to misperceive key aspects of waste and recycling systems.

## Methods

**Participants** 995 participants were recruited and completed a survey via Amazon Mechanical Turk (MTurk, [www.mturk.com](http://www.mturk.com)). Participants' responses were excluded if there was evidence the survey was being filled in by a bot, the participant was not proficient in English, or it was evident that the participant took the survey more than once from different accounts. After exclusions, 863 participants remained in our sample. Participants were compensated \$4 dollars in their MTurk accounts. Mean age was 37.6 years ( $SD = 11.09$ ) and 46.1% (391) of participants were female. Median income was between \$50,000 – \$79,999 and the majority of participants had a college degree or higher (554, 65.3%). Participants lived in 48 states and the District of Columbia. Politically, 48.9% (415) indicated they were liberal, 30.6% (259) indicated they were conservative, and 20.5% (174) indicated they were politically moderate.

**Survey Materials** This survey was modeled after Attari (2014)'s questionnaire of individual perceptions of water use. At the beginning of the survey, participants were asked four open-ended questions in randomized order. These questions were about the most effective thing they and other Americans could do to reduce landfill waste and reduce plastic pollution in the oceans. Participants then estimated how much waste they, and in a second question, the average American, generates on a weekly basis, and of those estimates what percentage of that waste is thrown away, recycled, and composted. These questions were presented in a random order.

Next, we had several measures to assess participants' knowledge of the recycling system. First, they estimated how long they thought it takes for certain items (a plastic water bottle, plastic bag, glass bottle, and aluminum can) to be made into a new product from the time they are collected when recycled. We then asked participants to estimate the percent of plastic that has been recycled or has ended up in landfills/the natural environment out of all the plastic that has ever been produced. Participants indicated how much they (and the average American) know about recycling on a Likert scale from 1 ("None at all") to 5 ("A great deal"). To assess actual recycling knowledge, participants then indicated whether they thought a series of 18 items (e.g., paper coffee cup, waxed beverage carton, aluminum can, used diaper) were "recyclable at almost all recycling facilities", "recyclable, but only at select recycling facilities", or "not recyclable anywhere." These categories were chosen because what is recyclable varies considerably from one location to another. For example, aluminum cans are recyclable almost everywhere, items like waxed beverage cartons and coffee cups are accepted in some locations and not in others, and used diapers or paper towels are not recyclable anywhere in the U.S. Recyclability of each item was assessed using the website Earth911 ([earth911.com](http://earth911.com))'s recycling guide, a website that the EPA links to on their "How Do I Recycle?" page for users to find recycling resources and locations (US EPA, 2013b).

We also asked participants to indicate the extent to which they engaged in behaviors that can contaminate recycling. These included ‘wishcycling’ behaviors (i.e., placing non-recyclable items into recycling containers without knowing whether or not they are recyclable; Robinson, 2018). Participants indicated how often they (and the average American) put something in the recycling that they are not sure is recyclable on a Likert scale from 1 (“Never”) to 5 (“Very often”). To assess beliefs about contamination behaviors, we asked participants to indicate the extent to which they agreed with statements on a Likert scale from 1 (“Strongly disagree”) to 5 (“Strongly agree”). For example, “If someone does not know whether or not something is recyclable, it is better for them to throw it away than to put it in a recycling bin” or “When recycling, it is not a big deal if items have some food residue left on them.”

Participants then filled out a series of questions to assess whether or not they considered waste when making purchasing decisions. Sample questions include: “How often do you take into account how you will dispose of an item when you purchase it?” and “How often do you decide NOT to purchase something because you are concerned about creating waste?” which participants answered on a scale from 1 (“Never”) to 5 (“Very often”). We also asked participants whether or not they buy products specifically because they are made out of recycled materials, and, if so, what kinds of products they buy for this reason. Lastly, participants responded to standard demographic questions.

This research was approved by the University of Virginia’s Internal Review board and pre-registered through the Open Science Foundation (osf.io).

## Conclusions

**Perception of the “Most Effective Thing.”** Participants responded to a series of open-ended questions about the most effective thing they and other Americans could personally do to reduce landfill waste and reduce plastic pollution in the oceans. Two judges identified 37 categories by reviewing the first 100 surveys together and then independently coding the remaining surveys, which were later collapsed into 30 categories. Interrater agreement was very high for all four questions,  $\kappa$ ’s > 0.8. Similar to Attari (2014)’s categorization of actions for water as curtailment or efficiency, we then classified each action as either a disposal or source reduction behavior. Some items (e.g., “the three Rs”) were identified as both source reduction and disposal, whereas others defied this process of categorization and were put under miscellaneous (i.e., indirect or other pro-environmental behaviors, such as “drive more fuel-efficient vehicles”).

When thinking about reducing landfill waste, the majority of participants recommended disposal actions such as recycling (Table 1). This was an expected finding, as recycling is widely seen as a pro-environmental behavior (Dunlap et al., 2000) and infrastructure and messaging encouraging recycling is prevalent in the U.S. This contrasts with expert recommendations for waste management strategies (see Figure 1). Many participants also indicated the importance of mindful or sustainable purchasing habits to reduce landfill waste, including purchasing items with less packaging, products that could be easily recycled, or durable items that would not break down easily. This suggests that people are connecting waste generation to their



purchasing behaviors, but instead of foregoing buying items they are trying to buy products that produce less waste.

Activity	Source reduction (SR) or Disposal (D)	You	Other Americans
Recycle	D	43.2%	43.7%
Reuse	SR	8.7%	8.8%
Vague/miscellaneous suggestions (e.g., “Waste less”)	--	7.6%	8.1%
Use less plastic	SR	7.2%	6.3%
Consume or buy less	SR	7.0%	7.8%
Compost	D	4.5%	2.4%
Purchase items with less packaging	SR	3.7%	3.7%
Mindful purchasing	SR	2.8%	2.3%
Purchase items that can be recycled	D	2.0%	2.0%
Buy biodegradable products	D	1.4%	1.2%
Donate or sell old items	D	1.4%	1.4%
Indirect/other pro-environmental behaviors	--	1.2%	2.0%
Advocate for systemic change	--	1.2%	1.3%
Burn/bury waste	D	1.0%	.5%

Table 1: Perceptions of single most effective thing to reduce landfill waste.

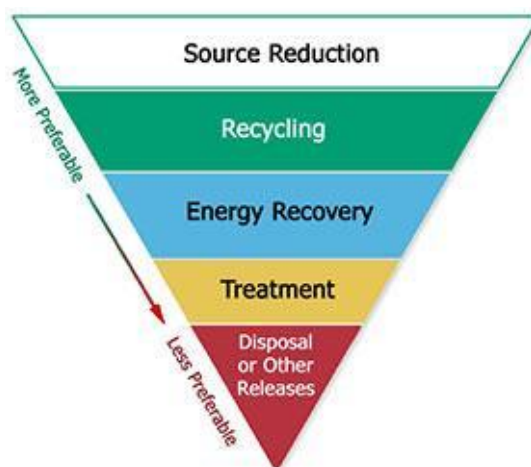


Figure 1: EPA Waste Management Hierarchy (U.S. EPA, 2019).

However, when thinking about reducing plastic in the oceans, the majority of participants cited source reduction behaviors such as using less plastic (Table 2). This was an unexpected finding that aligns with expert recommendations to reduce waste. In contrast to landfills, making the ocean salient led individuals to think higher on the waste management hierarchy. This could be because people have a sense that waste “belongs” in landfills and not in the ocean. Emphasizing that waste does not belong in the natural areas where landfills are found may be a strategy to get people to think about reduced consumption rather than waste disposal strategies. Another reason that thinking about the ocean leads people to land on the expert recommendation may be the amount of publicity ocean plastic has received in recent years and its negative

effect on marine animals and human health. Similarly, highlighting the various environmental problems with landfills (e.g., methane gas production, groundwater contamination, public health issues), which are the most common destination for waste in the U.S. (U.S. EPA, 2017) may make issues with waste generally more salient for the public.

Many participants also mentioned the importance of not littering (with several specifically emphasizing not to litter or bring plastic near the ocean), suggesting that people tend to think of ocean plastic comes from proximal dumping and do not have accurate understandings of the many ways that plastic waste can end up in the ocean (e.g., fishing equipment, in transit to landfills or recycling centers, from rivers, etc.). Therefore, there is a need for greater transparency and awareness about the various ways that waste arrives to the ocean beyond beach proximity. Participants also recommended participating in beach-cleanups, suggesting that many people are thinking about remediation strategies after waste has already been produced rather than reducing sources of waste in the first place.

Activity	Source Reduction (SR) or Disposal (D)	You	Other Americans
Use less plastic	SR	37.9%	36.1%
Recycle	D	22.4%	24.5%
Reuse	SR	10.1%	8.7%
Don't litter	D	4.9%	7.5%
Vague/miscellaneous suggestions (e.g., "Waste less")	--	4.2%	5.2%
Purchase items with less packaging	SR	3.7%	2.0%
Participate in beach clean-ups	--	2.9%	2.1%
Advocate for systemic change	--	2.8%	3.5%
Consume or buy less	SR	2.4%	1.7%
Substitute other materials	SR	2.2%	2.2%
Buy biodegradable products	D	1.4%	.7%
Spread awareness/educate others	--	1.2%	.6%

Table 2: Perceptions of single most effective thing to reduce plastic pollution in the ocean.

### Perceptions of Waste Generation and Disposal

Before conducting this survey, a pre-test was done to test survey language for participant understanding. The EPA provides per capita waste generation estimates on a daily basis, but pre-test participants found it easier to think about how much waste they generated and disposed of on a weekly basis. Therefore, in the current study we asked participants to estimate how much waste they generated on a weekly basis, and how much of that waste they threw away, recycled, and composted. We also asked participants to estimate the same parameters for the average American.

Participants estimated that they generated significantly less waste ( $M=22.7$  lbs. per week,  $SD=32.6$ ) than the average American ( $M=28.7$  lbs. per week,  $SD=25.8$ ),  $t(859) = -6.9, p = .000$ ). Although they also estimated that they generated significantly less

waste than EPA estimates of per capita waste generation  $t(860) = -8.0, p = .000$ ), participants tended to have a better than expected understanding of how much waste they and average Americans generate (see Figure 2). This may be because waste is a more tangible than energy and tends to accumulate in one place, unlike water which tends to be measured and experienced as a flow. In most of their estimations, participants demonstrated the better-than-average effect (Alicke & Govorun, 2005) – that is, they estimated that they generated less waste, threw away less, and recycled more than what they estimated for the average American and what the EPA estimates (US EPA, 2017). In composting, however, participants estimated that they compost less than the average American and less than what the EPA estimates. This may be because people tend to think of food waste for composting and not grass and yard trimmings, which make up a large majority of the composting data from the EPA. Additionally, it may be because there are far fewer municipal composting programs than trash and recycling (Sheppard, 2012). Conversely, this difference could also be an example of the better-than-average effect, as generating food waste that has to then be composted may be perceived as a negative action. Correcting perceptions of how much waste individuals generate and making it more salient may be an important component of addressing waste at the point of generation.

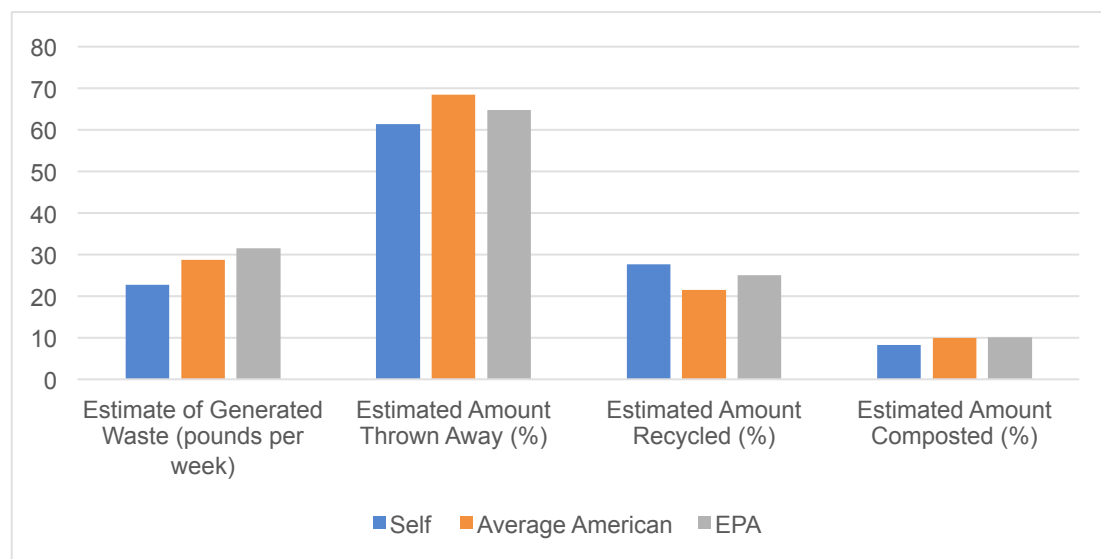


Figure 2: Participant Estimates of Waste Generation and Disposal.

### Perceptions of the Recycling System.

Do people have any idea what happens to their waste after it is thrown “away” or put in a recycling bin? One way that we assessed perceptions of the recycling system was by asking people to estimate how long it took a water bottle, plastic bag, glass bottle, and aluminum can to be made into a new product from the time they were collected. We also asked a series of experts in the recycling industry to estimate the same, and we compared expert estimates to participant estimates. We excluded any response that had an estimate of over 25 years, as these were considered to be extreme outliers. In every case, participants thought items took much longer to be recycled than experts estimated. We excluded all estimates over 25 years. For water bottles, participants thought it took them about five and a half months to be made into a new product compared to a mean expert estimate of less than 2 months, ( $M=165.3$  days,  $SD=533.7$ ),  $t(843) = 6.3, p = .000$ ). Similar overestimates were true for plastic bags

( $M=170.8$  days,  $SD=543.5$ ),  $t(841) = 7.5$ ,  $p = .000$ ), glass bottles ( $M=166.6$  days,  $SD=577.9$ ),  $t(842) = 7.0$ ,  $p = .000$ ), and aluminum cans ( $M=144.4$  days,  $SD=427.6$ ),  $t(844) = 4.7$ ,  $p = .000$ ).

These misperceptions about how long items take to be recycled may be a result of increased news coverage about recycling and China, or a general sense of a broken or inefficient recycling system. Knowing what products become when they are recycled into new items (e.g., seeing a plastic bottle become a jacket when recycled) encourages good recycling behaviors (Winterich et al., 2019), and the same could be true for general familiarity with the recycling process. If individuals think that the recycling system is inefficient or disjointed, that might affect their recycling behaviors negatively. An alternative explanation might be that people think the recycling system is more complex than it is, which might account for wishcycling and contamination behaviors. For example, if people think that recycling processors take a long amount of time to clean and sort recyclables before sending them downstream, that might lead them to put dirtier or unrecyclable items in the recycling stream because they think it has the capacity to deal with them.

We also asked participants to estimate the amount of plastic that has been recycled and that has ended up in landfills/the natural environment out of all plastics ever produced. Participants greatly overestimated the percent of plastic they thought had been recycled when compared to expert estimates (Geyer et al., 2017), but still estimated a surprisingly low number ( $M=23.1\%$ ,  $SD=20.2$ ),  $t(844) = 23.1$ ,  $p = .000$ ). This suggests that participants are familiar with problems associated with recycling – yet they still perceive it as their most effective option to reduce landfill waste.

When assessing their own recycling knowledge, participants thought they knew a moderate amount ( $M=3.0$ ,  $SD=0.9$ ) on a 5-point scale and estimated that they knew more than the average American ( $M=2.6$ ,  $SD=0.8$ ),  $t(844) = 14.0$ ,  $p = .000$ ). On the measure of actual recycling knowledge, most items had only one acceptable answer (e.g., “not recyclable anywhere). However, due to regional variations in recycling discussed above, for some items we accepted multiple answers as correct. For example, for glass we accepted either “Recyclable at almost all recyclable facilities” or “recyclable, but only at select recycling facilities” because until recently glass was recyclable almost everywhere, but many municipalities have stopped accepting it in curbside collection (Winterich et al., 2019). For each answer, participants either got 1 (correct) or 0 (incorrect) points, and this number was summed and averaged over the total number of items for a total score out of 100%.

Overall, participants performed better than expected on the assessment of recycling knowledge with a mean score of 66.7% ( $SD=15.45$ ). However, that score belies some grave misunderstandings of the recycling system. For example, 22.4% of participants indicated that they thought used diapers were recyclable at all recycling facilities (8.3%) or select facilities (14.1%). Dirty diapers have been found in waste marked as recyclables (Choi, 2019). While there is technology that can recycle dirty diapers (Khoo et al., 2019), none is currently in use in the U.S. (Jewkes & Geller, 2018; Recycling Today, 2003). Some specialty diapers can be composted through special services, but this is a different process than recycling. Items like used diapers put in the recycling stream in the U.S. contaminate recycling loads, which adds cost and can lead to otherwise-recyclable items being trashed (Robinson, 2018).

In their assessment of wishcycling behaviors, participants indicated that they put items in the recycling that they are not sure is recyclable rarely or occasionally ( $M=2.4$ ,  $SD=1.0$ ) but that they thought the average American did it more frequently ( $M=3.5$ ,  $SD=0.8$ ). Participants were uncertain about other contamination behaviors, however, indicating that they weren't sure whether or not it was better to throw away or recycle items when uncertain and how important it was for recyclables to be clean and free of food residue. For consumers, improving messaging about what can and cannot be recycled and in what condition is important, and so too is reducing the number of items produced that cannot easily be recycled in existing systems. For recyclers, understanding how consumers perceive the recycling system could enable technology-aided adaptations to accommodate consumer behavior.

### **Purchasing Behaviors and Waste Awareness**

Participants report that they tend not to think about waste generation at the point of purchase. When asked: "How often do you take into account how you will dispose of an item when you purchase it?" on a scale from 1 ("Never") to 5 ("Very often"), participants reported that they rarely to occasionally think about it ( $M=2.8$ ,  $SD=1.2$ ). Similarly, participants indicated that they would likely still buy items that came in packaging that could not be recycled or composted (1 representing definitely would not buy and 5 indicating definitely would buy,  $M=3.6$ ,  $SD=.93$ ). They also indicated that they rarely forego a purchase due to concerns about creating waste (1 representing they never forego a purchase due to waste concerns, 5 indicating they do so very frequently,  $M=2.5$ ,  $SD=1.1$ ). Being more concerned about waste at the point of purchase was significantly associated with throwing away less waste,  $r(850) = -.529$ ,  $p=.000$ , and recycling  $r(850) = .356$ ,  $p=.000$  and composting more  $r(850) = .403$ ,  $p=.000$ . However, it was not associated with reduced waste generation. This indicates that even when people think about waste at the point of purchase, they tend to think about 'sustainable' waste disposal strategies and not about avoiding waste generation in the first place. Rather than focus messaging on recycling and composting, future waste strategies should also incorporate messaging focused on purchasing behaviors that avoid waste creation.

### **Discussion**

When asked about effective actions they can take to reduce waste, participants answered differently depending on the spatial description of where waste ended up. When thinking about landfills, participants recommended disposal strategies, but when thinking about the ocean, participants thought higher up on the waste management hierarchy and recommended reduced consumption strategies. This may be because people think that waste "belongs" in one of those locations and not in the other. Future research is needed on why oceans, and not landfills, gets people to think higher on the waste management hierarchy. Understanding those mental models will be an important component to designing a better waste management system and changing communication strategies regarding the naturalness of waste.

This research has several limitations, including using an Internet sample of participants that is not representative of the U.S. population and lack of monetary rewards for accuracy. Additionally, estimates of recycling time come from experts

and not actual recycling data. The behaviors and attitudes reported here were self-reports, which may not be totally reflective of actual participant actions and beliefs.

This research shows several misperceptions that people have about waste systems that span both waste generation and disposal. Education about recycling has been widespread, yet issues stemming from poor consumer behavior persist. This research suggests need for a better designed national recycling system, products that are simple to recycle, and better education on source reduction as an effective waste management strategy.

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### **Author Contributions**

M.B. and S.Z. designed research; M.B. performed research; M.B. and P.H. analyzed data; M.B., wrote the paper; P.H., S.Z., and L.K. offered feedback and edited the paper.

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***Empowering Communities by Optimizing the Deployment of Neighborhood-scale  
Resilience Hubs: A Case Study of Maui Island***

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**Abstract**

As a part of an integrated planning approach to develop programs intended to support communities increasingly facing impacts of natural disasters, including those associated with climate change, neighborhoods must strengthen their local community cohesion and resilience. One way to support neighborhood-scale resilience is to create recognized and accepted local resilience hubs. These hubs are physical spaces intended to serve as a community resource during normal non-emergency periods, while also having the ability to serve as backup emergency shelters and emergency recovery hubs during and immediately following emergency events, such as natural disasters. Critical services are integrated into such resilience hubs, including back-up power supply, potable water, telecommunications, medical resources, and food provisions as complements to other support systems. This paper provides a case study of how resilience hub sites are selected and enhanced for resiliency using bottom-up community engagement methods coupled with technical resilient power feasibility studies. This methodology results in the creation of resilience hubs that are accepted, trusted and stewarded by neighborhood residents, while meeting specified community needs. The community engagement process in this study informed resilient power feasibility analyses of three targeted sites on the Island of Maui. Communities who implement this approach will increase their resilience, including their community cohesion. This study is intended to inform related research exploring how a distributed network of resilience hubs can serve as a critical component of resilient island and remote communities, which face increasing and disproportionate vulnerability to disaster impacts resulting from climate change.

Keywords: resilience hubs, resiliency, community cohesion, community engagement, natural disasters, climate change, adaptation, islands

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## Introduction

In general, small islands are disproportionately vulnerable and negatively impacted by the effects of shocks and stressors, including those associated with climate change (Nurse et al, 2014). This includes increased vulnerability to impacts from phenomena such as: sea level rise, increased frequency and severity of high wind events and rain storms (including hurricanes and tropical storms), wildfires exacerbated by drought conditions, inland flooding (e.g. riverine flooding) resulting from high intensity rain events, and coastal flooding associated with extreme high tides (e.g. king tides). As such, in small island communities, the development and implementation of community-based climate change adaptation measures coupled with disaster risk reduction efforts can have comparatively larger positive impacts than they would when applied to less vulnerable communities (Nurse et al, 2014). Economic sectors particularly vulnerable to the impacts of climate change include agriculture and tourism. In addition, critical “life sustaining” resources, such as fresh water supply and fisheries, can be compromised by climate change impacts such as salt water incursion into fresh water basal lenses and nearshore coral reef decline or die-off (Hay et al, 1995). A compounding effect that adds to the increased vulnerability of island communities is that, given their limited resource base and size and their relative isolation and dependency on imported resources, many residents (including those with higher levels of education and technical skills) choose to relocate to areas that offer more economic and social opportunities often coupled with a lower cost of living. This results in a phenomenon colloquially referred to as the “brain drain”, whereby knowledge and technical expertise is continually lost from the region and substituted by temporary outside expertise that is expensive and often ill equipped to address the local customs and constraints of island communities (Hay et al, 1995).

In order to mitigate the aforementioned impacts of climate change and to strengthen the adaptive capacity of their communities, islands can pursue community-based and locally driven initiatives that enhance community resilience. Although several definitions of resilience exist in scientific literature, this article refers to resilience as defined by the Urban Sustainability Directors’ Network (USDN) to mean “the ability of communities to anticipate, accommodate, and positively adapt to or thrive amidst changing climate conditions or hazard events and enhance quality of life, reliable systems, economic vitality, and conservation of resources for present and future generations” (USDN 2019).

One way that island communities can enhance their resilience is to develop networks of resilience hubs throughout their neighborhoods. According to the Urban Sustainability Directors’ Network (USDN), resilience hubs are building structures and their associated grounds that provide services to local communities to support and enhance the quality of life of its residents (USDN 2019b). This includes the provision of services such as:

- assisting in the equitable access to and distribution of resources to the community (i.e. both physical/material-based and knowledge/information-based resources);
- facilitating communication (e.g. emergency and non-emergency telecommunication, internet access/connectivity, and emergency and non-emergency informational bulletins and advisories);

- providing low carbon or carbon neutral services that mitigate greenhouse gas emissions; and
- delivering carbon sequestration services (e.g. tree planting, regenerative community-based agriculture, aerobic composting, etc.).

Several different types of community oriented facilities can lend themselves to serving as resilience hubs. These include community centers, faith based and non-faith based non-profit organizations, and recreation, arts or cultural centers.

## **Methodology**

The island of Maui is located in the remote Hawaiian archipelago in the middle of the Pacific Ocean, approximately 2,500 miles from the nearest continental land mass. Maui island is a part of Maui County, which is comprised of the islands of Maui, Moloka‘i, Lāna‘i, and Kaho‘olawe. Due to its remoteness, isolation, and high level of dependence on imported resources and tourism, the island of Maui is highly vulnerable to the impacts of climate change and natural disasters. The island of Maui is therefore well positioned to significantly benefit from climate adaptation and resiliency measures. Having been exposed to the concept of resilience hubs through its membership in the USDN, the County of Maui initiated an effort in 2019 to develop a resilience hub network throughout its County.

As a starting point, the local County of Maui government engaged the local community using a variety of engagement methods in order to inform its residents of the concept of resiliency and resilience hubs, as well as to solicit feedback from community stakeholders to serve as a basis for the launch of a pilot phase for developing a resilience hub network across its community. The community engagement methods were informed in part by recommendations from USDN based on its resilience hub work with other communities within the State of Hawaii and throughout North America. Additionally, community engagement methods were shaped to meet the cultural context of Maui, which is often more informal and less rigidly structured than in many other North American communities.

The community groups targeted for engagement included County of Maui officials serving across various critical departments of the County of Maui organization, including: the Office of the Mayor, the Office of Economic Development, the Department of Planning, the Department of Housing and Human Concerns, The Department of Parks & Recreation, the Office of Management, the Department of Water Supply, the Department of Environmental Management, the Department of Transportation, the Department of Public Works, the Maui Emergency Management Agency, and the Maui County Council. Participants from community groups outside of the County of Maui organization included State House Representatives, natural resource conservation representatives, community disaster preparedness and response organizers, local electric utility representatives, private sector representatives, non-profit sector representatives, university faculty, administrators and students, and other interested non-affiliated residents.

One of the engagement methods used was to organize and hold a training workshop session based on the USDN’s Game of Extremes methodology (USDN 2020). This training exposes participants to some of the primary decision making processes involved in addressing natural disasters. By having participants role play in roles

other than their typical role in the community, participants are exposed to the difficulty of trade offs in decision making that are associated with representing different constituents than they typically do and trying to address multiple hazards and community needs with limited available resources. Participants are asked to conduct hazard vulnerability and risk assessments for a mock scenario that includes hazard events such as riverine and coastal flooding, and to then suggest climate adaptation measures intended to address these hazard risks and vulnerabilities within a limited budget and under a time constraint. This training allows participants to be exposed to community planning, resource equity, and climate adaptation concepts, while providing an opportunity to view these issues from a fresh and different perspective than their own.

Having been exposed to climate resilience and community planning concepts through their participation in the USDN Game of Extremes training, the same stakeholders were invited to participate in a subsequent resilience hub workshop facilitated by USDN and County of Maui resilience and sustainability staff. During this workshop, participants were exposed to the definition of resilience hubs and to basic characteristics that resilience hubs should have. Participants were then asked to describe the attributes they would like to see in a future resilience hub within their own communities and neighborhoods. Participants were asked to categorize these attributes into three separate categories: attributes desired in a basic resilience hub, attributes desired in an enhanced resilience hub, and attributes desired in an ideal/optimized resilience hub. This categorization allows for attributes to be prioritized and assessed for feasibility based on budgetary, technical and other possible constraints. Participants were then asked to identify specific sites in their communities that they perceive as strong candidates to serve as resilience hubs. The facilitators encouraged participants to consider hazard vulnerability and risk, as well as equity, and building structure and programmatic aspects of proposed sites. For example, an infrequently used site that would be vulnerable to coastal or riverine flooding and would not provide equitable access or community services, in addition to needing major structural repairs or improvements, would not be considered a strong candidate to serve as a resilience hub. Conversely, a trusted site with a building in good structural condition located outside of natural hazard zones that is readily accessible by all members of the community and offers critical community services, would be considered a strong candidate to serve as a resilience hub. The final component of the resilience hub training consisted of identifying proposed sites on a map and then sharing with participants various online resources to assist in assessing each site for hazard vulnerability. These online resources included visual GIS mapping tools and reports to help assess hazard risks from tsunamis (NOAA 2019b), wildfires (HWMO 2019), sea level rise (NOAA 2019, PacIOOS 2019), and riverine/inland and coastal flooding (FEMA 2017, PacIOOS 2019).

## **Results**

The following tables describe the results collected from participants who attended the resilience hubs workshops. These include results for basic desired attributes, enhanced desired attributes, ideal desired attributes, and proposed sites to be considered as candidates for establishing community resilience hubs. The desired attributes are also categorized by operating mode or condition to describe the desired

attributes during normal conditions, disaster response conditions, and disaster recovery conditions.

	<b>Normal Mode</b>	<b>Disruption/Response Mode</b>	<b>Recovery Mode</b>
<b>Basic</b>	Connectivity of resilience hub site with nearby neighborhoods	Site as location or zone for distribution of critical/emergency resources	Proactive pre-established contracts for critical services (e.g. sanitation plans, debris plans, dumpsters, staging)
<b>Basic</b>	Programming (classes; basic trainings based on community interest and need)	Backup battery storage coupled with backup power generation	Availability of Very High Frequency (VHF) Radio
<b>Basic</b>	VHF, Cell Phone, telecommunications infrastructure and equipment	Solar charging stations for charging devices	Critical equipment is dedicated to the site and stays in the area rather than mobile units that are not always available
<b>Basic</b>	Charging stations for plug load devices (e.g. smart phone, laptop, etc.)	VHF Radio	Charging stations for plug load devices (e.g. smart phone, laptop, etc.)
<b>Basic</b>	Public restrooms	Spare clothing and toiletries	Trauma recovery support (PTSD, etc.)
<b>Basic</b>	Has an existing waste management system in place	Emergency sheltering capacity	-
<b>Basic</b>	Water fountain, Water bottle refill station, purified water availability	Childcare services	Childcare services
<b>Basic</b>	Hybrid energy systems that can also provide economic benefit during normal conditions	Purified water	-
<b>Basic</b>	One stop wellness (basic), spectrum of wellness offerings	Meals Ready to Eat (MRE) - locally sourced	-
<b>Basic</b>	Shipping container for storage and shelter	Comfort and Support (e.g. mental health counseling)	-
<b>Basic</b>	Storage room	Temperature regulated (cooling, heating, shading)	-
<b>Basic</b>	Refrigerator/cold storage	-	-

Table 1: Results from resilience hubs workshops for basic desired attributes.

	<b>Normal Mode</b>	<b>Disruption/Response Mode</b>	<b>Recovery Mode</b>
<b>Enhanced</b>	Programming (1st Aid and CPR, other educational training, staff training for mental health and wellness)	Childcare + support	Contracts with tree trimming companies to assist with tree debris removal
<b>Enhanced</b>	One stop wellness (advanced: health care, proactive trauma)	Locally produced food delivered then stored on site	Location to bring all types of debris
<b>Enhanced</b>	Childcare on-site + children's activities	Commercial kitchen	-
<b>Enhanced</b>	Food generation on-site or around site	Dry + chilled food storage and other resources storage	-
<b>Enhanced</b>	Composting toilets	Solar dehydrating systems for food	-
<b>Enhanced</b>	Showers + toilets	Facility size drives sheltering capacity	-
<b>Enhanced</b>	Minimizing waste program	Purified water fountains and bottle refill stations	-
<b>Enhanced</b>	On-site composting	-	-
<b>Enhanced</b>	Storage for dry goods and refrigerated goods (chill)	-	-
<b>Enhanced</b>	Energy Microgrid and grid services options	-	-
<b>Enhanced</b>	Purified water	-	-

Table 2: Results from resilience hubs workshops for enhanced desired attributes.



	<b>Normal Mode</b>	<b>Disruption/Response Mode</b>	<b>Recovery Mode</b>
<b>Ideal</b>	Programming (skills training, education, jobs training, university/college connection)	Healthy, local food grown on-site	Uses for or from debris
<b>Ideal</b>	Health, Dental, Mental health, Trauma	Commercial kitchen	Massage and acupuncture for recovery
<b>Ideal</b>	Child care + programming	Excess food dehydrated and stored	-
<b>Ideal</b>	Community gets food from on-site year round	High tech water systems (water storage/supply; water treatment; wastewater treatment; stormwater management)	-
<b>Ideal</b>	Bathrooms + showers + greywater reuse	-	-
<b>Ideal</b>	Community solar benefits (CBRE)	-	-
<b>Ideal</b>	Microgrid with backup power generation for XX days (14+ days)	-	-
<b>Ideal</b>	Waterless toilets	-	-
<b>Ideal</b>	Zero-waste facility with reuse and composting (integrated waste management)	-	-
<b>Ideal</b>	Affordable housing and temporary housing	-	-

Table 3: Results from resilience hubs workshops for ideal desired attributes.

Molokai Community Center (Molokai)
Koele Lodge (Lanai)
Manele Hotel (Lanai)
Community Gym (Lanai)
Lahaina Civic Center
Velma McWayne Santos Community Center
UH Maui College
Haiku Cannery
Haiku Community Center
Pukalani Community Center
Keokea Community Center
Kula Hospital
North Kihei Technology Park
Kihei Charter School
Kihei High School
Kaupo Community Center
Camp Keanae
Hana Community Center
Hana Ranch
Kipahulu Community Center
Puu Kukui by Kahakuloa

Table 4: Results from resilience hubs workshops of proposed sites by participants.

## Discussion and Conclusions

The development of a network of resilience hubs throughout local communities and neighborhoods of Maui County is a climate adaptation and community resilience strategy with the potential to significantly reduce natural hazard risk and vulnerability, while at the same time furthering community equity and social cohesion. This includes providing critical community services to help alleviate on-going stressors (e.g. poverty, crime, health risks, homelessness, etc.) faced by residents of Maui County during normal periods, and mitigating future shocks (e.g. hurricanes, tsunamis, wildfires, etc.) the community may face during disaster events. As a part of launching a pilot phase for the development of a resilience hub network for Maui County, the County of Maui selected three sites across the island of Maui intended to serve as use cases and testing sites to inform future expansion of the proposed resilience hub network. All three sites were identified by participants of the resilience hubs workshops as viable candidates to serve as resilience hubs. In order to facilitate access to information and data (e.g. building plans, utility data, etc.) for the three pilot sites as well as being able to easily gain entry into the buildings and grounds of the proposed sites, the County of Maui selected three County owned community centers located on the island of Maui. These are: the Velma McWayne Santos Community Center located in Wailuku, the Lahaina Civic Center located in west Maui, and the Hana Community Center located in east Maui.

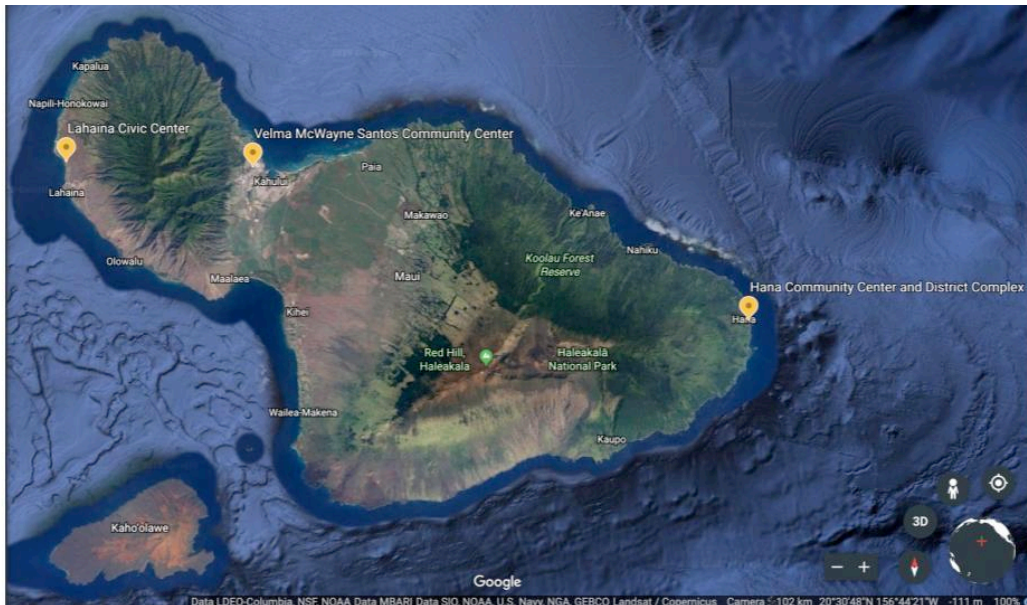


Figure 1: Resilience hub pilot sites selected by the County of Maui.

In addition to being geographically dispersed throughout the island of Maui, each of these sites offers a unique use case. The Velma McWayne Santos Community Center offers an urban high population density use case given its location in the heart of Wailuku close to local government, business and industrial centers, as well as serving many nearby multi-family and single family residential units. The Lahaina Civic Center offers a use case that serves a significant suburban resident population as well as a large visitor population due to its proximity to nearby resorts and the tourism destination of Lahaina Town. Additionally, this site is adjacent to nearby Hawaiian Homelands that are home to a large Native Hawaiian population. The site also includes first responder police and fire stations. Finally, the Hana Community Center provides a rural use case located in the remote community of Hana on Maui's east side. This community is isolated from the population centers and primary service centers of Maui, as well as being home to a large Native Hawaiian population and many homesteaders. Communities looking to pilot resilience hub sites are encouraged to use a similar approach for the selection of pilot sites, so as to disperse the pilot sites geographically and test various use cases relevant for their community context.

Currently, the County of Maui is in the process of conducting resilient power feasibility studies for each of the selected pilot sites. This will allow the sites to have power systems designed to optimize resilience during disaster response and recovery periods, by providing backup power to the sites' critical power loads. In addition, these power systems will be designed to provide optimized financial benefits during normal periods. This includes providing the sites with the ability to participate in revenue generating or cost savings electrical grid services programs (e.g. time of use, demand response, etc.), as well as providing these sites with the ability to power equipment for revenue generating activities (e.g. commercial kitchens, equipment repair, refrigeration, etc.).

The resilient power feasibility studies are being conducted in partnership with the Clean Energy Group and American Microgrid Solutions. This methodology includes data collection and analysis of the following parameters:

- Data collection (e.g. energy, electrical plans, capital improvement plans, etc.)
- Conduct site audits (e.g. energy audits to assess power demand and energy efficiency and energy conservation opportunities; renewable energy deployment potential analysis; assess current baseline condition of facility; etc.)
- Develop power load profiles (i.e. model time of use with occupancy and programming/activities)
- Reduction of peak power loads to reduce demand charges and backup system size requirements
- Analyze utility rates to input into financial analysis and assess opportunities for rate reductions
- Analyze utility rates and associated charges
- Evaluate energy incentives (including energy efficiency rebated and renewable energy tax credit opportunities)
- Assess emerging incentive structures (e.g. ability to participate in demand response or time of use programs)
- Assess rate escalation potential over time
- Assess electric and other energy meters and develop optimized solutions (e.g. submetering)
- Model proposed solutions
- Conduct a technical and economic feasibility analysis
- Compare modeled system performance with actual real world system performance (i.e. groundtruthing)
- Optimize power system resilience based on site hazard vulnerability and risk assessment

As described by the Clean Energy Group (Clean Energy Group 2014) and American Microgrid Solutions, this resilient power feasibility study methodology provides users with a “spectrum of resilient power options” that can accommodate various budgets, regulatory environments and site conditions. Users are able to weigh the benefits of increased resilience during power outages against the social, environmental, and financial/economic benefits provided by resilient power systems during normal operating conditions. One end of this resilient power spectrum could be a power system that does not provide inherent economic or social benefits during normal operating conditions, while providing highly reliable and extended backup to critical loads during power outages. On the other end of the resilient power spectrum, a power system could provide net zero energy for a site during normal conditions by completely offsetting any grid purchased power, while not providing reliable backup power during power outages. As described by the USDN (USDN 2019c), a hybrid resilient system is the optimal power system for most resilience hub applications. In addition to being connected to the existing electrical utility grid when available, hybrid resilient power systems combine both renewable power generation (e.g. photovoltaic system) and conventional power generation technologies (e.g. diesel backup generator that could be operated using biodiesel fuel), while also providing energy storage technologies (e.g. lithium-ion battery storage system). This suite of power generation and storage technologies, coupled with grid interactive charge controllers and inverters, allows for an optimal balance between power resiliency and economic viability.

With increasing climate change associated threats being faced by island communities and by many other parts of the world, developing locally driven resilience hubs networks is an adaptation and resiliency measure that can yield significant benefits to such communities. These include benefits to communities during normal periods as well as during disaster response and recovery periods. Communities interested in pursuing resilience hub initiatives can benefit from the community training and engagement methodologies developed and promoted by the USDN that are described in this article, and adapting them to their local contexts. Future research will provide additional technical analysis of power and building structural systems, as well as findings from the current resilience hubs pilot program underway in Maui County and its associated resilient power feasibility studies described in this article.

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