University of Strathclyde

Department of Architecture

Developing a Regenerative Design Framework for the Built Environment:

A case study in Chiang Mai, Thailand

By

Sasiprapa Srikraiphak

A thesis presented in fulfilment of the requirements for the degree of

Doctor of Philosophy

2023

Acknowledgements

First of all, I would like to thank the Office of the Higher Education Commission and the faculty of Architecture at Chiang Mai University for the funding that provided me with many opportunities that benefited my PhD study and life experiences while studying at the University of Strathclyde, Glasgow, Scotland.

Secondly, I would like to thank my supervisor, Dr David Grierson, who has been supporting me since day 1 of my PhD. Your kindness and understanding helped me a lot throughout my study time. Thank you for always giving many valuable suggestions, encouragement, and support. Thank you for believing in me and guiding me in the way that makes this thesis happen. When I struggled with studying or my mental well-being, your kind words helped calm me down and simultaneously helped me continue my studies confidently. I think you are a role model of mine, and I would like to follow and treat my future students like you treated other students and me under your supervision. Thank you very much again for everything.

Thirdly, I would like to thank Dad, Mum, Namfon, Grandpa and everyone in our family who always believed in me and supported me in every single way to achieve my goal. I know that all of you need nothing from me, but always bless me to be happy and healthy. Unfortunately, our beloved Grandma could not see this achievement, but I know you see it from somewhere over the sky with your beautiful smile. I love you all so much that no words can explain it here. I will not promise anything, but I will try to be a better person to make all of you proud. Without your love and support, I could not be here. So, thank you very much from the bottom of my heart.

Moreover, to my dear friend Natthakit Phetsuriya, my life in the UK would be so lonely without you. You and I have known each other for over half of my life. We have become best friends since undergrad school, and we came to the UK to study for a PhD together. I felt so blessed knowing that you would be here with me on this land. I remember our talks every midnight about things we had faced each day: happiness, silliness, funniness, sadness, and pain. We have shared many things, even thorough sometimes, we fought, argued or disagreed on something, but in the end, our friendship always led us back together. I want you to know that you must be with me forever. I will not take our friendship for granted because you are important to me, my dear friend. I love you so much, and you know that.

Last but not least, I would like to thank all my friends here and in Thailand for being fantastic supporters. We laughed, cried, hangout, discussed, and supported each other, and we had so many memorable moments together that I will value and keep them safe in memory. Apart from friends, I would like to thank Sapporo teppanyaki Glasgow, Ting Thai Caravan, Oaka and Thai Siam restaurant for allowing me to work with you guys as part-time staff. Especially for Thai Siam, all the staff there are like my family. You were kind to me, supported me when I had a tough time and shared joy with me when I had a wonderful moment. This friendship will last forever; when I think about it, I always have a big smile on my face. Lastly, Thank you for having me "GLASGOW". It's been a memorable four years. You have taught me many things and have shaped me to be a tougher version of myself in a better way. I hope I can see you again often. You are my favourite city of all time. I love you, Glasgow.

Abstract

Regenerative design offers a sustainable design approach that aims to go beyond mainstream paradigms by prioritising the role of nature as a crucial part of the built environment design. However, previous studies show that current regenerative design frameworks have several factors that impact the efficiency and credibility of their use. Therefore, this study proposes a Regenerative Design Framework for the Thai context (RDF-T), aiming to develop a new framework that can address the gaps in previous studies. Regenerative design is relatively unknown among Thai design practitioners, and this approach has not yet been applied to Thai built environment design projects.

RDF-T's structure combines the principle of regenerative design with the 'Backcasting technique' and 'Thai's Rating of Energy and Environmental Sustainability (TREES)' to strengthen its credibility and capability. This research investigates the potential of RDF-T as a contextual built environment design tool through its application in a 3-day workshop on the development of design guidelines for proposals within an area called Nong Bua in Chiang Mai, Thailand. Qualitative methodology is the main approach of this study, while a quantitative methodology is adopted to support the comprehensive outcomes.

Findings reveal that RDF-T can produce a contextual built environment design for the case study area and has the potential to be applied to other built environment projects in Thailand. However, the findings also show that Thai Socio-Ecological Characteristics are important additional factors that can help underpin the efficiency of this framework for future users. In addition, an outcome of this study, the RDF-T manual, offers primary material for regenerative design in the Thai context and supports the application of the framework in different regions across the world.

Contents

List of Figures

List of Tables

Chapter 1

Introduction: Regenerative Design Framework for the Thai context

Environmental problems have been a significant issue for decades due to their damaging impact on all living systems of this planet. Obviously, this has been the critical factor that continues to cause the degradation of an ecological system. Most environmental problems have occurred from human activities involving invading and ineffectively using natural resources. Consequently, since the 20th century, a majority of campaigns have aimed to protect the environment by using the core idea of sustainability being implemented to solve environmental problems. According to the Brundtland Report for the World Commission on Environment and Development in Rio de Janeiro, 1992, "Sustainable is defined as "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (*Our Common Future : the World Commission on Environment and Development*, 1987). Regarding sustainability in architecture, the sustainable principle suggests incorporating diverse design approaches such as sustainable design, green design, environmentally friendly building design, et cetera.

In contrast, the acceleration of environmental problems has led researchers and scholars to question this. If a sustainable approach is a workable solution for environmental problems, these issues should not increase dramatically (du Plessis, 2012; Littman, 2009; McDonough & Braungart, 2002; Reed, 2007). Subsequently, this

study intends to research an alternative approach that is a possible tool to reduce harmful environmental impacts. Meanwhile, this alternative approach should help to strengthen a robust ecosystem to create genuine sustainability that can respond to the present generation's needs without encroaching on the needs of future generations.

1.1 Research Overview

Regarding conventional design's capabilities, mainstream green design practices have focused solely on human comfort, human needs, and human activity in terms of using resources and energy efficiency to decrease environmental impact. Despite the green design practices' purpose of maintaining sustainability for all living systems by "doing less harm" and emphasising the importance of natural function and elements to be adapted in the built environment design, the degradation of the environment implies that current mainstream design practices lack adequate aspects in terms of maintaining the quality of the ecosystem. (Cole, 2012b, p. 41; Mahir, 2014, pp. 13-14). Thus, the origin of this study stemmed from curiosity towards the capabilities of mainstream green design practices when it is supposed to reduce a harmful impact on the environment and ecosystem. However, the occurrence of environmental problems that are rapidly rising possibly implies that some factors affect the ability of sustainable design approaches in terms of decreasing ecological issues.

Interestingly, John Tillman Lyle, who developed a regenerative design principle, suggested that to sustain the ecosystem continually, humankind's well-being should not be the sole concern; besides, nature should be allowed to be evaluated along with humans. This could genuinely sustain the ecology and encourage harmony in all living systems. This study has discovered that a regenerative design principle is one of the sustainability design fields with slightly different details when compared with conventional sustainable practices.

Generally, mainstream sustainable practices such as sustainable design and green design mainly focus on the efficient use of natural resources that humans have been consuming continually to respond to our needs. Even the sustainability principle mentioned that the consumption of natural capital should meet the needs of the present generation without interfering with the needs of the future generation. Yet, this does not mean that natural capital could provide adequate resources for future use since there is a great deal of demand regarding the present consumption of natural resources that contrasts with the supply in nature. Obviously, the production of nature does not

respond to the excessive needs of humans. It requires time to recover and re-establish its prosperity. Therefore, mainstream green design practices typically measure the efficiency of design, which determines net-zero impact as an ultimate goal. However, Mahir (2014) mentioned that this indication does not cover the entire factor that distributes holistic sustainability (Mahir, 2014, p. 10). If there is a balance between carbon emissions and removed carbon, then the amount of carbon in the atmosphere will not reach a severe level. However, is this idea sufficient to help restore a better-quality ecosystem? Without certain natural regeneration, the degradation of the environment will still occur (Cole, 2012b; Mahir, 2014).

This study is interested in a regenerative design principle as it emphasises a co-evolution of humans and nature to genuinely create sustainability (Cole, 2012b; du Plessis, 2012; Mang & Reed, 2012; Reed & Regenesis, 2011). All living species on this planet have an interdependent relationship in regard to survival. Over the decades, scholars and researchers have studied and developed regenerative design and development. Therefore, several regenerative design frameworks, such as the Regenesis Approach, REGEN Framework, LENSES Framework, and Perkins+Will Framework, have been applied in developing areas worldwide. These frameworks combine their techniques with different details using the regenerative design principle. The results of the regenerative design frameworks' application appear to have successfully regenerated the degraded ecosystem. Nevertheless, even though the regenerative design principle has been studied and developed for decades, there are questions about its evaluation. This is due to the results of the application of these frameworks requiring time to prove their success, and the performance of results cannot be measured with a simple metric (Cole et al., 2012).

Subsequently, this study focuses on the regenerative design principle and current regenerative design frameworks and discovers gaps in those frameworks insofar as ensuring the credibility of results, a potential assessment tool, and performance measurement. This study intends to develop a new framework from this discovery and determines to apply this framework in the Thai context as an area of study. In order to fill the gaps in those existing frameworks, this study has combined a regenerative design principle with two other elements, which are a Backcasting technique and Thai's Rating of Energy and Environmental Sustainability (TREES), to create the structure of a new regenerative design framework to suit the Thai context. Initially explained, the

Backcasting technique is a well-known normative scenario approach in the sustainable planning field. The distinguishing of this technique is that it begins with determining a desired normative future and designs a plan to create a pathway as a strategy to achieve it. This approach is a backwards process in that the essential steps are typically planned to obtain a preferred goal in the future scenario (Miola, 2008). In addition, Thai's Rating of Energy and Environmental Sustainability (TREES) is an environmental certification system designed to be compatible with the Thai ecosystem to guarantee the quality of Green buildings in Thailand. Then, with regard to developing the study, this work intends to propose a new Regenerative Design Framework for the Thai context (RDF-T) to be a contextual built environment design tool for regenerating the quality of the ecosystem, especially in Thailand.

To investigate the capability of the RDF-T, this study has applied this framework in a case study area in Chiang Mai, Thailand, called Nong Bua. This study utilises qualitative research data collection and thematic analysis as a study methodology. This study invited and gathered stakeholders who were related to the Nong Bua area to participate in a 3-day workshop. This engagement aims to apply the RDF-T in a contextual built environment design process to find a suitably built environment design that could benefit the Nong Bua area and the local community. Therefore, this engagement process determines using the RDF-T to create policy guidance for developing Nong Bua as a regulation to follow further. The results of the 3-day workshop have been analysed and developed to improve the capabilities of RDF-T continually, and all of the findings lead to the conclusion of this study.

In refining the framework's terminology, the title shifted from "Thai Regenerative Design Framework (TRDF)" to "Regenerative Design Framework for the Thai context (RDF-T)." However, remnants of the term TRDF persist in each chapter due to its use during data collection before the switch to RDF-T. TRDF and RDF-T are considered equivalent, acknowledging the name change during the study to avoid confusion. For uniformity and clarity, the term RDF-T will consistently represent the Regenerative Design Framework for the Thai context throughout each chapter.

1.1.1 Research aim

This study aims to develop and test a novel regenerative design framework (RDF-T) for application in the built environment context of Thailand.

1.1.2 Research question

1. What are the key principles of regenerative design, and how do these differ from other environmental design approaches?

2. What are the key characteristics of a regenerative design framework, and how can this be developed and tested in the built environment context of Thailand?

3. Which characteristics demonstrate the greatest efficacy through case study application?

4. What are the limitations, and how can future research work respond to these?

1.1.3 Research objective

1. To examine the key principles of regenerative design and describe how these differ from other environmental design approaches.

2. To develop the RDF-T, integrating the Backcasting technique and the Thai Rating of Energy and Environmental Sustainability (TREES) method.

3. To test the application and efficacy of the RDF-T framework through case study analysis in the Nong Bua area of Chiang Mai, Thailand.

4. To identify the limitations of RDF-T and propose future research work that can address these.

1.1.4 Research hypothesis

A focal point of this study emphasises the analysis and development of the application of the regenerative design principle combined with other disciplines, which are the Backcasting technique and Thai's Rating of Energy and Environmental Sustainability (TREES) to create the RDF-T and propose it as a contextually built environment design tool which has been created to suit the environment and ecosystem of Thailand. This novel regenerative design framework has replenished the gaps in current regenerative design frameworks that have been applied worldwide in developing areas. Furthermore, this framework focuses on understanding the synergy between humans and nature, which uses the regenerative design principle as a basis.

Intentionally, the RDF-T will be utilised in the initial process of a contextual built environment design engagement to encourage the stakeholders who participated in this process to have an identical understanding of a framework's instruction and urge the stakeholders to design a primarily built environment for a case study area. This will be followed by establishing the consensus-built environment development policy that can be used as a strategy to achieve the desired results later. In terms of summarising the success of this framework, this study will evaluate its potential by examining its capability in regard to how it helps regenerate the co-existence of the life cycles of humanity and nature to produce a healthier ecosystem and how it can continue sustaining the future environment of Thailand.

Therefore, this study attempts to use the outcome of the results to develop an alternative way to create genuine sustainability for the Thai built environment and aims to be potential research for future relevant studies.

1.2 Chapter outline

The chapter outline is a brief of the study that distinguishes the content of each chapter in this thesis to assist and reveal the whole idea of this study to the reader, which can lead to a clear understanding of profound information in a full description of each chapter. Chapter 1 acts as an introduction, establishing the study's genesis and the pertinent research fields preceding the formulation of the RDF-T. It expounds upon the research aims, questions, objectives, and hypothesis, outlining the methodology combining qualitative and quantitative approaches. It provides an account of the 3-day workshop involving diverse stakeholders in the Nong Bua area, Chiang Mai City, aimed at experimenting with the RDF-T to derive a framework for built environment design and development. Chapter 2 encompasses a critical review of literature pivotal to the study's fundamental contributions. It explores the evolution of the RDF-T, differentiating it from sustainable and green building design practices. Additionally, it examines existing regenerative design frameworks, laying the groundwork for the study's methodology. Chapter 3 elucidates the methodology employed in conducting the research, using previous research papers and emphasising involving stakeholders in designing the built environment. It aims to improve current regenerative design methods by finding gaps and working towards a new framework combining different knowledge areas.

Then, Chapter 4 intricately details the creation of the RDF-T, addressing identified gaps in existing frameworks and amalgamating the regenerative design principle with

Thailand's Rating of Energy and Environmental Sustainability (TREES) and Backcasting techniques. The chapter outlines the RDF-T's structure and experimentation using the Nong Bua as a case study. In Chapter 5, the focus shifts to the selection criteria of the case study area and the rationale behind choosing Nong Bua, elaborating on the environmental challenges due to urbanisation. It delineates the activities and outcomes of the 3-day workshop, involving diverse stakeholders in the built environment design process. Chapter 6 presents the analysis and validation of the RDF-T's capabilities, incorporating participant feedback and additional data collection methods such as interviews and online focus groups. Chapter 7 reflects on the findings, refining the RDF-T by integrating Thai Socio-Ecological Characteristics and defining Regenerative Design for the Thai context. It introduces manuals for the RDF-T, aiming to disseminate understanding among local practitioners. Finally, Chapter 8 concludes the study by summarising findings, addressing limitations, and suggesting a roadmap for future work in regenerative design and development within Thailand. It reflects on the RDF-T's potential application beyond Thailand and its adaptability based on specific socio-ecological characteristics.

Chapter 2

Literature review

2.1 A Question to Sustainable Principle

The notion of Sustainability is a principle that has been developed as a solution and strategy against environmental problems. The most considerable problem is human activities that demand natural resources and invade nature. However, it is reasonable that humans need natural materials to help humankind survive and support our collective well-being. Unfortunately, excessive need and harmful activities have massively impacted the natural system. The sustainable principle thus emerged, and the definition of Sustainability, presented in the Brundtland Report for the World Commission on Environment and Development in Rio de Janeiro, 1992, mentioned that Sustainable Development is “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (*Our Common Future : the World Commission on Environment and Development*, 1987). Subsequently, since the 20th century, most campaigns have intended to use the notion of sustainability to solve environmental problems. Sustainable development is presented in terms of preserving natural resources for the next generation, creating sustainability for human life, improving natural conditions, and using the preservation and development of the ecosystem as a regular approach (Azizi, 2006). Over a few decades, sustainable development and design have been applied in every sector to help improve and protect the world environment from degradation. Obviously, the sustainable principle has been

applied to Sustainable architecture, Sustainable human resources, Sustainable agriculture, Sustainable economics, et cetera (Pourdehqan et al., 2015)

Generally, the structure of Sustainability, as shown in Figure 2.1, is presented through the concept of three pillars: Social, Economic, and Environmental. This is known as "the triple bottom line" and is related to the "3Ps", which are "People", illustrating equity and community well-being; "Profit", demonstrating the vitality of economics; and "Planet", illustrating environmental conservation. Sustainability means balancing the triple bottom line from an individual scale (individual habitat) to neighbourhood, local community, town, country, and across the world. Sustainability development suggests using the triple bottom line as the main idea that shares standard criteria to decrease harmful impacts on the environment and ecosystem while maintaining the well-being of humankind (Al-Kodmany, 2018). Consequently, the sustainability principle has been studied and researched for decades and continually developed for the benefit of the current generation and future generations. However, it will be more practical if the sustainable principle includes all crucial factors that can establish genuine sustainability across all living systems.

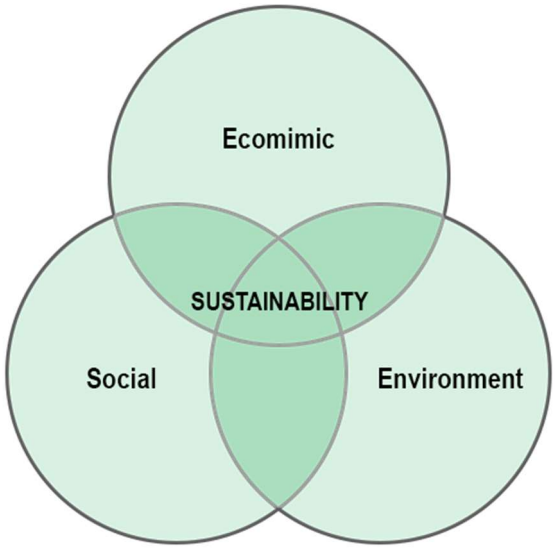


Figure 2.1 The concept of the triple bottom line for Sustainability

The rising of environmental issues provokes the awareness of re-establishing genuine sustainability in terms of developing the conventional design practice to suit the current challenge in ecological development. The researchers and scholars said environmental issues should decrease continually if mainstream design and development approaches are workable for solving problems (du Plessis, 2012; Littman,

2009; McDonough & Braungart, 2002; Reed, 2007). Mitchell Joachim, a professor of architecture at Columbia University and an Ecological designer, shared his opinion on sustainability in an interview with Tom Vanderbilt of Wired Magazine, saying, "I do not like the term. It is not evocative enough. You do not want your marriage to be sustainable; you want to be evolving, nurturing, learning. Efficiency does not cut it either, it just means less bad"(Vanderbilt, 2008). Therefore, critics of sustainable development mention that the original purpose of sustainability of the global dimension is to reconcile the problematic relationship between humans and nature that was dismissed along the process. Moreover, du Plessis (2012) mentioned that sustainability is not a compilation of the Social, Economic, and Technological solutions; instead, it emerges from the interactive process of these three systems (du Plessis, 2012). These arguments imply that efficient sustainability does not solely maintain and revitalise the vitality of society, economy, and environment; it instead focuses on the interdependence of these three aspects to continually generate and nurture their quality for long-term benefits.

The application of sustainable design and development adapted in architecture has been shown in diverse approaches such as sustainable design, green design, and environmentally friendly building design. Notably, in terms of sustainable architecture, the current impact of sustainability is solely examined concerning the enormous impact of buildings on the environment. This practical standard does not supply a viable solution for the next generation yet is solely concerned with the present while ignoring the effect on the future (Littman, 2009). Moreover, Mahir (2014) illustrates that the current sustainable practice designs solely focus on the efficiency of the building in aspects of energy effectiveness and the productive consumption of resources. A building is designed to be as passive as possible without causing a harmful effect on the surrounding environment. (Mahir, 2014).

In some cases, the building design focuses on reducing consumption from one of the ecosystem services by designing it as a zero-energy or water-positive landscape design. These design approaches could improve and conserve one part of ecosystem services, yet it is also important to consider other aspects. When one is improved, the other should not be degraded (Daily & Matson, 2008), meaning that the improvement and conservation of ecosystem services should be considered in tandem, including every element. An example of an effect is that a plantation that aims to reduce carbon dioxide without an awareness of choosing the tree species that are compatible with the area

could affect local organisms' living system when uncommon tree species invade a native plant area (Zari, 2017). These statements imply that a current conventional sustainable practice mainly focuses on building performance that considers using less natural capital to reduce harmful effects on the environment. On the other hand, it reveals that in the design process, there is a recognition of human activity and consumer behaviour, including technology, which possibly does less harm to nature, and these are potential solutions and design approaches for maintaining the quality of the environment without having natural factors in an equation of sustainable design. Nature is put aside while humans seek a way to retain it by considering it an important thing that humans need to protect.

According to McDonough and Braungart (2002) and Reed (2007), acknowledging ecosystem services, which means the various benefits that humans receive from natural capital for our well-being and quality of life, is the ideology of stimulating humans to think beyond the general "recycle, reduce and efficiency" of sustainability standards (McDonough & Braungart, 2002; Reed, 2007). Therefore, the role of current sustainability may be different in the next decade, as containing the vibrancy of a living system requires continual maintenance of its flexible ability to generate novel and changeable elements (Julia Parzen and John Cleveland and Scott Bernstein and Robert Friedman and Carolyn, 1996). Based on Charles Krone's framework "Level of work", demonstrated in *Figure 2.2*, this framework is influenced by the work of David Bohm with the theory of the living system. As depicted in the four levels of work, to encourage genuine sustainability, the engagement of these four levels by entire living systems is needed due to the interdependent relationship of all living systems that share in the world nest of diversity, complexity, and dynamicity (Krone, 1992).

Figure 2.2 The diagram of Understanding regeneration as a level of work, modified from (Mang & Reed, 2012, p. 27)

The lower level represents the work of existence development, which shows conventional sustainable practices that have been emerging to maintain the current system's operation to sustain itself. This is in terms of resource productivity or the efficiency of resource consumption. Interestingly, the upper level indicates beyond potential development by showing a continued involvement of the two working systems (improvement and regeneration) and focuses on the potential of life in terms of evolving the capability of every single unit and integrating with a greater level to improve and regenerate the whole biodiversity system which possibly provides benefits for all. Thus, to encourage genuine sustainability, the combination of these two upper and lower levels is required (Mahir, 2014; Mang & Reed, 2012). Regarding opinions against the sustainable principle, Littman (2009) says that responding to sustainable living means humans require few needs for life that are essential for the current and future. Littman asks why we wouldn't go beyond sustainability and move forward for better health, wealth, and abundance. Our ambition should not be solely a dynamic of sustainability for humans; instead, we should consider a dynamic of regeneration. Recent human lifestyle and behaviour have degraded the world's ecological quality and increasingly caused permanent damage (Littman, 2009)

As has been discussed, the uncertainty about sustainable development and design has led to the study of regenerative sustainability as a developed part of ecological approaches in regard to evaluating built environment design (Mang & Reed, 2012). This showed that the challenge of sustainability requires reconciling with nature by reweaving humans' activities and harmonising their relationship with the greater level of life's web for mutual benefit with nature and other organisms. At the same time, this process can help restore and regenerate a capacity of natural resilience and strengthen social living systems (Benne & Mang, 2015; du Plessis, 2012). Further sustainability development led to the study of the regenerative sustainability paradigm as a coherent approach that was first introduced in the mid-1990s (Mang & Reed, 2012). The concept of regenerative design and development is examined within the theoretical aspect of sustainability (du Plessis, 2012), in which the regenerative approach possibly increases the natural and social resources that potentially help resilient the better ecosystem when compared with the previous design development paradigm (Birkeland, 2008). A robust ecosystem from a regeneration process potentially reinforces mutual benefit for humans and nature as it is at the heart of designing and understanding true sustainability. A

precise description of regenerative design and development is explained in the next section.

2.2 What is regenerative design?

Regenerative design is one design paradigm in the planning and sustainable design fields. Many of the theoretical cores that combine to present regenerative design have thrived from the previous study of professional planning and design fields concerning ecological design and pattern literacy (Miller, 2012, p. 10). Many premises are mentioned in literature on planning and design, stating that the integration of natural systems and humans can emerge through the built environment design process.
A seminal book by Ian McHarg, "Design with Nature (1969)", was an initial document that presented the idea of an "ecological worldview" in terms of the suggestion that each place has to plan based on its local natural processes (McHarg, 1969). Therefore, similar notions shown in "A Pattern Language (1977)" and "The Timeless Way of Building (1979)" by Christopher Alexander identified the essence of pattern literacy presented in landscape design as an approach to design with nature. These notions of pattern in nature have an important role in underpinning the current concept of unbanning ecology and ecological restoration, including regenerative design (Alexander, 1977, 1979; Miller, 2012).

The notion of regenerative design has been presented since the mid-1990s when the term was developed by John Tillman Lyle, a professor of Landscape architecture at the California State Polytechnic University in Pomona, California. He is the author of "Regenerative Design for Sustainable Development (1994)". He was the principal architect and erected the Centre for Regenerative Studies at the California Polytechnic. He identified the connection with the "regenerative organic agriculture" concept of Robert Rodale, who was the president and chief executive officer of the Rodale Institute. Initial regenerative organic agriculture was developed for agricultural land use and was known as "permaculture" (Rodale Institute, 2014), which is a terminology of permaculture that was coined and developed by David Holmgren, an Australian environmental designer and ecological writer and educator; thus, he is well known as one of the co-originators to develop the permaculture concept in practice with Bill Morrison (Mollison & Holmgren, 1978). Additionally, according to Bill Mollison, the co-originator of permaculture at The Permaculture Research Institute, permaculture is a philosophy and method to design sustainable settlements for humans to apply to land

use that is delicately connected with plants, animals, water, soil, microclimate, and humans' needs to create a productive and ecologically harmonious community. With these practical approaches, Lyle saw the possibility of adapting these ideas into the whole system that could maintain life since regenerating means to 'create again'. Therefore, Lyle provided the definition of regenerative design, which is the replacement of a recent linear flow system with cyclical flows at sources where natural resources have been utilised in the consumption process. Those natural resources are then regenerated and returned to the sources. Within this operational process, the use of materials in a regenerative system provides continual replacement throughout its operation (Lyle, 1994, p. 10; Zanni et al., 2013). *Figure 2.3* shows a cyclical flow of natural resources in the regeneration process extracted from Lyle's thought.

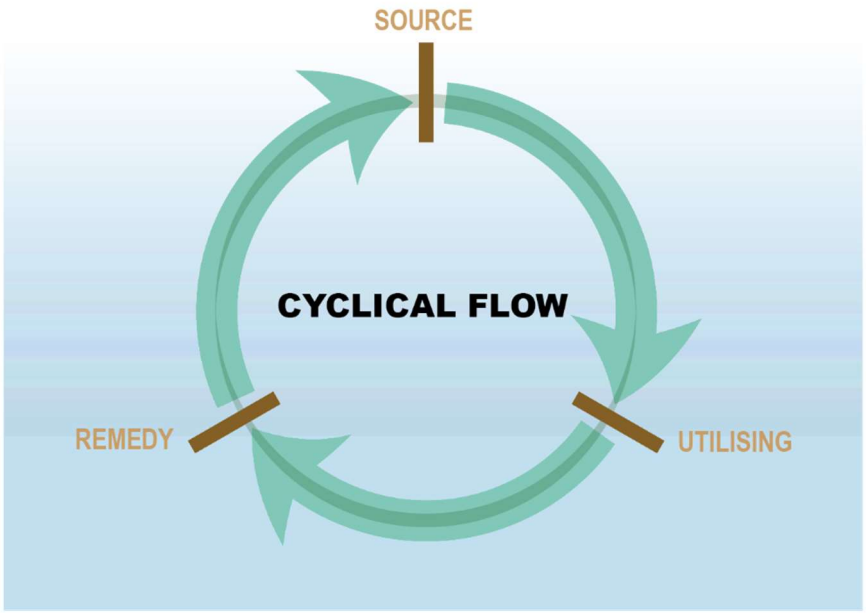


Figure 2.3 A Cyclical flow of natural resources in the regeneration process

Moreover, Lyle explained 12 strategies that the regenerative design process should follow in terms of producing an effective design when considering humans and nature in the development system for the most suitable benefit and harmony of the ecosystem. The 12 strategies for effective design are: -

1. Let nature do its work
2. Considering nature as an instance and context
3. Do not separate but aggregate

4. Looking for appropriate levels for varied functions, which is not a minimum or maximum for one individual
5. Matching needs with technology
6. Replacing power with information
7. Providing multiple directions
8. Looking for general solutions for different issues
9. Managing storage
10. Shaping a form for guiding a flow
11. Shaping a form for manifesting a process
12. Prioritising for sustainability

After Lyle coined regenerative design, many scholars and researchers have studied and further provided interesting descriptions of it. Based on previous studies, regenerative design is the study of mapping the relationship between humans, nature and its place condition for the mutual benefits of a whole living system. Throughout a regenerative cyclical flow system, a foundation of a sustainability paradigm strengthens an ecosystem that emphasises that humans and nature are involved in part of the design process (Lyle, 1994). There are other opinions about regenerative design shown in this section; for instance, in 1996, Sim Van Der Ryn (Architect, Researcher, Author and Educator) and Stuart Cowen (Director of Regenerative Development for the Capital Institute) illustrated their thoughts about regenerative design in their book "Ecological Design". This work asserted that regeneration is expanding natural capital through the degradation of ecosystems and communities' active restoration. This process is renewing and healing that helps harmonise the wealthiest possibilities of culture with nature. Regeneration is not solely preserving and protecting natural capital, but it helps restore an abundance loss (Van der Ryn & Cowan, 1996; 2007, p. 37). Pamela Mang (2001), the principal and co-founding member of Regenesis Group, Faculty and Curriculum Designer, The Regenerative Practitioner, provided an interesting view of regenerative design. She said that regenerative design is the proposal of a design approach which potentially shapes the structure of the subsequent development process within a sustainable design field. The importance of regenerative design to sustainable

design must be considered, yet it depends on its relationship in the context of how the whole of the field has evolved (Mang, 2001). Therefore, Sim Van Der Ryn, Stuart Cowen, and Pamela Mang emphasise that regenerative design has a significant role in terms of harmonising design with nature. At the same time, this approach is able to renew the fruitfulness of natural capital and restore a degraded ecosystem.

Furthermore, Bill Reed (2007), the founder of the Integrative Design Collaborative (IDC) and 'Regenesis Group', holds that the beginning of the regenerative design process stems from an ambition of the need to understand the working systems of life in each particular place. The role of designers and stakeholders is to move the focus onto our correlation to one that potentially provides mutually beneficial correlations for an entire system. This operation shows that green design is capable of moving us beyond a sustainable environment; however, it is potentially regenerating better conditions for both humans and nature (Reed, 2007, p. 674). A supporting opinion from Raymond J. Cole (2012), a researcher and professor of the School of Architecture and Landscape Architecture at the University of British Columbia, Vancouver, Canada, mentions that the regenerative design approach supports the co-evolution of natural systems and humans in an aspect of a partnership. The building is not regenerated by itself as self-managing to contribute to the living system. However, the performance of a building can positively stimulate change that is suitable for the particular context (Cole, 2012a, p. 1). In the same year, Chrisna du Plessis (2012), The head of the Department of Architecture at the University of Pretoria, South Africa, shared her thoughts towards regenerative design, saying that the regenerative ideal manifests an alternative design approach that is involved with living systems by emphasising the co-creative of a partnership between humans and nature with regeneration, resilience, and adaptation strategies. Moreover, the regenerative design paradigm is related to the ecological worldview in terms of creating a basis for a sustainability model (du Plessis, 2012, p. 7).

The timeline of the original explanation of regenerative design and development from the above scholars and researchers is shown in *Figure 2.4* (Cole, 2012a, p. 1; du Plessis, 2012, p. 7; Lyle, 1994, p. 10; Mang, 2001; Reed, 2007, p. 674; Van der Ryn & Cowan, 1996; 2007, p. 37).

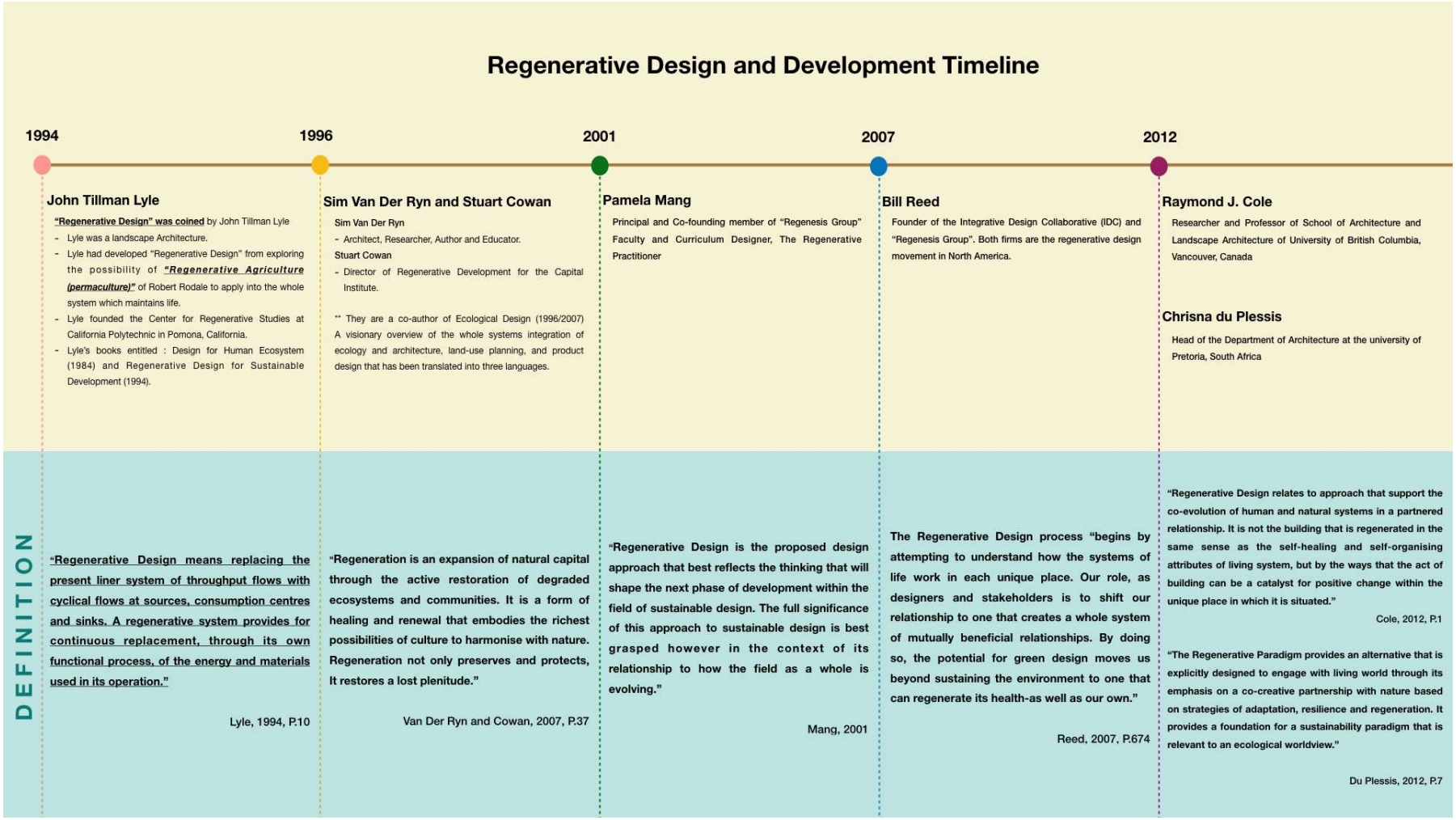


Figure 2.4 The timeline of the original explanation of the regenerative design and development

As previously mentioned, regenerative design thinking focuses on the co-evolution of humans and nature to work as a partnership to help regenerate an ecology for the mutual benefit of a whole living system. This design paradigm has shifted from an efficient building that can organise itself to an interdependent development with nature and the capability of genuine sustainability. Importantly, the regenerative design promotes a sustainable approach regarding underpinning robust natural systems (Mithun, 2004; Williams, 2012) while immersing them within the regeneration approach. This is in various degrees of significant design concepts, i.e. green building design practice, resources and material recycling, the efficiency of resource flows, processes and functions of the ecosystem, and ecological footprints, for the specific focal point of "upcycling" which means a continuous improvement of quality that includes the function and process in an ecosystem and the flows of resources (McDonough & Braungart, 1998; Waldron et al., 2013). These notions of the regenerative design concept show that this design paradigm endeavours to strengthen ways to reach genuine sustainability with the emphasis on integrating the design approach with an internal function and processes of living systems to create new and healthier ecosystem conditions that could urge the whole system to co-evolve for an extended period. The basis of regenerative design and development is that the interdependence of all living systems is woven and fostered by one another in a complicated and sophisticated nest of the biosphere, which helps create a diversity of life on this planet.

To simply understand the core idea of regenerative design and development, *Figure 2.5* shows a comparison of regeneration and degradation as these two concepts are divided into two parts on the scale, with sustainability at the middle point. *Figure 2.5* demonstrates that regenerative design has derived from the theoretical movement of sustainability in terms of differing from a common sustainability paradigm to go beyond 'doing less harm' or preventing degradation to maintain the quality of the ecosystem. Researchers and practitioners such as Bill Reed (2007) and Josette M. Plaut et al. (2012) mentioned that each conceptual paradigm shown on the scale distinguished the general definitions of Degradation, Sustainability, and Regeneration. Degradation means to decrease the value of the surrounding function in the systems, Sustainability means to maintain and sustain the value of the surrounding function in the systems, and Regeneration means to create new life, strengthen, restore and improve the values of the surrounding function in the systems.

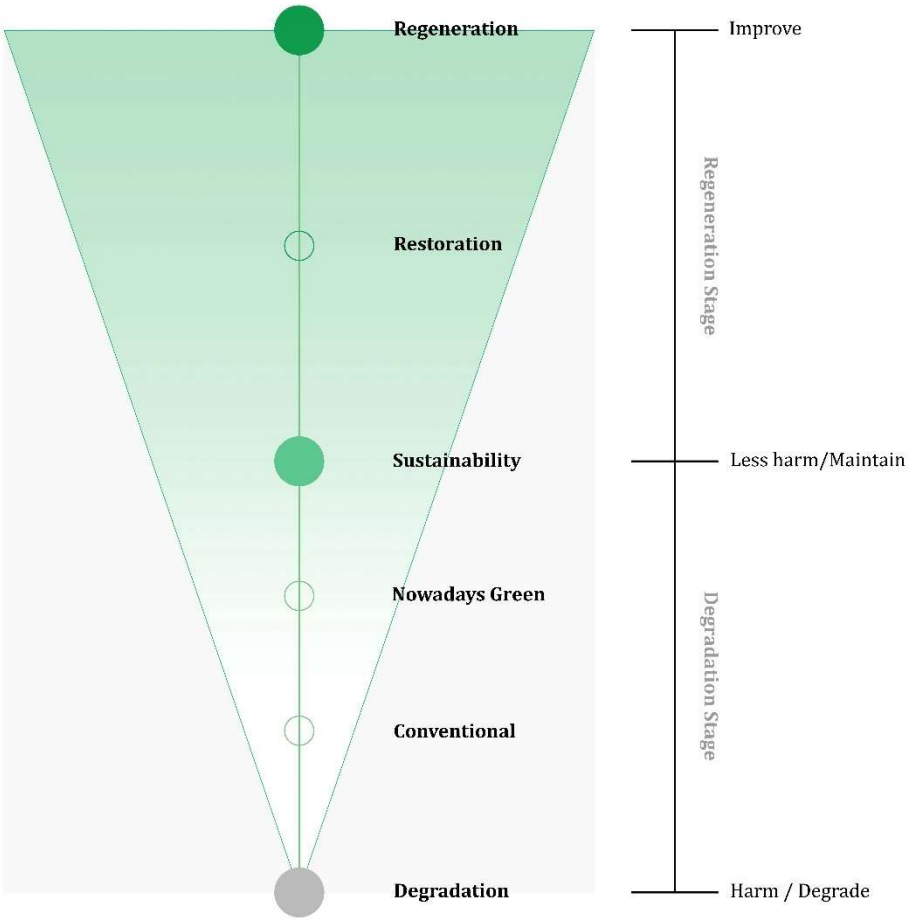


Figure 2.5 The diagram shows the difference between regeneration and degradation. (This diagram is modified from (Miller, 2012, p. 11; Plaut et al., 2012))

2.2.1 The Differences between Green building design Sustainable design and Regenerative design

The evolution of regenerative design and development has been improved to advance the capability of sustainable practice in terms of supporting a robust natural system in the ways that have been mentioned previously. Therefore, *Figure 2.5*, as shown earlier, can distinguish the differences between Green building design, Sustainable design, and Regenerative design. This diagram illustrates that nowadays, green or green design practices have developed from conventional practices that could lead to a degradation stage of natural resources and the ecosystem. With the change of time, it has been developed into a sustainable design that aims to maintain and sustain natural functions and systems with the mission of preserving natural resources for the needs of the next generation. On the other hand, theoretical regenerative design practice believes that natural capital's maintenance and sustainment are insufficient due to excessive

consumption demand to fulfil human needs. Natural capital and the ecosystem require continuous remedy, restoration, and regeneration to balance consumption and production.

Generally, the difference between 'green' and 'regenerative' is commonly illustrated as sustainability in achieving a net-zero impact (Cole, 2012b). Therefore, current green building design practices remain essential despite the fact that green building design needs to be aware of the contexts in social and ecological dimensions (Moffatt & Kohler, 2008). Consideration of the reconciliation of humans and natural systems in a particular condition and context reveals that there is a need to recontextualise existing approaches and explore new intelligence (Cole et al., 2012). It is normally accepted that green building design assessment procedures clearly stimulate greater requirements to ensure the performance of being a successful environmental building. However, an interaction between a design team and relevant stakeholders is crucial and necessary; this action potentially leads to a practical green building performance assessment in which regenerative design and development differentiate ways of thinking to focus on the design process and responsibility in a professional manner. Regenerative design and development prioritise the importance of the participation of stakeholders in relevant sectors to building design as an awareness of the real concern of socio-ecological aspects. It contrasts with a typical green building design that emphasises the comfort of humans and reduces harmful impacts from the construction of the built environment without considering involving natural system functions in the design process (Cole, 2012b). With a similar concern, Birkeland (2012) states that green building design is devoted to the comfort of occupants while ignoring the impacts of an external environment (Birkeland, 2012).

Following sustainable design practices, they are approvable and measurable in terms of responding to the needs of the present generation without disrupting the needs of future generations, sustaining nature and the ecosystem by grasping the triple bottom line to maintain the environment, economy, and society in a proper condition to create a sustainable world. However, criticisms regarding environmental issues have increased, leading scholars and researchers to question its capability and strategies as it might not cover all aspects in order to establish a genuinely sustainable planet for all living systems. Obviously, the goal of sustainable design and development is solely focused on energy efficiency through green strategies. Nevertheless, regarding reducing negative

impacts on the environment, such as zero carbon emissions, efficient energy usage, and water and waste recycling, these activities are valuable yet slightly challenging in the architecture and urban design field. In order to design a built environment, there is a need to step beyond attempts to limit and control adverse outcomes to the environment and aspire to a net-positive for environmental benefits. The implication of these ideas reveals that the built environment process would require more than just a consideration of natural capital consumption; at the same time, restoring the environmental damage of the past and present is needed (Zari, 2012).

The main idea of net-positive and net-zero development is a fundamental aim of a sustainable approach; however, both do not adapt to all essential factors for an actual holistically sustainable practice. To give an example, whilst the net-positive concept is applied in buildings in terms of energy effectiveness – in turn, the external environment, biodiversity, natural resources, and water flows may have a negative impact (Mahir, 2014; Plaut et al., 2012). Mahir (2014) has distinguished the critical characteristics and the differences between general sustainable design practice and regenerative design practice, which is beneficial in terms of providing a clear understanding of this manner, which is shown in *Table 2.1*.

Table 2.1 The critical characteristics and differences between general sustainable and regenerative design practices (modified from (Mahir, 2014, pp. 26-27)).

The Critical Characteristics	**The differences in practice**	
	Sustainable Design Practice	**Regenerative Design Practice**
Acknowledgement	The best practice at present	The practice of regenerating natural conditions before the actual development
Potentiality	Depending on the nation or world standards	Depending on the particular site story and local natural capital
Operation	Depending on the mechanical worldview	Interdependent with an ecological worldview
Assessment of success	Building performance that individually developed	Building performance that developed as a part of co-evolution with nature

The Critical Characteristics	The differences in practice	
	Sustainable Design Practice	**Regenerative Design Practice**
Designer's role	Acknowledging the site's conditions	Understanding and illustrating the site's potential
Information exchange	Multidisciplinary	Multidisciplinary on a broader scale
Natural resources	Decelerating degradation or maintaining quality	Accelerating the development and improving quality
Aim	Reduction of consuming resources	Regenerating natural sources
Consideration	Quantity	Quality
Net-Flows	Focus solely on energy flows in terms of Net-Positive	Focus on holistic flows in terms of Net-Positive
Relevant Technology	Technology related to the control of renewable resources	Technology related to renewing natural resources actively
Measurement of resilience system	Energy Efficiency	Biodiversity
Archetype	Existing urban systems	Nature systems
Analysis	A capability of individual function in the system	A relationship pattern with functions in the systems
Evaluation tools	Measuring with the quantitative metrics	Mostly measuring the quality through the process

Based on studies of development from conventional design to sustainable design practice and going further to regenerative design practice, *Figure 2.6* depicts the tendency of ecosystem quality according to variable design approaches. The focus of green design practice has valued human comfort and activity to decrease environmental impact as the design core. In contrast, the sustainable design practice intends to achieve a net positive/net zero by focusing on human needs and activity in terms of using resources and energy efficiency. In comparison, regenerative design practice considers a partnership and co-evolution between humans and nature to generate a healthier ecosystem as a crucial strategy to create a holistically sustainable world for all living systems. Existing research reveals that green design and sustainable design practices mainly prioritise humans' importance in dominance over nature; it could be said that natural well-being depends on human activities, and even those activities potentially restrain ecosystem degradation. In contrast, regenerative design practices involve working with nature by including the function of natural systems in an account of the design process as an equal partnership to help restore and continue to generate the net flows that benefit both humans and nature.

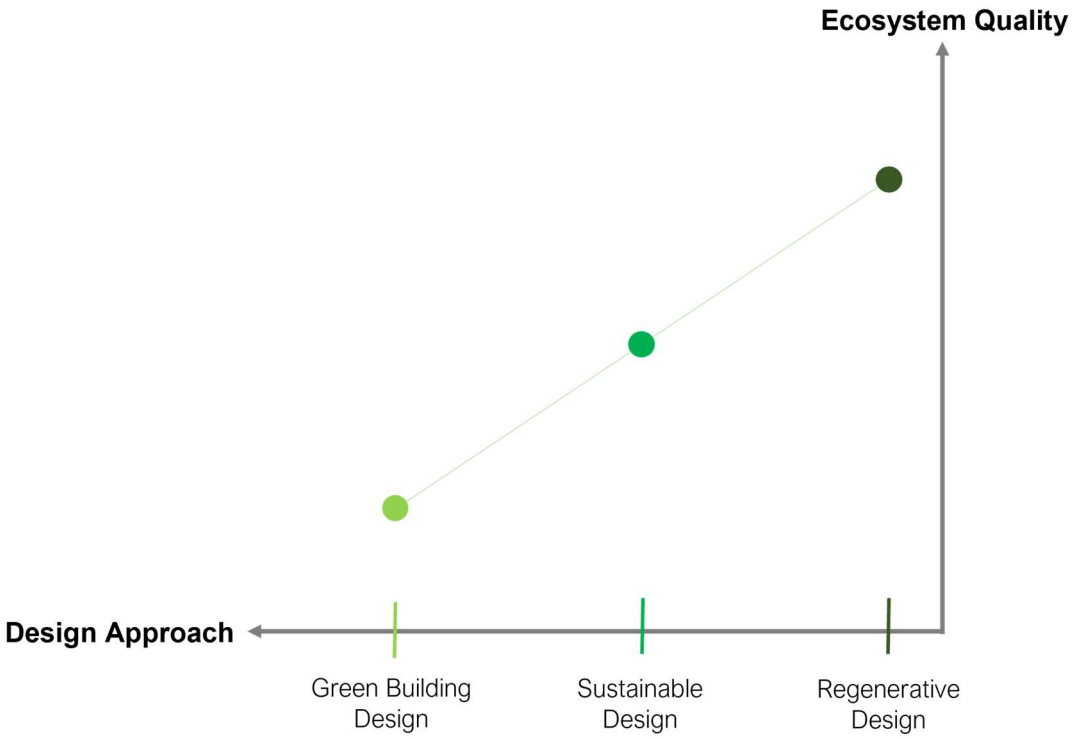


Figure 2.6 Ecosystem quality according to the variable design approaches

It could be claimed that genuine sustainability is balancing production and consumption with the consideration of humans and natural well-being. Although commonly, green design is an initial practice for a complete sustainability goal, regenerative design has reconsidered current sustainable design in terms of the beginning stage and developed its principle further as a potential implement that could create a healthier ecosystem in order to regulate the natural resource loss from urban development over the last few decades (Birkeland, 2012; Mathews, 2011).

2.2.2 Regenerative design approach

As mentioned above, the regenerative design principle is that humans and nature work together as a partnership in terms of regenerating an ecosystem for the benefit of whole living systems in their specific place (Cole, 2012b; du Plessis, 2012; Lyle, 1994; Mang, 2001; Reed, 2007; Van der Ryn & Cowan, 1996) as demonstrated in *Figure 2.7*. This diagram depicts the work between nature and humans in regenerative design as a partnership to help generate a healthier built environment. The regenerative design approach will consider natural function and allow nature to be a significant partner in the design process by prioritizing building design to be suitable for the place's condition.

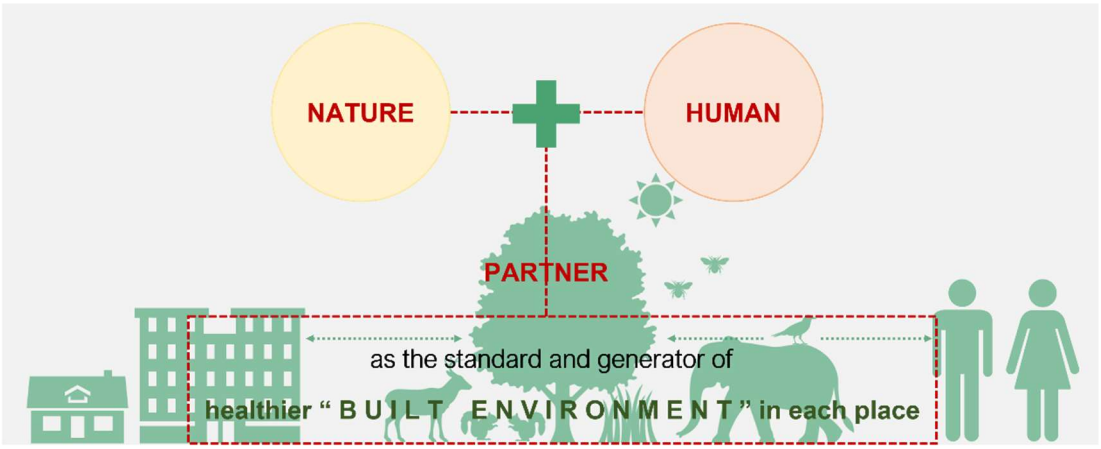


Figure 2.7 The partnership of Nature and Humans in the regenerative design process

A crucial design approach is to understand "A Story of Place" for the greatest benefit of both humans and nature. The story of place can help all stakeholders who have a responsibility for the human role in terms of understanding the place's physicality, topography, microclimate, the pros and cons of the place, the relationship between the ecosystem and community, and the way of life of the local people, including the socio-cultural of a community in which these factors affect the development of a built

environment. Therefore, in a built environment design process, regenerative design requires the stakeholders who are related to the place from various fields, such as property owners, local people, community architects, landscape architects, ecologists, botanists, the local authority, historians (if the place has a historical value), et cetera. Their different backgrounds of knowledge can urge them to share their thoughts and understand the story of a place from diverse perspectives. At the same time, they can exchange their knowledge for effective built environment design, which possibly responds to the needs of the majority of people in the community and provides genuine benefits for all, both humans and other organisms who share the same ecosystem. *Figure 2.8* shows a conceptual diagram of regenerative design summarised from the regenerative design and development experts.

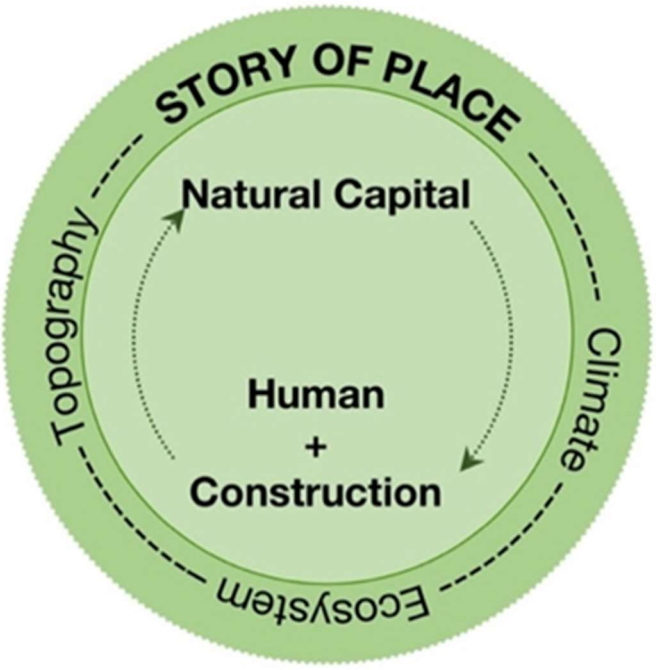


Figure 2.8 Regenerative Design Conceptual Diagram

Normally, a partnership between humans and nature means they have their individual roles – the human role will consider the building design and landscape design for the suitable built environment in the specific place. In contrast, nature's role will utilise its function as a remedy tool to help regenerate the ecosystem. The human role performs in building design by using green design and sustainable design approaches such as Eco-Friendly Design, Biophilia Design, Roof Garden design, et cetera. Landscape design is performed in the forms of Native plant gardens, Edible Landscaping, Community wetlands, Raised Beds, Container Garden, et cetera (Kilroy, 2014). Nature's

role will consider using natural functions effectively, such as tree leaves and roots performing as natural filters, nutrient absorption, and natural remedy for greywater before infiltrating into the ground level, et cetera (Kilroy, 2014). The example of the regenerative design approaches below shows the combination of human and nature's roles within built environment design. These approaches employ the role of humans and nature to benefit both human needs and the ecosystem, which this study has divided into two parts – Regenerative design approaches for Site Invention and Regenerative design approaches for Building for clearer understanding.

Regenerative Design Approaches for Site Invention

Construction/ Restoration Stream daylighting: Stream daylighting above the ground as a natural channel compared with the pipe and culvert stream systems reveals that the stream daylighting system potentially helps carry stormwater runoff that flows from the path around it and can help reduce floods. Therefore, the flow system of stream daylighting can urge bacteria in the water to fix nitrogen from stormwater to naturally infiltrate the groundwater (Kilroy, 2014, p. 10; US EPA, 24 September, 2012).

Construction/ Restoration Wetland: The wetland significantly helps in terms of draining and reserving excessive stormwater runoff to prevent flooding and provide water for cultivation in the dry season; at the same time, the wetland could be a habitat for small aquatic animals. Moreover, a wetland is capable of restoring water quality before absorbing it into the groundwater level. Due to most of the stormwater being full of pollutants – planting vegetated buffers around the wetland could filter massive debris and sediment from the stormwater runoff as a natural remedy process and help to restore water quality. In addition, these vegetated buffers can absorb the nutrients back to the ground instead of letting them flow through the public sewer. Thus, having a clean water resource could prevent and reduce disease that comes along with water flow and might infect aquatic animals and be transmitted to humans (Kilroy, 2014, p. 10).

Using native plants: The use of native plants in landscape design as the physical condition of native plants is the most suitable for the geography and surrounding climate of the site. Hence, the native plants have strong growth potential without the extra maintenance, and with the physicality of the native plants' roots, they can possibly grasp the ground surface and excavate into the dirt level to constantly maintain and enhance the ground quality. Furthermore, we can use the edible native plants in raised beds, container gardens, and urban farms as edible landscapes for all members of the

community. With this approach, it could create a community food production centre and reduce gas emissions during transportation between the community and the marketplace (Kilroy, 2014, pp. 11-14).

Designing a vegetated buffer: A vegetated buffer is a simple method that uses grasses, bushes, soils, and plants to help delay the flow of stormwater runoff. At the same time, the vegetated buffer has the possibility to reduce the amount of phosphorous and help remove nitrogen and sediments from waterways by up to 90%. This remedy can filter debris and sediment before providing groundwater to recharge its quality. For long-term restoration, the vegetated buffer can help improve water quality and tackle streambank erosion and soil erosion. In addition, the vegetated buffer allows the remediation of nature to take part in terms of reducing pollutants that come with waterways and stormwater runoff and possibly help maintain flood problems. Basically, the vegetated buffer should be aligned along the waterways with a minimum slope of around <5%. The maintenance and management of the vegetated buffer is achieved by using the native plants in the local area due to their physical suitability to local topography, climate, and environment (Kilroy, 2014, p. 11).

Reducing impervious paving surfaces and using a pervious pavement: Impervious pavement absorbs solar radiation and emits heat to increase the city temperature; heat emission is the cause of urban heat islands, which will develop into a climate change problem (Akbari, 2005). In other aspects, impervious surfaces contribute to flooding due to stormwater runoff being unable to flow through these surfaces to ground level (Kilroy, 2014, p. 11). Impervious surfaces tackle the flow of stormwater runoff and constrain it to only drain through a public sewer; it is possible that if a public sewer could not bear the massive stormwater runoff, then it could overflow over the city streets. Basically, pollutants come from impervious pavements such as oil, solid debris, and grease from vehicles. The stormwater carries these pollutants, which possibly flow to the natural waterways and could cause wastewater problems. To prevent and reduce these environmental problems, pervious pavements such as modular paver blocks and porous asphalt pavement should be used and installed over evenly shaped limestone rocks. This can help slow the stormwater runoff flow, filter the solid debris and sediments, and easily allow water infiltration into the ground level (Kilroy, 2014, pp. 11-12).

Designing a suitable landscape for the local environment: The purpose of plant selection for landscape design is not solely for decorative function. A regenerative landscape has

the potential to coordinate an ecological function with aesthetic needs while considering using a diversity of native plants that suit the site's condition and purpose in the landscape design. Therefore, understanding the site and surrounding area's histories can help the designer acknowledge the pattern of the ecosystem to re-establish its condition and strengthen the place's fruitfulness and local environment. Regarding regenerative design, the importance of the site is as crucial as the building design. The landscape design can underpin the biodiversity quality that benefits humans and other organisms on site. Moreover, in the initial design stage, a consideration of the landscape can determine the natural characteristics to be preserved and structure a development plan for post-landscaping construction (Kilroy, 2014, p. 12).

Green stormwater management: Stormwater management is one of the most critical regenerative design approaches, as this management can restore the quality of water before it infiltrates groundwater. Since heavy rainwater cannot flow through impervious surfaces, stormwater runoff may carry pollutants such as oil, grease, and sediments into local sewages or waterways. These water contaminations can cause water pollutants. However, if the poor quality of the water is well managed, local waters will be less harmed, and aquatic animals can survive to generate a healthy ecosystem cycle (Kilroy, 2014, p. 12).

Rain Gardens and Bioswale: Rain gardens or Bioretention basins are shallow basins that grow plants to help store, absorb, and then filter stormwater runoff from surrounding streets, courtyards, pedestrians, and roofs. Moreover, rain gardens can help delay water runoff flows, and the physicality of native plants and grasses that are grown in the basins can discharge rough debris and sediments. This process helps filter the pollutants, and it is a natural remedy that allows water to recharge its quality before being absorbed into the groundwater level. In addition, managing excessive water can flow through the pipe connected to the local stormwater system (Kilroy, 2014, p. 12). Bioswales differ from the rain basins; they are the liner plant gardens alongside driveways or at parking lot edges. Likewise, bioswales can help delay the stormwater runoff from driveways. It additionally uses native plants and grasses to capture rough debris and uses the mixture of soil and sand of the bioswale plots as a pollutants filter before allowing the stormwater to recharge and then infiltrate the soil into the groundwater level (Kilroy, 2014, p. 12). These processes help the ground level contain moisture and restore the groundwater quality, potentially affecting soil quality significantly.

Xeriscaping: Xeriscaping landscape uses native plants that require less water; the physicality of those plants fits with the local climate, topography, geography, and local ecosystem. Xeriscaping landscape needs low maintenance while maintaining soil quality, yet mulch should be used to prevent evaporation and restrain weed growth (Kilroy, 2014, p. 12).

Rainwater harvesting: The main benefit of rainwater harvesting is to help reduce the demand for water from the local municipal water supply. Therefore, storing rainwater in a tank can save it for building usage and water bill costs (Kilroy, 2014, p. 13).

Community food production (Urban farm, Edible landscape): Planting edible native plants provides food for the community and can help reinforce natural features and systems (Kilroy, 2014, p. 13).

Diversity of garden design (Raised bed, Container Garden, Rooftop): In the regenerative design approach, a different type of garden design, such as raised bed gardens, container gardens, and rooftop gardens, can be designed for an aesthetic purpose. Likewise, these garden designs help provide food for a single dwelling and community by selecting edible native plants as primary vegetation that suits the design purpose. At the same time, these gardens can be habitats for small organisms, which can potentially increase the area's biodiversity (Kilroy, 2014, p. 14).

Regenerative Design Approaches for Building

Choosing a green building system: The effective way to generate a positive energy impact on the building is by reducing energy usage. Moreover, considering the various active and passive design approaches to apply in the building may reduce the energy requirement while not interfering with residents' comfort. For instance, natural sunlight is the best passive energy to use in the building. It can help reduce the demand for artificial light, which costs energy expenditure for buildings. However, the high temperature and glare of the sun from natural light may affect the residents' comfort (Kilroy, 2014, pp. 14-15).

Solar orientation and tree shading for building: The orientation of a building according to sunlight direction is immensely important due to human comfort partly depending on indoor light and temperature, i.e., if natural light is necessary for the usability of the room, then the layout and void spaces of a room should correspond to the sunlight's direction to reduce the demand for electricity during the daytime. On the other hand,

excessive natural light could increase indoor temperature (Akbari, 2005, p. 21; Kilroy, 2014; Vaz Monteiro et al., 2019) since concrete building surfaces have the possibility to absorb solar radiation during the day. Therefore, this directly affects the indoor temperature, impacting human comfort and increasing demand for air conditioners. A simple way to cool down the building temperature is the use of a tree for shading to intercept sunlight before it directly hits the building surfaces, and the vegetated area could reflect solar radiation better than artificial surfaces (Vaz Monteiro et al., 2019). When the demand for electricity declines, the number of power energy production will automatically reduce, which could mitigate the CO_2 emission of fossil fuel combustion from power plants (Akbari, 2005).

Designing building void ventilation: Designing ventilation pathways through the building void design can effectively reduce the demand for air conditioners. Therefore, when fresh air flows into the building, it can enhance indoor air quality and, at the same time, can help transplant air pollution, humidity, and stale air to the outside (Kilroy, 2014, p. 22).

Cool roof and green roof: A type of cool roof, such as a shingle roof or high solar reflectance roof materials, is able to reduce excessive solar radiation to a building. A green roof can also increase heat resistance, reduce noise transmission from the outside, and assist a building to keep warm during winter and cool down the building temperature during summer. This means a cool roof and green roof can reduce air-conditioner and radiator usage, which emits much CO_2 into the outside air. In addition, a green roof could provide a habitat for tiny organisms. It would be better to grow native plants on the green roof since they require less maintenance and could help revitalise the microclimate and biodiversity around the building (Kilroy, 2014, p. 21).

Dividing a building zone/Considering system sizing/Choosing Energy Star product/ Choosing a digital programmable thermostat: Dividing a building zone in these terms means dividing the building spaces into similar sizes to control thermal needs equally for each space. Servicing those spaces with an HVAC system can help keep different temperatures for the different building spaces. Therefore, for a mixed-use building, this system allows residents to control the heating and cooling system and manage a schedule to set individual temperatures and times. This system can reduce the unnecessary use of building energy. Moreover, the consideration of system sizing to suit the size of building spaces, such as electronic equipment and the mechanical system that

is used for the building operation, potentially reduces the costs of electricity and energy bills. Likewise, using an Energy Star product and a digital programmable thermostat helps save energy and building expenditure (Kilroy, 2014, p. 23). Moreover, these energy-saving approaches can reduce the demand for electricity from the local power plant, which means the production of CO_2 is automatically decreased.

Using green construction material: Recyclable, upgradable and durable materials for building construction derived from the local natural resources are suitable for green building in the long term. Therefore, materials that have few or no volatile organic compounds (VOC_s) can reduce impacts on the human respiratory system and the lifecycle of other organisms in the surrounding environment (Kilroy, 2014, p. 24).

Table 2.2 and *Table 2.3* have summarised regenerative design and the approaches mentioned above, which employ the role of humans and nature to benefit both human needs and the ecosystem. *Table 2.2* has divided the benefits of the site intervention approaches into four categories – Biodiversity development, Water and soil development, Food production, and Renewable resources, respectively. *Table 2.3* has divided the benefits of Building performance improvement approaches into four categories – Biodiversity development, Energy and cost saving, Humans and other species' comfort, and Renewable resources sequentially. Therefore, *Figure 2.9* and *Figure 2.10* shows examples of regenerative design approaches.

Table 2.2 Site Intervention Approaches in Regenerative Design and Practice

Benefits for human and ecosystem	Site Intervention Approaches
Biodiversity Development	Using native plants for Landscape Design and **Edible Landscaping, Raised Beds and Container Garden, Rooftop**
Water and Soil Development	Stream Daylighting, Wetland Construction and Restoration, Vegetated Buffers, Pervious Paving, Stormwater Management, Rain Gardens and Bioswales, Xeriscaping, **Raised Beds and Container Garden, Rooftop**
Food Production	**Edible Landscaping, Raised Beds and Container Garden, Rooftop**
Renewable Resource	Rainwater Harvesting, Greywater System

Table 2.3 Building Performance Improvement Approaches in Regenerative Design and Practice

Benefits for human and ecosystem	Building Performance improvement approaches
Biodiversity Development	**Green Roofs**
Energy & Cost Saving	Cool Roofs, Solar Orientation, Divided Zoning, System Sizing, Energy Star Product, Digital Programmable Thermostat, Passive Solar Heating & Lighting
Humans and Other species' Comfort	Shading, **Green Roofs**, Ventilation Void, **Materials**
Renewable Resource	**Materials**

Figure 2.9 The example of using native plants in landscape design that is applied to the actual site at the University of Strathclyde, Glasgow, United Kingdom

Figure 2.10 The example of an edible landscape design that is applied to the actual site at Chiang Mai Urban Farm, Chiang Mai, Thailand

Notably, *Figure 2.11* shows the potential of the development scale of regenerative design approaches that can be applied from an individual scale to a regional scale. In addition, the regenerative design for the particular site should examine the whole scale of the surrounding environmental conditions and natural patterns from the region and narrow these down to an individual segment of the building to understand its condition as a big picture for the most efficient design that has the possibility to increase and improve biodiversity for a local community (Kilroy, 2014, p. 8).

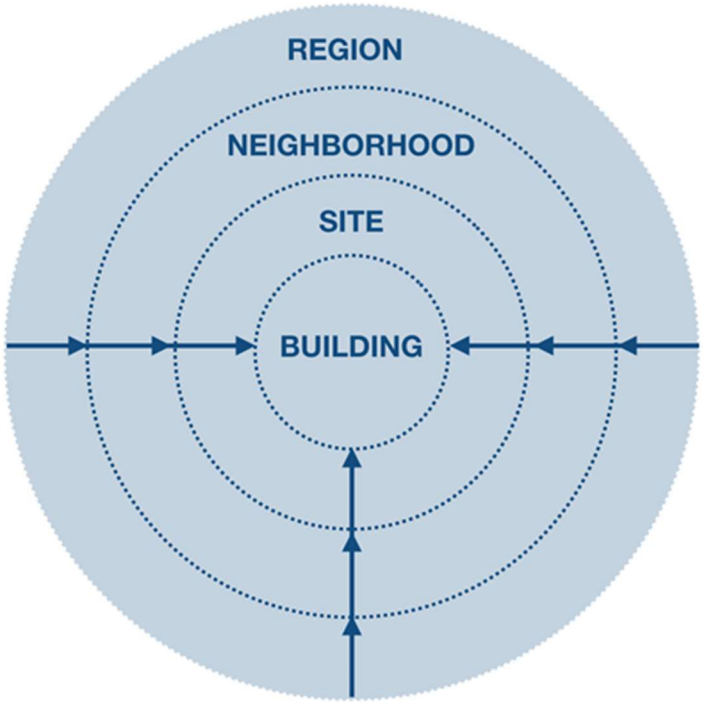


Figure 2.11 The intervention scale of Regenerative Design: Applied from (Kilroy, 2014, p. 8)

However, a regenerative design for architecture requires the participation of stakeholders to create an understanding of the regenerative design principle. Furthermore, the selected participants should not be solely from a design field and occupants but should cover other ecological field experts. Their expertise can help design teams focus more on revitalising an ecosystem. Therefore, the participants can exchange their diverse disciplines among them for the most effective building design overall.

2.2.3 Regenerative design and Ecological system

Environmental problems are a crucial issue that humans and other organisms have been facing for decades. Obviously, the biggest negative effect on all living systems is climate change, which has an enormous impact on an ecosystem that leads to natural disequilibrium when the harmful activity of humans towards nature is the main reason

(Paital, 2020). The majority of research illustrates that one of the severe crises is the urban heat island phenomenon, which affects the temperature of towns and cities. The urban heat island state generally means that the air temperature in cities is higher than in rural areas (Vaz Monteiro et al., 2019). An urban heat island occurs from excessive heat in the buildings and pavement surfaces, and this excessive heat can transfer to the surrounding air and ground level. It is the leading cause of rising temperatures in cities, making humans require air conditioners for comfort. When the demand for electricity increases, the number of electricity production from power plants will be higher, which means the emission of CO_2 and other dangerous gases will dramatically rise. In addition, smog is one of the results of the warmer temperatures in cities; usually, smog formation is a result of a photochemical reaction when it absorbs light energy in the contaminated air, which leads to a chemical reaction that compounds with toxic gas in the air and results in smog-forming. The direct effect of smog on humans has presented in the form of respiratory diseases; it also affects the life cycle of animals, and severe cases might entail the extinction of some animal species (Akbari, 2005; Vaz Monteiro et al., 2019). Therefore, when it comes to climate change and environmental problems, these adverse effects have been the leading cause of zoonotic diseases as the deterioration of the ecosystem affecting animal life cycles and reproductive behaviour and ultimately causing mutations in some animal species that possibly become the cause of acute infectious diseases transmitted from animals to humans (Mills et al., 2010; Paital, 2020; Singh et al., 2011; Wilcox & Gubler, 2005).

According to regenerative design, in terms of enhancing the quality of the ecosystem, the role of regenerative sustainability is to transform a 'mechanical worldview to an ecological worldview or a perspective on a living system' (du Plessis, 2012). Furthermore, regenerative development is an awareness of place conditions and the participation of humans, meaning that the co-development of both potentially encourages a working partnership between nature and humans in regards to regenerating nature and social capital rather than demolishing them, therefore increasing care will likely generate actual sustainability (Cole, 2012b). Regenerative design utilises natural functions in a design partnership with humans, which means that in the design process, the natural function will be effectively used to revitalise and strengthen the quality of nature by itself. Therefore, the regenerative design approach does not solely focus on building design; likewise, it aims to emphasise the surrounding and landscape design to create a comprehensive benefit to entire organisms who share

the mutual ecosystem in the community (Cole, 2012a; du Plessis, 2012; Mang, 2001; Reed, 2007). Currently, amongst a majority number of environmental studies, the regenerative design practice is capable of increasing social and natural capital, and can enhance the development of ecology (Birkeland, 2008) since the regenerative design does not solely conserve and restore an ecosystem; besides, it will revitalise the loss of natural capital's prosperity(Van der Ryn & Cowan, 2007). As McDonough & Braungart (2002) said, instead of using nature as a responsive tool for humans, likewise, humans should be able to become a tool in response to natural needs (McDonough & Braungart, 2002). Therefore, the regenerative design approach focuses on a clear understanding of the story of the place in the aspects of topography, morphology, geography, microclimate, ecosystem, native flora, and the flow of natural resources and includes the anthropological study of local people to utilise this data to underpin the built environment design process for comprehensive benefits to human and nature (Mang & Reed, 2012) This leads designers to design the appropriate built environment which suits the community and potentially establishes a better-quality of life for the ecosystem wherein a human can comfortably live and nature can sustainably rise.

As with the discussions above, there is a possibility that regenerative design is able to mitigate the causes of climate change and other environmental problems in terms of encouraging and amending the poor relationship between humans and nature. Therefore, the regenerative design approaches, such as native plant landscaping design, reducing impervious pavement surfaces, using Energy Star products, cool roof design, and solar orientation and void ventilation designs, could possibly produce green infrastructure and help reduce excessive thermal heat in the surrounding air and ground level. These approaches can help adjust the ecosystem's equilibrium for the survival of all living organisms and nature.

2.3 The Study of Original Regenerative Design Practices

In the past decade, regenerative design and development have become a new therapeutic ecosystem practice through the concept of the co-evolution of humans and other living species. It holds that nature should not solely be a tool for responding to human needs, and humans should work with nature to respond and maintain its prosperous condition. Regarding the regenerative design principle, humans and nature should work together as a partnership to regenerate an ecosystem to benefit the whole living system in the place. During the past decade until now, regenerative design and

development have been considered as an alternative built environment design tool that adjusts the mainstream sustainable and green designs to be compatible with the local natural ecosystem while focusing on the importance of natural functions as a crucial part of co-evolution with humans according to the belief of genuine sustainability for all. Currently, there are several regenerative design methodologies and frameworks that have been employed for built environment designs across the world. The Regenesis Approach, REGEN framework, LENSES framework, and the Perkins+Will framework are examples of regenerative design practices. This part will explain the basis, intention and application of each framework, their strengths and weaknesses, and distinguish their operation before analysing and adapting them into a new framework, which will be explained at the end of this chapter.

2.3.1 Regenesis Approach

REGENESIS Group invented the Regenesis Approach, which intends to use a Story of Place to increase a connection and create harmony with the place (Mang & Reed, 2012, pp. 23-24). In addition, this approach was based on early regenerative practices over the past 16 years, i.e., premises of regenerative methodology (role of humans, a new mind, a new role, working developmentally, et cetera.). Primarily, this approach adjusted these scientific methodological paradigms to structure and distinguish its use while integrating the explored strategies to reinforce its capability in terms of being an effective indicator for the efficiency of the operation process. Based on the studies, the REGENESIS team researched and developed a regenerative development and design framework by distinguishing the exploration structure into three tiers, as shown in *Figure 2.12*; according to the study, tier 1 shows the guideline premises and supportive rationale, including principles that differentiate particular paradigms to underpin the application. The exploration at tier 1 can narrow down the thoughts of practitioners to identify the system of processes and sub-processes at tier 2 that will be used as a framework and strategy to direct the design direction. Tier 3 is a selection of specific methods and technologies that the practitioners have seen and selected these materials as a proper methodology to apply in the development and design project.

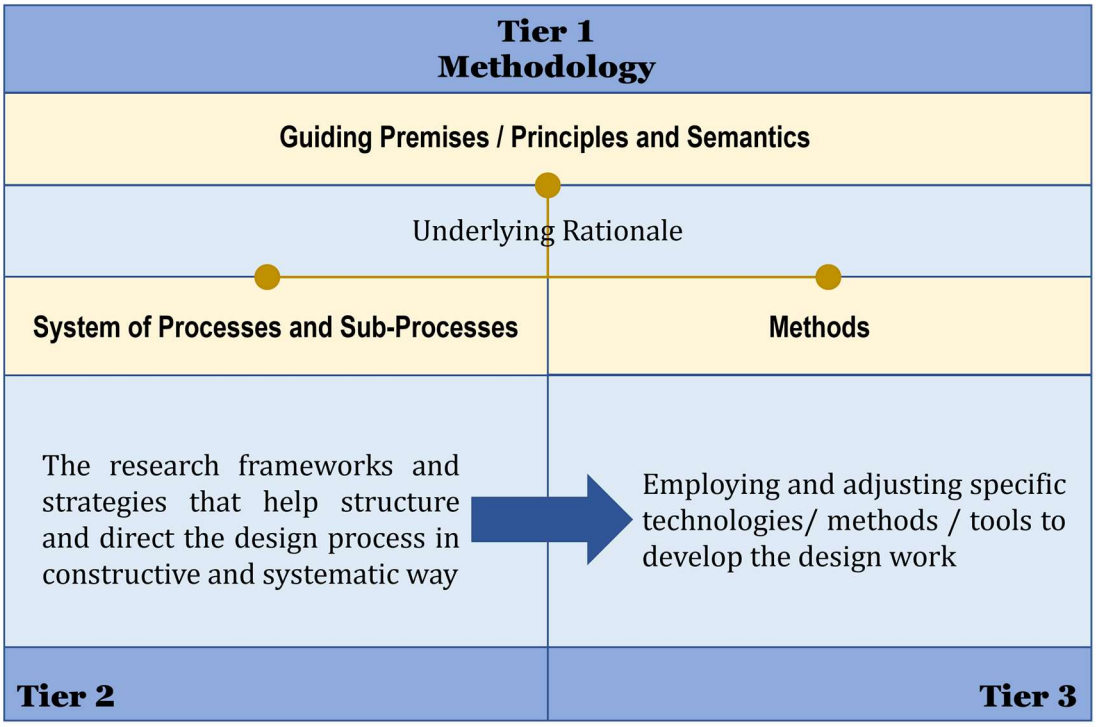


Figure 2.12 The framework shows the way of thinking behind a methodology for understanding the reason for choosing particular principles and methods to apply to the design work (modified from (Mang & Reed, 2012, p. 24))

The REGENESIS practitioners explored a framework through these three tiers' structure and mapped the critical elements, as shown in *Figure 2.13*, which revealed the invention of a sub-design framework depicted in tier 2 and employed it in their projects. As has been mentioned, tier 3 is the selection of specific methods and technologies that are considered along with the sub-design framework; in tier 3, the three distinctive approaches – Living system thinking, Developmental change processes, and Permaculture are fundamental to their regenerative framework development (Mang & Reed, 2012, p. 24). For more explicit details shown in *Figure 2.14*, this sub-design framework represents a Regenesis approach used as a structure and guideline that includes the idea of a regenerative design and development for the REGENESIS Group members to follow. In this sub-design framework, 3 phases of design processes are crucial for the design methodology – Understanding place, Design for harmony, and Co-evolution as the underlying parameters of this framework. Based on the study, the three developmental processes, which are Growing stakeholder partnership, Living system thinking, and Developmental integrative processes, are the main factors in regenerating sustainability for the holistic living system. The REGENESIS group mentioned that these development processes are essential for making this spiral progression, potentially

stimulating the superior built environment design in an actual regenerative design project (Mang & Reed, 2012, pp. 24-25). Apart from the sub-design framework, their regenerative design projects applied specific technologies and methods such as Integral assessment, Pattern analysis, Story of place, Regenerative concept, and Design for a pattern, which these components are capable of reinforcing the outcome of the design process.

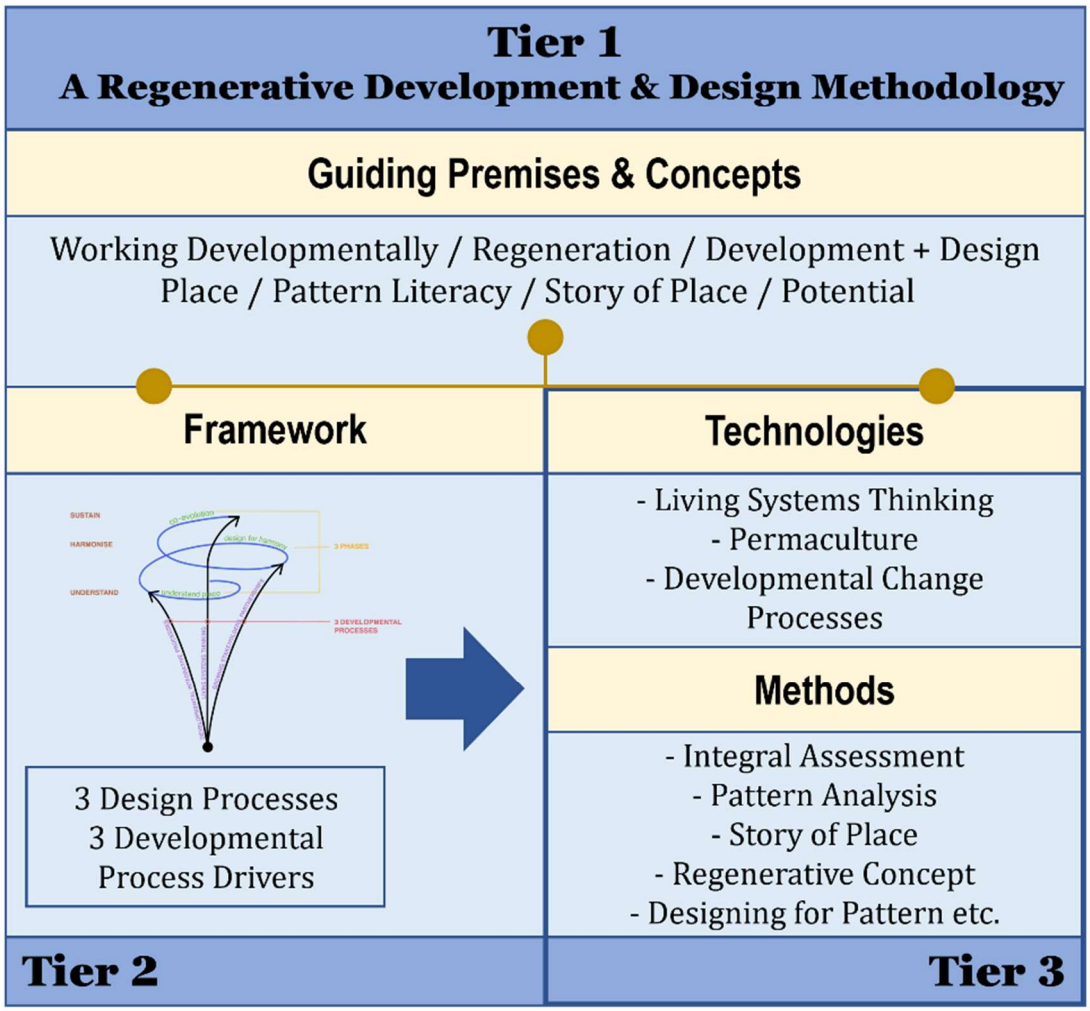


Figure 2.13 The mapping of the critical elements that the REGENESIS practitioners explored through these 3 tiers' structures to apply to a regenerative design and development work (modified from (Mang & Reed, 2012, p. 25))

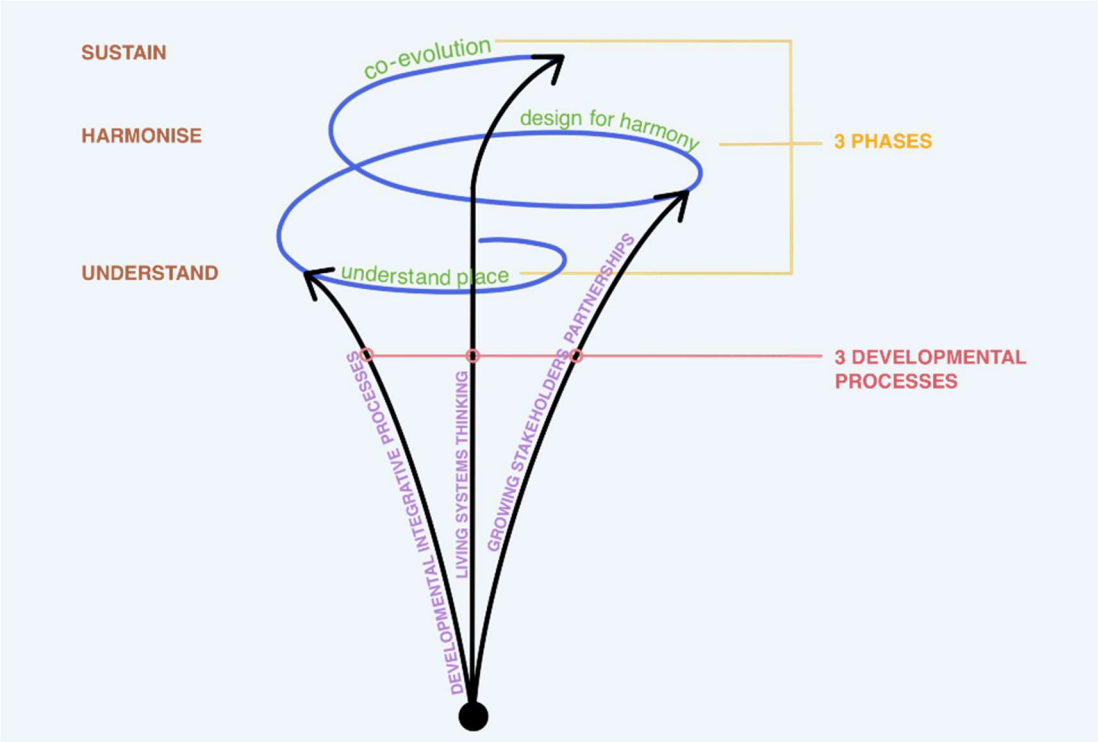


Figure 2.14 The overall design framework that is used as a structure and guideline that includes the idea of a regenerative design and development as a Regenesis approach (modified from (Mang & Reed, 2012, p. 31))

According to the study, the REGENESIS group believed that the core contribution of regenerative development and design is the story of the place; it is the most critical factor that can enlarge understanding of a place's condition to practitioners to create a harmonious design and co-evolution with the surrounding ecosystem. Therefore, understanding and selecting a suitable method to apply in a design work can underpin an efficient design outcome, and this design paradigm provides a possibility to restore the abundance of natural capital that benefits both humans and nature for holistic sustainability.

Therefore, the study reveals that a Regenesis approach shifts the way of thinking from a mechanistic worldview to an ecological worldview for a greater built environment design. The ecological system is sophisticated and complex to imitate its pattern since natural capital in specific conditions and contexts is different. Essentially, practitioners need to acknowledge the actual condition of the place in diverse dimensions before using this information as a support material in the design process. The Regenesis approach focuses on the stakeholder engagement process, which gathers experts, specialists, and community members to co-create a consensus-built

environment design that refers to a connection and deeper understanding of the place from diverse stakeholders' perspectives based on their expertise.

The Regenesis approach implies that by increasing the integration of mutual benefits for humans and nature, the way of thinking is beyond a particular building scale; the implementation of this approach considers the ecological development on a regional scale that starts from a single unit. The previous studies mentioned that the strength of this approach is the possibility of creating a dialogue and understanding between a design team and stakeholders during the engagement process for the ultimate built environment design outcome. However, Miller (2012), mentioned that utilising the Regenesis approach is a slight mention of sharing this approach with the other practitioners outside the REGENESIS group, which could be a limitation of this regenerative design approach (Miller, 2012, pp. 17-18).

2.3.2 REGEN framework

The REGEN framework has been developed by the US Green Building Council (USGBC) focused on developing this framework to be an accessible web-based project database, which is an archive for valuable data to support regenerative design practices that can benefit all design practitioners, i.e., planners, architects, designers, other stakeholders or interested parties in regards to using data in the design projects. Simultaneously, the design practitioners are able to access and input the essential parameters of the specific project in the web database (Svec et al., 2012, pp. 83-85). Initially, the REGEN framework is based on the approach of the principle of biomimicry by Janine Benyus, “Law of Nature” (1997), The living building imperatives (International Living Building Institute,2009), and The LEED 2012 impact categories (USGBC, 2012) (Miller, 2012, p. 32). The REGEN framework is comprised of three intentions: (1) the framework stimulates thinking systems and provides the relevance of particular strategies to share with others for acknowledging different strategies in regard to designing buildings, (2) the framework provides place-based resources that contain information and data related to the particular site, which design practitioners can use in the design projects, and (3) the framework is an archive of examples of regenerative design projects that future design practitioners or interested parties potentially take benefit from the web database.

The web-based feature divides the REGEN framework into four quarters, each with relatable parameters directly concerning regenerative design and development

principles. As shown in *Figure 2.15*, these four quarters are categorised into Robust and resilient natural systems, High-performing constructed systems, Prosperous economic systems, and Whole social systems, with an example of the inputted data (Svec et al., 2012, p. 88). The REGEN framework is intentionally open for diverse regenerative design notions, and it is built to input and store the data of particular locations that potentially help design practitioners access and discover places' stories and use the data for specific projects. *Figure 2.16* illustrates the web-based feature that interacts with and generates data when inputted, presenting the results to the users.

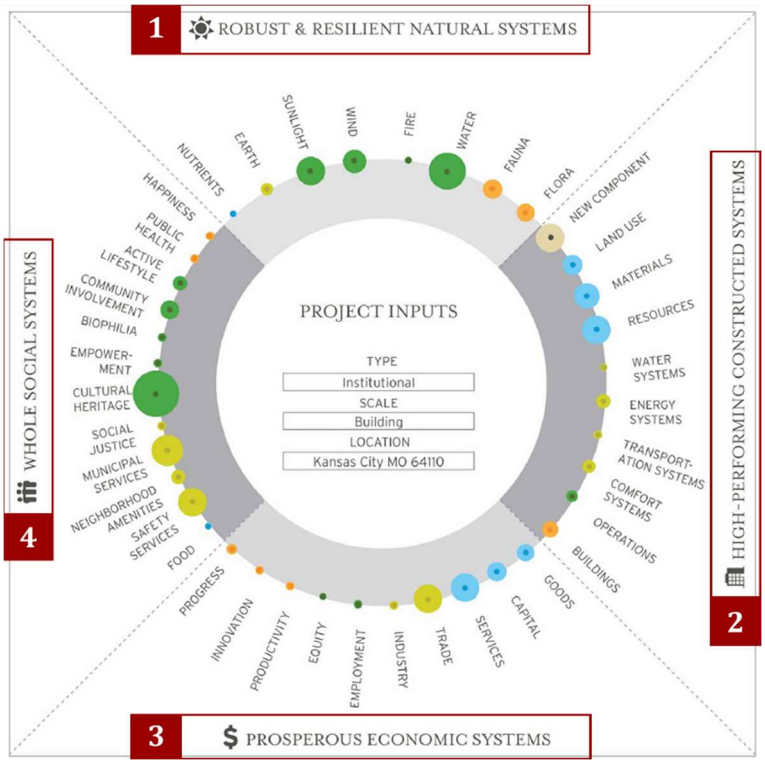


Figure 2.15 The original figure shows the 4 quarters of the REGEN framework, showing the framework's concept with an example of the input data (modified from (Svec et al., 2012, p. 88))

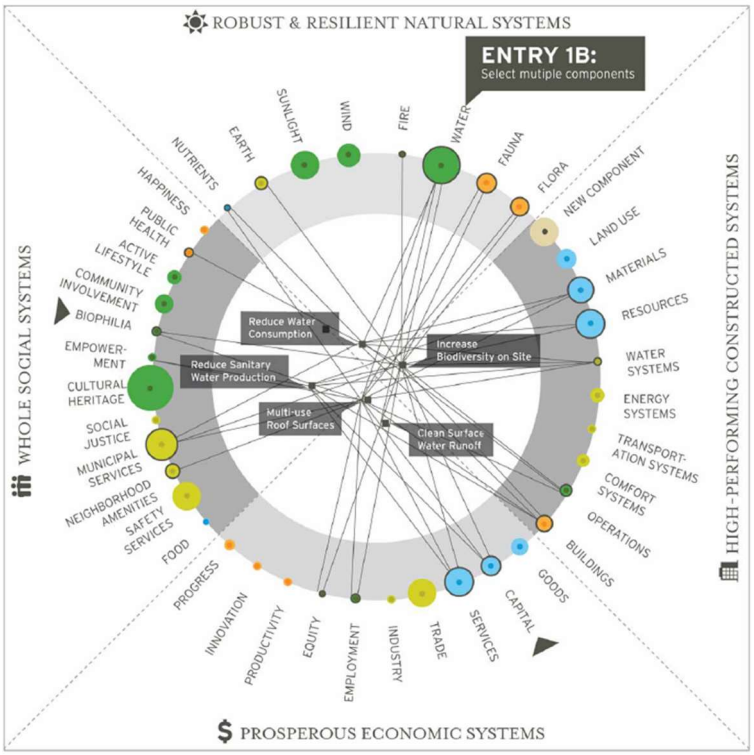


Figure 2.16 The original figure shows how the multiple input data connection to the whole components in each quarter relates to the development with a regenerative design approach (Svec et al., 2012, p. 90)

The REGEN framework is a tool in the form of a web database source that collects the story of place in multi-dimensions, showing the current condition, pros and cons of the places. Meanwhile, this database is constantly updated and enlarged when it receives more inputted information on completed projects. Therefore, this database can encourage design practitioners to access information about previous regenerative design projects and use the acquired data as examples and helpful materials when planning their design projects. For example, design practitioners can learn how to manage limited water supply and apply the design strategies of previous projects to their projects, which can help them acknowledge and design the projects with an awareness of water efficiency.

On the other hand, the design practitioners can use different strategies and approaches to improve the water supply and further provide knowledge for relevant innovations that can help follow interested parties who search for similar information through this platform. Moreover, each quarter under the section – Robust and Resilient Natural Systems, High-performing Constructed Systems, Prosperous Economic Systems, and Whole Social Systems – contains various factors that indicate the particular place's

story and have an impact on the regenerative design. Therefore, all of this data can guide design practitioners to consider the possibility of creating a holistic design for all that share the same environment.

Despite the convenient accessibility, there is the potential for place-based data that has collected the synergy of information as it has been built upon and used by design practitioners. In contrast, Miller (2012) said the obvious weakness of the REGEN framework is the insufficient inputted data in the web-based system due to there rarely being information regarding ecosystem condition and function. With this fact, it remains vague and challenging to organise when application is needed in other regenerative design development projects. Furthermore, the REGEN framework does not mention the stakeholder engagement strategy beyond the initial acknowledgement of the place's information and how to create a shared understanding of the project site. Moreover, the REGEN framework does not necessarily apply to larger projects as opposed to individual building scales, which contrasts with the regenerative design principle that needs to go beyond single-unit development. Interestingly, the study reveals that the REGEN framework is infrequently implemented in the development of the projects, which is considered to be the main weakness of this framework (Miller, 2012, p. 34).

2.3.3 LENSES framework

LENSES framework is the short form for Living Environments in Natural, Social, and Economic systems. This framework has been created by Colorado State University's Institute for the Built Environment and the Rocky Mountain Institute with the intention to link the main idea of LENSES to a principle of the triple bottom line (Natural system, Social system, and Economic system) that has obviously known for being the fundamental basis of sustainability. Furthermore, LENSES needs to shift the concepts of green building as product-based towards the regenerative design approach, which focuses on both product-based and process-based, as this has a possibility to produce positive results through the lifespan of a built environment project that utilised this framework (Plaut et al., 2012, p. 113). Regarding LENSES utilisation, it aims to be a tool for project design and decision guidance based on contextual appropriation for comprehensive support to create healthier Natural, Social, and Economic systems.

The LENSES framework has been inspired by the synthesis of the principle 'Levers for creating change within the human system' by Meadow's and Doppelt's (Plaut et al., 2012, p. 115), which has seven crucial levers of Shifting mindsets, Creating and

rearranging teams, Altering goals, Restructuring rules of engagement, Aligning communication, Correcting feedback loops, and Aligning system and procedures respectively. Interestingly, the LENSES has focused on the top three levers (Shifting mindsets, Creating and rearranging teams, and Altering goals) in terms of using them as an essential idea for developing the framework. As shown in *Figure 2.17*, the LENSES framework has compounded three layers of Lens, and the figure presents the bottom layer as 'The Foundation Lens', the middle layer known as 'The Aspects of Place Lens' and 'The Flows Lens' as the top layer (Miller, 2012, p. 35; Plaut et al., 2012, p. 116). These three lenses are visualised in the overlay layers that show the interrelationship between each component in each lens, which can guide users to understand the whole thinking system that contains essential factors related to regenerative design thinking. In addition, a synergy of these three lenses can define a strategy and direct the design appropriation, for instance, the pros and cons of the place, the current condition of the place, and the relation between place and community.

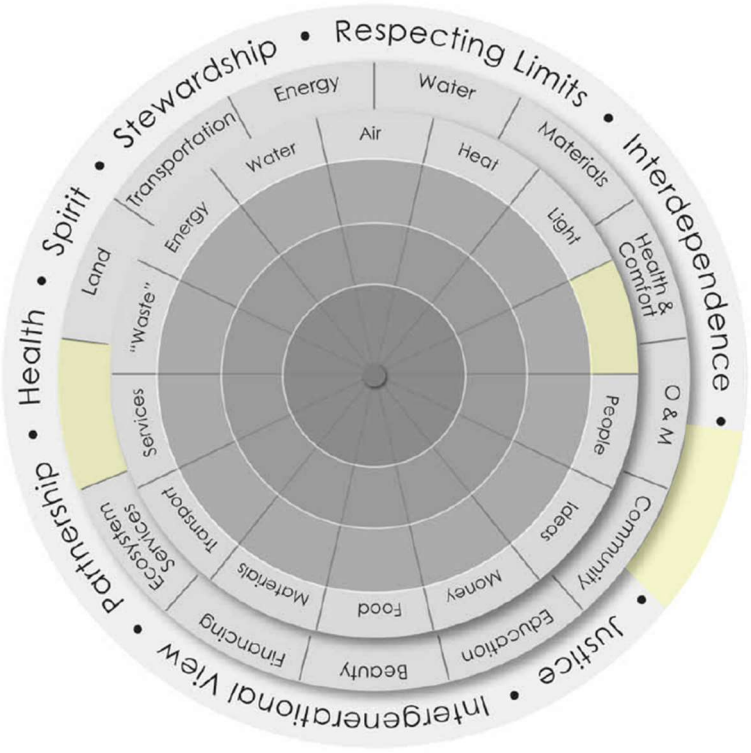


Figure 2.17 The original figure shows the LENSES framework compounded with 3 layers that reveal the interrelationship of each lens to reflect the necessary factors for a regenerative design (modified from (Plaut et al., 2012, p. 116))

In regard to applying these three lenses, the participation of stakeholders in designing focus groups and charrettes is necessary for this practice. In the operation

process, these three lenses have different roles. Firstly, The Foundation Lens will show the essential factors related to the project, combining eight subjects that link to the basis of the triple bottom line. Meanwhile, The Foundation Lens has been initially used primarily to stimulate group knowledge for all participants. Secondly, The Aspects of Place Lens represents a checklist that helps stakeholders evaluate their thoughts towards the regenerative design scope and relatable essentials; this lens provides vital factors that influence the built environment design, such as energy, water, land, materials, et cetera. This lens generally has been implemented in brainstorming processes among the stakeholders to identify a project-specific and potential measurement for the most appropriate outcomes that suit the local context of the place. Thirdly, The Flows Lens explains each element's movement and transformative flows that flow through the place to sustain the environment. Apart from this, this lens helps remind the stakeholders of the Living Environment's purpose for creating a permanent renewable and regeneration cycle in all flows for a continually self-sustaining system. However, consideration of the flow patterns and characteristics varies and depends on a particular region's physical aspects (Miller, 2012, p. 35).

Noticeably, The Aspects of Place Lens and The Flows Lens have similar vital factors, as shown on both lenses. The difference is that The Aspects of Place Lens has identified the project specifics that have been seen through the current physical appearances and attributes of the place. Meanwhile, the Flows Lens represents the movement and relationship with other living systems and distinguishes how these flows impact the place. The exploration of this information can be used in order to describe the interconnection of all flows between The Aspects of Place Lens and The Flows Lens about an occurrence in the place from the past until the present. Then, this can be applied to an overlaying of historical and current flows as mapping guidance to help participants gain a deeper understanding of the place for further decisions to create the most effective regenerative design outcome for the project place (Miller, 2012, p. 35; Plaut et al., 2012, pp. 117-119). Additionally, it is obvious that these three lenses provide an open space in each lens; the purpose is to require all participants to fill in the additional factor that they considered as an extra essential to the project place for the flexibility and adjustability of the comprehensive design.

To give an example of an actual project that applied the LENSES framework, Miller (2012) states that the LENSES framework focuses on prioritising the value and potential

of context, which meets the requirement of the regenerative design principle. Therefore, it could stimulate understanding among participants regarding the story of the place that significantly impacts to the built environment design, which is considered as a strength, while the weakness of this framework is that it might be complicated for participants who do not have a built environment design background or have specific knowledge in the field related to some vital factor categorised in each lens; this concern possibly creates obstacles during the built environment design operation (Miller, 2012, p. 36).

2.3.4 Perkins+Will framework

The Perkins + Will framework has been invented by the Perkins + Will firm in collaboration with the University of British Columbia. The Perkins + Will framework aims to explain and create design approaches and constructive discussions toward the principle of regenerative design and development through a specific project in a specific place. This framework is based on provocative questions that have provided practical orientation for design terms to evoke effective dialogue among the design team and clients. Moreover, this framework intends to expand and engage with various stakeholders through an interdisciplinary design procedure, such as engagement with botanists, hydrologists, ecologists, et cetera (Cole et al., 2012, p. 96).

Notably, the participation of stakeholders is required as this framework is a question-based approach, especially the engagement of the design team and clients to urge a consensus understanding of the design direction and procedure of the project. The basis of this framework has been constructed from the three intentions. First of all, it has to provide a clear underpinning of concepts and imply knowledge and understanding more than simply a checklist of performance issues. The second intention is the capability to adapt to different contextual designs, emphasising the engagement of various stakeholders that involve participants with different backgrounds apart from solely building design practitioners. The engagement process is applied in a preliminary discussion with the users and community members to design activities in which the design team will discuss the specific approaches related to the project. The study reveals that this framework has a consistent system, yet it is adaptable to different contexts and projects. Lastly, this framework acknowledges that some participants barely know regenerative design and development as these notions might differ in their fields. Then, as mentioned before, preliminary engagement is essential. Moreover, to support the engagement process, various green design strategies are the primary tools in regard to

creating a built environment design and using regenerative design approaches to reinforce the design outcomes. Based on the study, the Perkins + Will framework needs to convey how it could provide and strengthen better-quality built environment designs that benefit the surrounding ecosystem (Cole et al., 2012, pp. 98-100).

Referring to the original diagram of the Perkins+Will framework, *Figure 2.18* is the structure of this framework, which has been known as the 'Two Dimensional Representation of Place". Specifically, these two dimensions consist of the Representation of Human and Natural Systems and Representation of Resource Flows. As shown in the figure, the inner dimension presents human needs, which are categorised into four sections – (1) Social Vibrancy compounds the factors that help enhance the connection of society in a local community, (2) Health and Well-being compounds the factors that relate to human well-being; such as water, clean air, healthy foods, energy, et cetera, (3) Healthy Economy emphasises the factors that related to development of a healthy economy; such as reducing the costs of future operations and increasing opportunities for jobs and businesses, and (4) Cultural Vitality emphasises the factors that underpin the liveliness of the culture with strategies that strengthen a sense of place with natural connection.

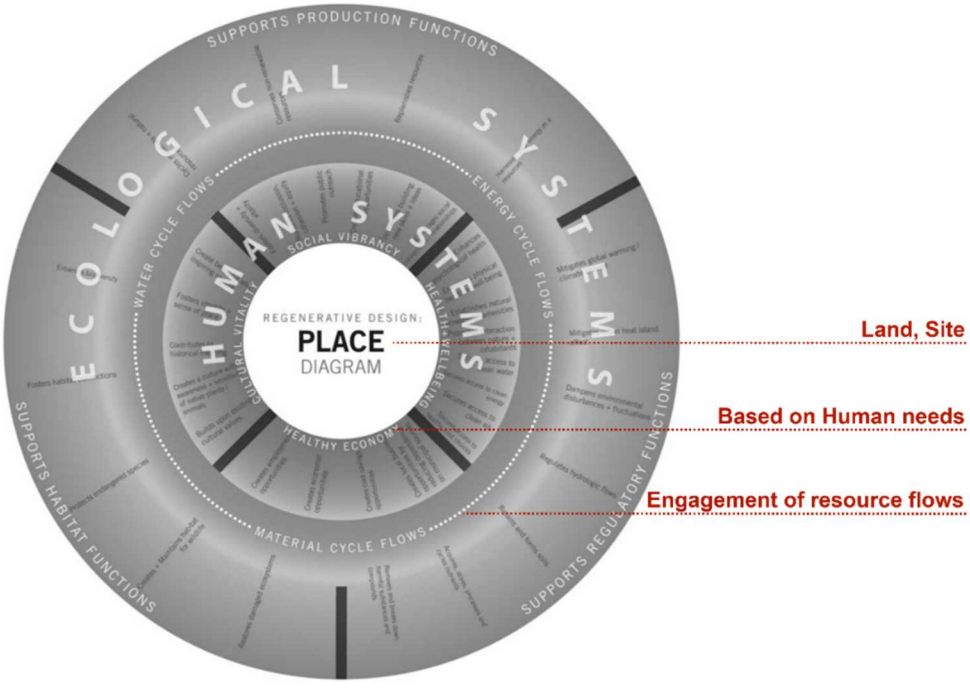


Figure 2.18 The original Perkins+Will framework (2011) that presented in Two Dimensional for representing the place that is based on the humans and ecological systems (modified from (Cole et al., 2012, p. 99))

While the outer dimension presents, resource engagement flows towards balancing an ecosystem. In addition, based on ecosystem services mentioned by De Groot *et al.* (2002), these resource flows are essential in contributing to specific ecosystem functions to support Production, Regulatory, and Habitat functions (De Groot et al., 2002). Moreover, the resource flow factors shown in the diagram are determined in relation to resource cycle design strategies as 'from nature back to nature', which this framework claimed it could continue to regenerate ecosystem fruitfulness. It has divided this resource cycle of all flows into four steps – (1) Produce: the resources are capable of renewing and generating either on-site or in the surrounding local area, (2) Use: the resources are effectively used and fully respond to the needs of humans, (3) Recycle: the resources are effectively reused for multi-purposes and benefits, and (4) Replenish: instead of diminishing the resources during the production and absorption of waste, the replenishment of resources and natural capital is more worthwhile. Therefore, this framework considers the direct and indirect engagement with flows that are perceived as the story of a place, which could help the participants in the design process on account of acknowledging the current conditions of the place compared with the past and applying this information in the built environment design (Cole et al., 2012, p. 99; Miller, 2012, p. 37).

The Perkins+Will framework has used regenerative capabilities as a key in terms of re-establishing and enhancing the capability of local ecosystem functions and creating efficient collaborative connections between a place's resource cycles and local ecosystems. In addition, regenerative capabilities help improve resource life cycle efficiency, creating resilience to fix undesirable stresses in nature and humans. Furthermore, enhancing the well-being, health and comfort of the building inhabitants that can connect to the ecological systems' processes likewise leads to the improvement of the well-being and health of inhabitants in the local community. At the same time, these operations provide opportunities to enhance social engagement for education, cultural development, and economic wealth in the local community. Therefore, these actions have the potential to generate practical change on a larger scale than the site boundary (Cole et al., 2012, pp. 103-105).

Relating to the application of this framework, as mentioned above, the Perkins+Will paradigm is based on the stimulation question. *Figure 2.19* is an example of the question used in the design charrette among stakeholders related to the design

project to stimulate their thoughts towards the awareness of place. Initially, the design team would start by introducing the framework and the idea of regenerative design to stakeholders to facilitate the direction of the engagement process. This would be followed by identifying the high level of a place-specific towards the regenerative design project to set the goal of a design charrette that is related to the two dimensions of the framework's cycles (Cole et al., 2012, p. 105). Then, a strategies and synergies stage will be implemented to indicate areas, objectives, or intentions that sync with a natural aspect to explore essential factors that benefit the design charrette. Finally, the ultimate stage, built upon the previous stage, will connect the strategies and synergies stage to achieve the maximum benefit to the ecosystem and humans. Notably, each stage of the framework is led by questions that are significant tools for urging stakeholders and participants' thoughts during the design charrette for a comprehensive result (Cole et al., 2012, pp. 105-109; Miller, 2012, p. 38).

According to the studies, this framework is capable of creating an effective dialogue between the design team and the client. However, it has been created to be used solely by the firm's experts with their projects, and that is not an accessible framework for people outside the firm, which is considered as a weakness of this framework. Unless, in the future, this framework will be designed to be shared with others to be used in general (Cole et al., 2012, p. 110; Miller, 2012, p. 39).

Content

Strategies

CONTEXT	Community/Client/User		Team Meeting/Charrette		Design Tasks	
INTENT	Identify project goals and aspirations related to energy flow cycle Identify high level place-specific strategies that will simultaneously benefit human and ecological systems health		Drill down to more detailed strategies, understand the potential of strategies to 'give back' more than they demand Link strategies and approaches so they maximize human and ecosystem benefits, and overall effectivess of energy cycle		Examine design strategies, their technical feasibility, implications and synergistic benefits	
QUESTIONS			How can this strategy be constructed/applied/designed so that it enhances resource cycles as a whole? What potential synergies can this strategy have with other resource cycle strategies? How can this strategy be constructed/applied/designed so that it helps achieve optimum efficiency for the project as a whole? How can these synergies act as an agent to positively affect the future regnerative capabilities of the energy cycle?			
CYCLE	Direct	Indirect	Direct	Indirect	Direct	Indirect
Produce	How can the energy required by the project be acquired and used in such a way that there is a net benefit for the health of the inhabitants, the community and the effected ecosystems?					
	What natural place-specific energy resources can be harvested? At what scale should energy independence be sought? How ameniable is the community/client to the visible expression of onsite renewable energy systems? How can energy processes be a focal point for cultural programs that celebrate unique identity of place? How can energy generation processes support economic opportunities?	What future changes may influence both onsite and offsite energy generation?	What natural place-specific energy resources are available to contribute to long term securing of a renewable energy source? How can sufficient long-term generation and ability of generation systems to withstand short term disruption be guaranteed?	How can the project ontribute to future community energy security and independence? What energy generation opportunities are available in close proximity to the project? How can energy generation/harvesting opportunities without compromising neighbouring opportunities?	Can the project generate more energy than it uses using onsite strategies? Can all inhabited spaces be 100% naturally ventilated? Can all inhabited spaces benefit from passive solar heating? Can all inhabited spaces be 100% naturally lit?	What are the potential sources of off-site clean, renewable energy? What future changes in the building context may affect the quality of outside air? What future changes in the building context may affect access passive systems? How can natural daylight to reinforce circadian rhythms and other natural cycles within inhabitants daily lives?
Use	How can the construction and operation of this building and other actions complete a regenerative energy cycle in support of human and natural processes across scale?					
	What behaviourand expectation adjustments could be made to match renewable energy sources? What changes in building form would be permissible to reflect the effectivess of onsite energy generation? What changes in the program are possible to improve effectiveness of energy use and exchange? How can the project engage inhabitants with place specific seasonal/diurnal energy related cycles? How can inhabitants be connected to larger scale energy systems through an understanding of their role within the ecosystem?	What future changes may influence energy use?	What are the opportunities/implications of energy use and generation to offset embodied energy? What possible services/amenities could be introduced on site to improve operational energy use? How can the project enable inhabitants understand energy processes and adjust the systems to meet their changing needs? Which spaces can potentially have multiple uses or be used more intensely?	Which services and amenities are close to the site? How can energy processes be made visible/accessible as an educational tool for inhabitants and/or community?	Where are the most effective ways to reduce initial and recurring embodied energy? What is performance is required of the building envelope to achieve a net energy generating building? How will the design aim for energy efficient spaces, systems and appliances? How will energy performance be measured and fedback to inhabitants and operations & management?	
Recycle	How can the building and its natural and constructed context function as a system that matches energy quantities and quality to the various needs in the most effective manner?					
	How amenable is the community/client to sharing energy resources?	What future changes may influence energy exchange?	How can energy recovery and exchange opportunities within the program be developed and secured? How will energy quality be matched to operation use and the cascading of energy quality captured?	How can energy exchange opportunities with neighboring sites be developed and secured? What opportunities exist to partner with neighbouring projects to reduce freight transportation and overall space for parking?	Where are the opportunities to recover energy? What are the most effective ways of using excess energy production?	What are the energy requirements or excess energy generation of adjacent buildings?
Restore	What are site and context opportunities for the project to be net carbon negative in terms of both operational and transportation emissions?					
	What changes are possible to reduce automobile emissions?	What programs exist/could be initiated for increasing public transit ridership?	What potential exists for the complete elimination of automobile use? How can onsite landscaping strategies be designed to contribute to carbon sequestration?	How can carbon sequestration be made visually and physically accessible to community (recreation, psychological health)?	How can direct construction emissions be mitigated/offset? How can operation emissions be mitigated/offset?	How can transportation emissions be mitigated/offset?

Figure 2.19 The original figure shows the example of questions in Energy cycle flows that led to the 4 cycle design strategies that were applied to the regenerative design project of the Perkins+Will firm (modified from (Cole et al., 2012, pp. 106-107))

2.3.5 The Summary of Regenerative Design Practices

Referring to all of the regenerative design practices mentioned above has explained the background of how each regenerative design practice works and that these practices are based on the regenerative design principle. Obviously, these regenerative design practices have different ways of gathering place data and implementation. Therefore, there are limitations to each practice that affect its implementation on a broader level. *Table 2.4* shows the summary of regenerative design practices – Regenesis Approach, REGEN framework, LENSES framework, and Perkins+Will framework, which this table has studied and summarised from the research of Cole et al. (2012), Mang & Reed (2012), Miller (2012), Plaut et al. (2012), and Svec et al. (2012). *Table 2.4* illustrates the key elements related to the Regenerative design principle, such as Implementation,

Provide benefits for all, Design from the story of place, Whole system thinking, Design scale, Stakeholders' engagement, Participation of community, Interdisciplinary application, Strength, and Limitation including a comparison between each practice for a clearer understanding.

As shown in *Table 2.4*, this study has learned that the Regenesis Approach is the framework that was created for use among the design team of the Regenesis group, which uses the design framework that shows three phases of design and three developmental processes, including the idea of regenerative design and development as a Regenesis Approach to structure and guide users during a design process. The implication of this framework shows that it focuses on the story of the place to use this data to assist in the design process. The crucial methodology is gathering stakeholders related to the project site, which are designers and include experts from various fields for awareness of interdisciplinary knowledge that potentially benefits the regeneration of the project ecosystem (Mang & Reed, 2012, pp. 24-25; Miller, 2012, pp. 17-18).

The REGEN framework is a web-based data that is an archive of the regenerative design projects that reveals information about the story of the natural capital, the pros and cons, and the relevant factors that impact the local ecosystem on each project site. The REGEN database has promoted its platform to all people who require this data to apply to their projects. While this platform is open for all people to input the data of their regenerative design projects, this data can be used in similar projects. Unfortunately, the database contains few data and regenerative projects, which implies that this framework is barely known at a broader level. Therefore, the REGEN framework is rarely taken into account or coordinated with development projects when compared to the other regenerative frameworks that are implemented in the actual projects and encourage the participation of stakeholders from various fields and local community members who are involved and related to the project site to discuss for the consensus of built environment design that benefits all living system (Miller, 2012, pp. 32-34).

The LENSES framework uses the three LENSES – Foundation lens, Aspects of place lens, and Flow lens to guide and stimulate the thoughts of stakeholders towards the key factors related to place for a comprehensive regenerative design project. Notably, the engagement process is the significant method of this framework. LENSES requires stakeholders to participate in the design engagement for discussion, exchange their thoughts and points of view, and employ their consensus agreement towards

regenerative design. The engagement process provides the opportunity for relevant stakeholders and designers to discuss and use the story of the place that is evaluated from the past and current condition of the project site related to the key factors in each lens for underpinning the built environment design (Plaut et al., 2012, pp. 113-119). Moreover, this framework is open for stakeholders to add extra factors into each lens as these factors are considered crucial and subjective and affect the local ecosystem's development. On the other hand, the study shows that it is slightly complicated for non-designers with different backgrounds of knowledge, which implies that it could be a weakness that needs an adjustment (Miller, 2012, pp. 34-36).

The Perkins+Will framework uses a question-based format to stimulate the thoughts of stakeholders towards the place condition and story of place, then uses four strategies – Produce, Use, Recycle, and Restore to help categorise the design direction and tools. Therefore, this framework requires stakeholders to participate in a design engagement to provide an opportunity to discuss and exchange ideas and perspectives towards regenerative design through constructive questions and answers. Then, the design team can develop a built environment design project based on the acquired data. The question-based strategy helps lead a design engagement process that gathers stakeholders from different backgrounds of knowledge related to place while discussing for an identical understanding with a design team (Cole et al., 2012, pp. 98-100). However, the concern about this framework is that it is strictly implemented in the Perkins+ Will design firm. Moreover, leading all stages of the design engagement process by using a question-based is possibly complex for non-designers who are experts in a different field and are new in the built environment design realm, which constrains the capability of this framework to be applied to a worldwide platform (Miller, 2012, pp. 36-39).

Table 2.4 The summary of regenerative design practices (applied and modified from (Cole et al., 2012; Mang & Reed, 2012; Miller, 2012; Plaut et al., 2012; Svec et al., 2012))

Key elements related to the Regenerative design principle	Regenesis Approach	REGEN	LENSES	Perkins+Will
Implementation	Using the design framework shows 3 phases of design and 3 developmental processes that include the idea of regenerative design and development as a Regenesis approach to structure and guides users during a design process.	Using a web-based access platform to gather the data of the place related to the place's condition and examples of design works in the same area. Then, the users can use this data to apply to their projects.	Using the 3 LENSES: - Foundation lens, Aspects of place lens, and Flows lens to guide and stimulate the thoughts of stakeholders towards the key factors related to place for comprehensive regenerative design work.	Using a question-based format to stimulate the thoughts of stakeholders towards the place condition and story of place, then using 4 strategies: - Produce, Use, Recycle, and Restore to help categorise the design direction and tools.
Provide benefits for all	Based on the framework that included 3 phases of design and 3 developmental processes, these design processes derive from understanding the story of the place to harmonise with a local ecosystem to create a co-evolution between humans and nature to sustain the whole living system.	Based on the 4 quarters of the REGEN web-based platform that include Robust and resilient natural systems, High-performing constructed systems, Prosperous economic systems, and Whole social systems. This thinking process indicates the key factors that involve all living systems into account for the exclusive benefit of all.	Based on the key factors in each lens of Foundation lens, Aspects of place lens, and Flows lens, considering the importance of improving the natural system, social system, and economic system, as these systems are crucial elements of the triple bottom line related to sustainability development	Based on the goals of: (1) Improving the well-being of community members, (2) Restoring local ecosystem functions, and (3) Generating cultural development opportunities, including the Two-Dimensional diagram, representing the way of thinking that includes humans and ecological systems in a design work process
Design from the story of place	The notions of Living Systems thinking, Pattern Analysis, Story of place, and Design for pattern are used as technologies and methods for regenerative design works.	The stakeholders and designers are able to input the project data related to the place's condition and the natural flow throughout the site, and this data is collected in a database and generates information for the users for application in their projects.	The stakeholders and designers can discuss and use the place's information that is evaluated from the story of the place related to the key factors in 3 Lenses for the design work.	The place-specific data is collected by asking designers and community members questions, as this data is a place attribute that can foster the quality of design work.
Whole systems thinking	There is a shift of thinking from a mechanistic worldview to an ecological worldview for built environment design for the holistic benefit of all.	REGEN framework shows evaluated data that is related to a connection between each system and potentially provides synergistic solutions for design work	The 3 spinnable layers of a visual model depict the connection between each lens and potentially help users understand the whole system to apply in design work.	The Perkins+Will framework focuses on improving both human and ecological system functions, and the whole process of this framework considers the well-being of all living systems as a priority.
Design scale	Intends to increase the integration of mutual benefits for humans and natural systems which this way of thinking is beyond a particular building scale	No specific mention	It is intended to be applied to multi-scale, from unit buildings to urban scale. Likewise, an application in multi-sector for project development, sustainable organisation, and logistics planning	It is intended to be applied to multi-scale, from unit buildings to urban scale. Likewise, an application in multi-sector for project development such as education, healthcare, residential, and commercial projects
Stakeholders' engagement	Start from defining the place to understanding the scale and scope of the site. Then, move to an integral assessment by acknowledging the core pattern and story of the place, which can establish shared understanding for stakeholders. Therefore, the stakeholder engagement process potentially creates guidelines that lead to the systematic regenerative design role.	As the REGEN framework is accessible via a web-based platform, a database is open for stakeholders and non-stakeholders interested in input and use for their design works.	The LENSES framework requires stakeholders to participate in a design charrette for discussion and exchange their knowledge and points of view towards regenerative design and development.	The Perkins+Will framework requires stakeholders to participate in a design charrette for discussion and exchange their knowledge and point of view towards the regenerative design and development question and answer. Then, the design team can develop a design work based on the obtained data.
Participation of community	The methodology gathers experts, specialists, and community members in the engagement process to co-create a design that is based on a connection and a deeper understanding of the place	As the REGEN framework is accessible via a web-based platform, a database is open for community members to input and use the data for their design works.	The critical strategy of LENSES is a design charrette among the stakeholders who are from different backgrounds of knowledge related to place and regenerative design work.	The important strategy of Perkins+Will is a question-based strategy that helps lead a design charrette among stakeholders from different backgrounds of knowledge related to place and regenerative design work, including a design team.
Interdisciplinary application	The Regenesis Approach is a structure and guideline that includes the idea of regenerative design and development for REGENESIS group members.	The REGEN framework is created to be a place story database centre for the users, stakeholders, community members, and everyone to input and update the information about the places and provide examples of regenerative design projects which can benefit further applications.	The LENSES framework enormously facilitates whole systems thinking, which the users can apply in the design works related to genuine sustainable development.	Perkins+Will can facilitate and help explore a deeper understanding of the place and how to develop its functions and quality. However, the framework is for sole use by the Perkins+Will team members.
Strength	The way of thinking behind the framework before choosing proper technologies and methods to apply to a regenerative design project is robust and potentially reinforces the design process. Therefore, it can create dialogue and understanding between a design team, participants, and the community based on the right relationship with a place.	The REGEN framework is designed to be a project database built upon by practitioners who use it. Therefore, the web-based feature is simple to access and provides opportunities for non-traditional stakeholders to use it.	The LENSES framework focuses on the connections between systems and strategies. Furthermore, it provides descriptive metrics for flexibility and contextually appropriate solutions.	Perkins+Will framework creates visible aspects of the production and consumption of resources and focuses on the benefit of regenerative design to create holistic design goals that carry the project beyond "Green Design" checklists. Therefore, its process engages design teams and stakeholders at a broader and more profound level.
Limitation	There is a slight mention of sharing this framework with other users outside the REGENESIS group.	The REGEN framework does not directly state that it can be used for projects that are larger than building scale. As a result, it is rarely taken into account or coordinated with development projects.	Notably, the LENSES framework is complicated for non-designers who do not have experience in regenerative design and development, especially the open spaces in each lens, which might be complex to fill in.	It is not very accessible to those outside the design realm and is constrained as it is designed to be used by the Perkins+Will team solely. Therefore, the question-based strategy is possibly complex for non-designers who do not have experience in regenerative design.

The previous studies' reflection on this study is a clearer understanding of regenerative design and development, including the current regenerative design practice, which influences the development of the RDF-T. Firstly, the regenerative design principle emphasises the relationship between humans and nature, which implies that the story of a place is essential in regard to acknowledging the condition of the place, the natural capital flow in the place for supporting the built environment design that is harmonised and suitable for the local ecosystem.

Secondly, most regenerative design practices are mainly used in individual firms, and some of the framework structure elements are difficult for non-designers involved in the design engagement process. However, the design engagement process is a crucial methodology for developing and regenerating an abundance of local ecosystems in the project site. Therefore, this process provides an opportunity for designers and relevant stakeholders to discuss and exchange ideas towards the built environment design based on an identical understanding of the regenerative design paradigm.

Lastly, the literature review urges new ideas. It distinguishes a profound structure of acknowledgement that this study grasped the solid knowledge learned from previous studies to apply in the study development in the aspect of research methodology, an essential reference that is necessary for the built environment design process, including the importance of various stakeholders who involved in the project site. In addition, chapter 2 is the core of supportive resources effected in each chapter that divines the relatable narrative through the whole study and significantly reflects the research aim and objectives, including the research questions. The more explicit explanation lies in the following chapters.

Chapter 3

Research Methodology

The research methodology primarily emphasises developing the gaps in existing regenerative design frameworks, which in Chapter 3 distinguishes these gaps into three subjects – Potential Assessment Tool, Credibility of Results, and Performance Measurement. Referring to the purpose of this study, which aims to develop a regenerative design framework that suits the Thai ecosystem, the subsequent explanation will be followed by exploring Thailand's sustainable design practices and comparing them with those globally. Then, this chapter reveals more about the situation and current Thai sustainable design strategies and the national guidelines and the analysed data is considered a solid factor that is possible to reinforce the development of this study further. Moreover, this chapter illustrates the application of the previous studies that applied in each part of the study. Subsequently, with the acknowledgement of these manners, the study focuses on elevating the existing practices' capability and creating the RDF-T as a new Regenerative Design Framework for the Thai context.

Furthermore, the research methodology shown in this chapter mentions the connection between the previous studies and constructs the explicit method that supports the flow of this study. Based on the pattern of this study, which focuses on developing the RDF-T derived from the adaptation of the previous studies and existing regenerative design frameworks, the methodology of this study determines using qualitative methods as a main direction to support the accuracy of outcomes. In addition, with respect to testing the capability of the RDF-T, the application of this framework in

the actual case study is suggested. Moreover, to underpin primary outcomes, this study considers using a Delphi method to ensure comprehensive findings before summarising the ultimate conclusion.

3.1 The Gaps of Existing Regenerative Design Practices

Criticisms of regenerative design mention whether it has plenty of premises that are used to support its way of thinking and its operation for urging genuine sustainability. On the other hand, this design notion has remained ambiguous and illustrates its strategies in a tangible form. Currently, the description of existing practices and approaches means it is slightly difficult for many practitioners to understand regenerative design's whole concept to proceed with their design projects. Subsequently, it is obvious that the widespread application of regenerative design and development is rarely mentioned in worldwide built environment design projects (Miller, 2012). Cole and his research team (2012) state that regenerative design and development cannot access and describe success in simple ways due to it focusing on the capability and quality of the project, which occurs from the success of the co-evolution of humans and nature in terms of re-establishing ecology and social from natural resource loss, the results of which cannot be easily measured from general metrics (Cole et al., 2012). Therefore, regenerative design performance cannot be evaluated during the design stage; it requires time to see substantial changes in regard to improving ecological systems that affect humans and nature in beneficial ways.

Notably, the difficulty in evaluating regenerative design performance is related to understanding the potential and capability of this design project as a tool to generate a sustainable future for humans and the ecosystem by considering holistic benefits for all as a priority. The most beneficial aspects of regenerative design are linked to positive impacts on the social, ecological quality, and economic health of the place where this design notion is applied (Cole et al., 2012). However, Reed (2007) asserts that instead of evaluating the success of regenerative design based on quantifiable measurement and achievement, it is more significant to examine its capability to extend awareness of stakeholders that have learned, invested and used their abilities based on their experiences to reinforce the future co-evolution of humans and natural systems (Reed, 2007, p. 678).

Therefore, after analysing the existing regenerative design practices mentioned earlier – the Regenesis approach, REGEN framework, LENSES framework, and the

Perkins+Will framework, it is obvious that some frameworks are limited to be used solely in their individual firms. Additionally, the implementation of these practices might be complex for non-designers or stakeholders who do not have a built environmental design background. Therefore, this issue possibly affects widespread application when compared to other sustainable and green design approaches. Besides, there is no specific explanation for measuring the capability of these regenerative design practices. However, the study provides the chance to improve the credibility of regenerative design and development. This study considers that three main gaps provoke the limitations in utilising these practices with current development projects. The details are shown below.

3.1.1 Potential Assessment Tool

With the limitation mentioned earlier, a regenerative design requires time to operate and evaluate its potential after stakeholders apply this design notion to their projects. The study shows that some existing practices have their tools as premises to support the applications and guide the stakeholders to make decisions. Unfortunately, current evidence reveals that no explicit standard assessment tool for the regenerative design building and surrounding environment could guarantee or rate a score to certify the results of these existing regenerative design practices. This study considers this issue one of the main gaps that constrain the capability of regenerative design practices compared to mainstream built environment approaches.

3.1.2 Credibility of Results

A regenerative design principle is one of the design approaches used to solve environmental problems, and at the same time, it could possibly help to generate a healthier ecosystem. Nevertheless, it is rarely used in current development projects since it requires time to establish the results. Moreover, there is no potential assessment tool to measure and evaluate the performance of existing regenerative design practices. This study has found that this issue has affected the credibility of results and led to the hesitation of most stakeholders in terms of choosing this design approach to be a tool for designing a built environment.

3.1.3 Performance Measurement

Regarding existing studies, evaluating performance outcomes in a regenerative design building requires time and understanding of the core regenerative design and development principle. A regenerative design principle does not solely examine the building performance but also concerns natural performance as it is a co-evolution of humans and buildings. However, a lack of performance measurement indicators that can evaluate the performance/quality/change in both pre and post-construction might be vague in terms of estimating the differences in design, i.e., an improvement of biodiversity, a better quality of human life and natural health conditions, and genuine sustainability that provides certainty for a social, ecological, and economic system. This study considers this issue as one of the crucial gaps that impact stakeholders' decisions for not choosing or barely investing in this design notion to be applied to their built environment design works.

3.2 The Current Sustainable Design Practices in Thailand

The Sustainable Development Goals (SDGs) are the global guidelines, including Thailand. The SDGs is a worldwide standard divided into seventeen sustainable development goals with a strong insistence "to leave no one behind", and this significant ambition is involved in all works of the United Nations in Thailand. Additionally, Thailand's UN Country team made an agreement in January 2022 under the UN Sustainable Development Cooperation Frameworks 2022-2026 with the Royal Thai Government, which strongly affirms that the UN Development System will support Thailand in achieving a sustainable and resilient country as a commitment led by the UN principles for leaving no one behind, human rights, gender equality, sustainability and resilience. Interestingly, the UN Cooperation Framework is similarly regulated to Thailand's 20-year National Strategy, written for the Nation Development Guideline (*Sustainable Development Goals | United Nations in Thailand*, 2023).

According to the National Strategy of 2018 to 2037, which is the first developed Thailand's long-term strategy consecutive to the Constitution. The National Strategy aims to become "a developed country with security, prosperity and sustainability in accordance with the Sufficiency Economy Philosophy" for the Thai people's well-being and happiness. Thailand's current situation is confronting various difficulties that affect the development of the nation in the aspect of Thailand's natural resources and environment; restoration and preservation of natural capital and environment

immensely be crucial factors to ensure the development of sustainability. According to effectively managing the productivity and responsibility of the public sector, cohesion and resilience to civic issues require improvement (*National Strategy 2018-2037*, 2018).

As mentioned before, the National Strategy aims to achieve the goal of being a developed country that considers the Thai people's well-being as a main priority and aims to provide security for people and ensure welfare, urging national competitiveness multidimensionally to ensure the consistency of economic growth, entrusting human resource at every level of a lifetime for being a proficient and virtuous citizenry, expanding chances to improve equality in society, contributing the development of environmentally-friendly with developed quality of life, and improving the effectiveness of governmental administrative to provide better benefits for public.

Additionally, the evaluation of the National Strategy's success is divided into six groups, which are:

1. Well-being of Thai people and society
2. National competitiveness, economic growth and income distribution
3. Development of human capital
4. Social equality and equity
5. Sustainability of national biodiversity, environment quality and natural resources
6. Government efficiency and better access to public services

The strategies shall properly balance the development of social, economic, and environmental stewardship during the development time frame. In relation to this study focuses on the strategy of the fifth group – Sustainability of national biodiversity, environment quality and natural resources (*National Strategy 2018-2037*, 2018, p. 2).

The strategy for Eco-Friendly Development and Growth intends to accomplish sustainable development in the aspect of providing fruitfulness in Society, Economy, and Environment by enforcing efficient governance that combines partnerships with both national and international. In addition, the operation and strategic plans are area-based design and implementation with respect to promoting all involvement of relevant sectors to extend the possibility. The procedure targets fostering interrelation growth

regarding the economy, environment, and quality of Thai people's well-being, and the concentration of balancing these three factors is related to the principle of sustainability in terms of maintaining an excellent quality for the future generation (*National Strategy 2018-2037*, 2018, pp. 12-13). This strategy has a focal point of development guidelines, as shown below:-

1. Promoting green growth and sustainable development – Increasing the economic value of bio-based along with the National Strategy for National Competitiveness Enhancement, Conserving and re-establishing biodiversity, Conserving and re-establishing rivers, canals, and national natural water sources, Maintaining and broadening eco-friendly green areas, and Contributing sustainable production and consumption.

2. Promoting sustainable maritime-based economy growth – Increasing the economic value of maritime bio-based, Developing, re-establishing and improving the ecosystem of entire marine and coastal resources. Resilianting beaches, protecting and managing an integrated policy of coastal management, and Improving and increasing activities in terms of supporting eco-friendly marine.

3. Promoting sustainable climate-friendly based society growth – Concerning the mitigation of GHG emissions, Adjusting the prevention and decrease of damages and losses caused by the impact of climate change and natural disasters, Considering the climate-friendly infrastructure development investment in the public and private sector, and Improving the arrangement and response procedure for emerging and re-emerging infectious diseases caused by climate change.

4. Developing urban, rural, agricultural, and industrial areas with a critical focus on sustainable growth – Creating ecological landscape plans to enforce the development of urban, rural, agricultural, industrial, and conservation areas based on integration to establish harmony and suitability with area capacity. Re-establishing urban, rural, both agricultural and industrial regions to suit the ecological landscape plans, Decreasing the pollution and chemicals from agricultural activities that impact the environment to serve the international standards, Sustainably conservation, re-establishing, and regenerating natural resources, architectural heritage, art and culture preservation, and promoting local identity and lifestyles, and Improving the urban and community institutions networks, including the involvement and participation of volunteers from local

5. Creating eco-friendly water, energy, and agricultural security – Promoting the management of the entire river basin system to ensure the safety of national water, Increasing the whole water system's productivity to enhance the efficiency of water use and generate incremental value for water consumption equally to international standards, Generating security of national energy and supporting eco-friendly energy usage, Reducing energy intensity to promote energy efficiency, and Improving safety in agriculture and food on account of quality, quantity, pricing, and promoting accessibility for national and community levels.

6. Improving the paradigm for determining the country's future – Contributing to a positive environment and quality of Thai people's life by enhancing the desired characteristics and behaviours of environmentally friendly, Establishing tools, integrity mechanisms and systems, and environmental prosperity, Establishing the organisational structures to manage critical problems relating the management of the environment and natural resources, and Innovating projects that potentially urge the improvement of a development paradigm in terms of determining the future of the country in regards to the sustainability of natural resources, environment, and cultural aspect based on effective governance and public participation.

As mentioned above, Thailand is following and applying the SDGs principles in terms of developing the sustainability of the nations while using Thailand's 20-year National Strategy, especially the fifth strategy that emphasises the Sustainability of national biodiversity, environment quality and natural resources for being a guideline to underpin the operation concerning improve the Thai environment. At the same time, the National Strategy openly encourage the improvement of paradigm for determining the country's future, which implies that the new development notion related to sustainable development, such as establishing tool, integrity mechanisms and systems, and managing organisational structure for improving the prosperity of the environment is essential and aligns with the National Strategy that requires the response action from both private and public sector to harmonise and strengthen genuine sustainability for Thailand (*National Strategy 2018-2037*, 2018).

Thailand's current sustainable design practices mainly apply mainstream sustainable design approaches for built environment design projects while encouraging new technology and techniques for being alternative tools. Besides, this study discovered that the regenerative design principle and development are slightly new for the

sustainable design field in Thailand. This study considers it an excellent opportunity to promote this notion to Thais and local practitioners involved in built environment design. Therefore, the study shows that this discovery is aligned with the National Strategy of Thailand in terms of developing design tools for establishing genuine sustainability for the Thai environment; with respect to the regenerative design approaches mentioned before, regenerative design can re-connect the relationship between humans and nature by determining the role of both in the design process. Moreover, regenerative design approaches encourage stakeholders from different fields of knowledge to participate in the design process to create an identical understanding and consensus agreement in designing a built environment that potentially benefits most of the members of society and is compatible with living creatures in the local ecosystem(*National Strategy 2018-2037*, 2018).

3.3 The Application of the previous studies

The literature review, including the study of existing regenerative design frameworks and the gaps in these frameworks compared with the current sustainable design practices in Thailand, implies that the rationale of creating the RDF-T as a new regenerative design framework for the Thai context is reasonable as Thailand's National Strategy is encouraging the further establishment of a design tool for supporting the sustainable environment and regenerative design notion is new to Thais and local practitioners while this notion has been applied globally. This study strongly believes that it is a great opportunity to develop the RDF-T further through the period of the study by constructing the sharp structure of RDF-T and implementing its capabilities in a specific case study in Thailand. Therefore, the pattern of this research methodology reflects the research aims and objectives, which intend to study and understand the notion of regenerative design principle and consider adapting it in the built environment design in the Thai context by developing and replenishing existing regenerative design frameworks.

The knowledge obtained from previous studies is applied to diverse parts of this study, as shown in *Table 3.1.* There are several subjects that this study summarises and intends to apply in terms of reinforcing the development of a new regenerative design framework that suits the Thai context. *Table 3.1* shows that (1) The discovery of the gaps in existing regenerative design practices is considered a solid material for developing the RDF-T, in which the discovered gaps are combined with the other techniques to underpin

the capability of the new framework in which it is an assumption of this study in regard to being an alternative built environment design tool as a solution to re-establish the prosperity of the Thai ecosystem. The application of this manner is illustrated in Chapter 4. (2) Considering the aims and objectives of this study, by understanding and discovering the capability of regenerative design and development in solving environmental issues and focusing on regenerating the Thai ecosystem, this obtained knowledge is used as a criterion for selecting a specific case study area of the research. (3) Applying the suggestion of including various stakeholders who are related to the project site and have different backgrounds of knowledge to participate in the built environment design process in the criteria of selecting stakeholders for this study. Based on the application of existing regenerative design frameworks mentioned, a diverse perspective of stakeholders can lead to an interdisciplinary built environment design that suits the local context and the needs of most people in the community. A more explicit explanation is shown in Chapter 5. (4) Adapting the stakeholder engagement patterns learned from the previous studies in the built environment design engagement procedure for the chosen case study. According to the engagement process, it possibly testifies to the capability of the RDF-T, and the outcomes can answer the research questions. The full explanation of the RDF-T's implementation is shown in Chapter 5. (5) Using regenerative design principles and approaches to lead the built environment design process of the case study area, which related to the aims and objectives in regard to applying the regenerative design notion with the RDF-T and testify its capability that possibly shows in the outcomes of the engagement process, which later the ultimate conclusion can further use in terms of underpinning the relevant future studies. The application is explicitly shown in Chapters 5, 6, and 7.

In regard to developing the RDF-T by filling the gaps and adapting knowledge from the previous studies and the implementation of existing regenerative design practices to this study – the next chapter illustrates the structure of the RDF-T. Moreover, the next chapter mainly focuses on explaining the two crucial elements that are combined with the basis of regenerative design to develop and underpin the capability of the RDF-T. Therefore, in Chapter 4, there is a precise explanation of the rationale for selecting a specific area in Thailand as a case study.

Table 3.1 The Application of the previous studies in each part of this study

Literature Review	Application to the study
▪ **The gaps in existing regenerative design practices**	Combined with other techniques to underpin the capability of the new framework, the RDF-T for the Thai context. The link to the study is illustrated in Chapter 3.
▪ **The selection of the case study area**	Considering the aims and objectives of this study and understanding the capability of regenerative design and development in solving environmental issues. This knowledge is used to select a specific case study area. The link to the study is illustrated in Chapter 4.
▪ **The selection of stakeholders**	Based on the existing regenerative design frameworks mentioned, various stakeholders involved in the project site and having different backgrounds of knowledge are required. Therefore, it can lead to an interdisciplinary built environment design that suits the local context and the needs of the majority of people in the community. The study uses this knowledge to apply to the selection of stakeholders related to the chosen case study. The link to the study is illustrated in Chapter 4.
▪ **The engagement process**	Based on the existing regenerative design frameworks, the engagement process of stakeholders who are involved in the project site is required. Then, this study will apply this idea in the engagement process of the built environment design of the chosen case study. Therefore, the engagement process can testify to the capability of the new proposal of a regenerative design framework for the Thai context. The link to the study is illustrated in Chapter 4.
▪ **The regenerative design approaches in a design charrette**	Using regenerative design approaches to lead the built environment design charrette of the case study area. The link to the study is illustrated in Chapter 4 and used for analysing the success of results after application in the engagement process, which is revealed in Chapter 5.

3.4 The summary of the research methodology pattern

As mentioned before, the implementation of existing regenerative design practices' procedures has been applied to this study. In this part, to extend a more explicit understanding regarding this application, the sequence of the research methodology pattern is shown below:-

1. Understanding the regenerative design principle and relevant elements and defining the gaps in the previous regenerative design practices.

2. Filling the discovered gaps in the previous regenerative design practices with the combination of supportive techniques to strengthen the capability of regenerative design and support the development of this study.

3. Comparing the global regenerative design approaches with Thai sustainable design practices to distinguish the similarities and differences.

4. Using the acknowledgement derived from previous studies to develop the structure of the RDF-T that must suit the Thai ecosystem.

5. Selecting the specific case study area in Thailand for being the place to testify the capability of the RDF-T.

6. Choosing the potential stakeholders to participate in the built environment design process for the case study area by considering the acknowledgement learned from previous studies as criteria to determine the speciality of stakeholders, which affects the accuracy of the design engagement process.

7. Using the RDF-T to lead a built environment design process to testify its capability shown in the design outcomes.

8. Summarise initial outcomes and consider additional research and supportive data for a comprehensive finding.

9. Considering the Delphi methodology in terms of finding the supportive data to underpin the accuracy of the ultimate study's conclusion.

10. Using all the analysed findings to summarise the study's conclusion. potentially identifying the success, limitations and suggestion roadmap of this study that could be used to develop further in future research.

A discovery of this study towards the RDF-T's experimenting process potentially indicates significant results that could benefit the study's conclusion. The study's findings can be used as potential material for further improvement of the RDF-T based on its strengths and weaknesses. This might help underpin its capability for being the most proper built environment design tool that suits the local ecological system, including the potential of providing mutual benefits based on the wealth of a social, ecological, and economic system.

Chapter 4

Research Development: The creation of a new regenerative design framework

Chapter 4 focuses on research development that intends to introduce and propose a new Regenerative Design Framework that suits the Thai context. This new framework is developed from the study of the regenerative design and development principle and the existing regenerative design practices mentioned in the previous chapter. Previous studies reveal gaps in current regenerative design practices: the Regenesis Approach, REGEN framework, LENSES framework, and Perkins+Will framework. This study has discovered that the identified gaps affect the widespread application of these regenerative design practices in terms of the lack of Potential Assessment Tool, Credibility of Results, and Performance Measurement. Furthermore, the previous studies mentioned that measuring the success of regenerative design cannot be achieved with simple metrics since its performance requires time to prove the change of pre- and post-construction due to the complex co-evolution of humans and nature. These changes might not be indicated with one specific tool. Notably, there is currently no standard tool for measuring the success of regenerative design practices to compare performances before and after their application within a particular site and context. However, most of the existing regenerative design practices have their support premises, such as techniques and methods related to regenerative design principles, the development of ecological systems, and the use of these premises to persuade users to apply their regenerative design practices. Unfortunately, some of these practices are designed for

their own design firms, and some are rarely used in actual development projects. For this reason, this study aims to develop a new regenerative design framework to improve its quality and credibility from all identified gaps. Furthermore, this study uses Thailand as a case study area in which a new regenerative design framework will be applied in a specific area and context to experiment with and investigate the capability of this framework.

The reason for choosing Thailand as a case study is that Thailand is one of the countries in Asia that is in a severe stage of facing accelerating urbanisation that causes environmental issues, as well as urban growth that affects transformations in an ecosystem, consumption of energy, and the explication of excessive waste that impacts climate change as a global environmental crisis such as urban heat island and greenhouse effect (Friend et al., 2016). Significantly, flooding is a harmful environmental problem that obviously occurs from urbanisation in Thailand, as exemplified by the severe flooding in 2011. One of the causes for this was that the natural water system was affected by urban transformation and the Chao Phraya River, as this major river in Thailand was unable to bear the massive overflow that came from every other part of the country. Normally, the topography of Thailand is a slope from the north and becomes a flat land in the middle part; during the rainy season, the rapid water flow has often caused huge floods in Thailand from the north to the south. At the same time, based on air pollution studies in Thailand over the past five years, the other severe problem is the Particulate Matter sized 2.5 micron ($PM_{2.5}$), which is air pollution that has been affecting Thailand's environmental systems, especially in middle and northern areas (Wongwatcharapaiboon, 2020). This is also due to congested traffic, which produces dust that causes black carbon, including biomass burned from agricultural sources (Squizzato et al., 2018).

With respect to these environmental issues and the previous studies related to Thailand's 20-year National Strategy, this study considers that it is a great opportunity to develop a new regenerative design framework to suit the Thai context as the first regenerative design paradigm that can be an alternative built environment design approach to solving the environmental problems in Thailand. Moreover, the regenerative design and development notion is not widely known in Thailand. Thus, this study intends to use the findings to help develop a regenerative design approach for future studies to improve it as a widespread design tool at a broader level.

4.1 The Creation of the RDF-T

A new framework (RDF-T) has combined the regenerative design principle with two distinctive elements – The Backcasting technique as a universal practice and TREES (Thai's Rating of Energy and Environmental Sustainability) as a contextual practice to underpin the development and fulfil the gaps in those existing regenerative design practices. As shown in *Figure 4.1*, a structural diagram of the RDF-T, this study has used the Regenerative design principle to be the foundation of this framework to control and lead the implementation of a built environmental design. It uses TREES to fill the gaps in the parts of the "Potential Assessment Tool" and "Performance Measurement," as TREES is used to evaluate green building performance and quality in Thailand. Thus, the Backcasting technique is utilised to fill the gap in the "Credibility of Results" as the Backcasting technique is mostly used in the sustainable planning field and has the potential to plan and form desired results that potentially create a reliance on the users. With the combination of these three elements, it has become the structure of the RDF-T.

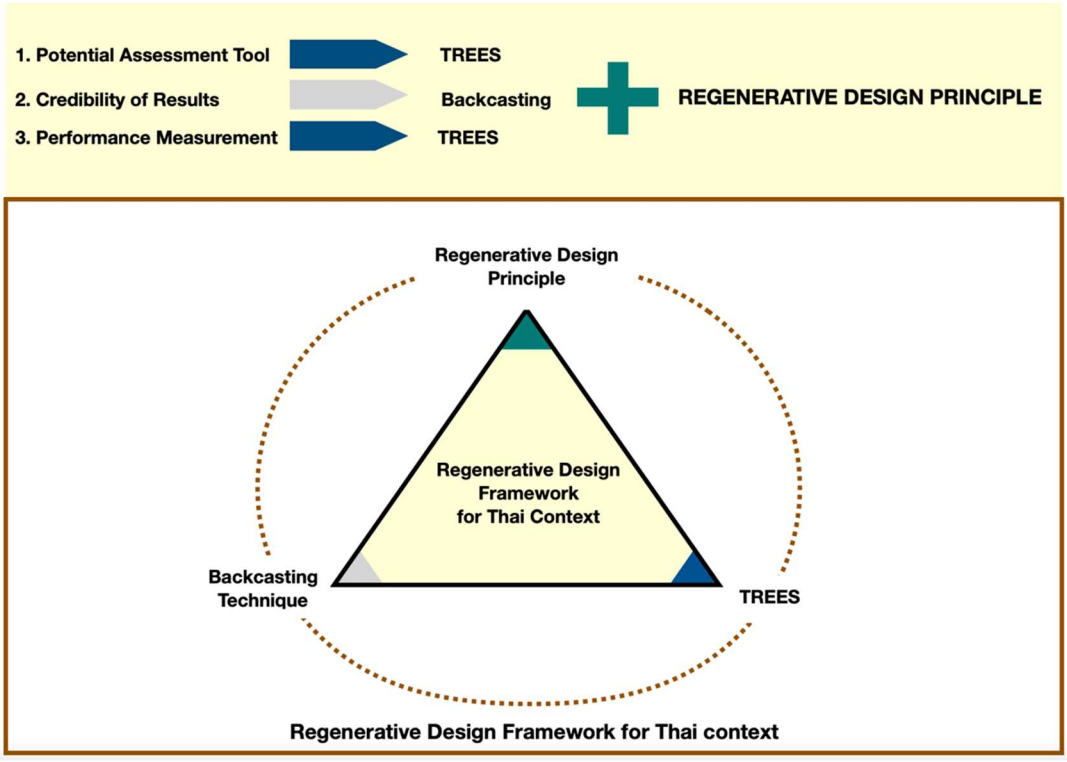


Figure 4.1 A structure diagram of RDF-T

As mentioned before, this study intends to propose this new framework as an alternative contextual built environment design tool. Furthermore, this study aims to use it as a hypothesis to experiment and investigate the results to answer the research

questions. The results of this study can possibly elevate the notion of regenerative design and development to become more well-known among Thais. Moreover, this study intends to use this research as a primary study of regenerative design in the Thai context for further relevant studies.

The section below explains the application of the regenerative design principle in the Thai context and the two distinctive elements of the RDF-T, which are the Backcasting technique and TREES, for a deeper understanding to reinforce the capability of RDF-T as a built environmental design tool that is designed to suit the Thai context as the primary case study area.

4.1.1 The Application of regenerative design principle for the Thai context

A regenerative design principle is an alternative sustainable design that rethinks ways of re-establishing the relationship and reinteraction between humans and nature for co-evolution in a genuinely sustainable environment. For this reason, this study needs to apply this notion in the case study to the Thai context. Apart from the firm basis of a principle, this study has developed its capability with regard to filling the gaps in existing regenerative design frameworks. Therefore, this study has chosen the Thai context as a primary case study to investigate the potential of the regenerative design approach in contextual built environment design. This study has applied a regenerative design and development paradigm in the RDF-T to be the framework that will be used in the built environment design process. This will help design architecture and landscape to consider the whole condition and function of natural resources as a priority, and this can be a supportive design tool to create an appropriate sustainable design that responds to the needs of local community members and the surrounding ecosystem.

Therefore, this study aims to combine the regenerative design principle with two crucial elements – the TREES rating system and the Backcasting technique. The regenerative design approach will be used as a design guideline for leading the built environment design process and using the TREES requirement to strengthen the design to suit a particular case study area in Thailand before using the Backcasting technique to shape the policy and direction of development to maintain a better-quality of built environment project. At the same time, it could provide credibility to the stakeholders who are relevant to the design project.

As mentioned in the previous chapter, the engagement process is a key factor that potentially defines the success of the regenerative design approach in a development project. In this case, this study has used the application of regenerative design and development as criteria for narrowing down the potential stakeholders for participation in the design engagement process. In fact, this study considers regenerative design and development application for the Thai context as a challenge since there is no explicit evidence showing that regenerative design has been used in a Thai built environment design project before. However, as this study is an initial study of regenerative design for the Thai context, the findings of this study potentially illustrate its capabilities and limitations, the implementation details of which will be mentioned in the next chapter. Furthermore, this study strongly believes that the findings can be used to develop further regenerative design and development studies.

4.1.2 TREES (Thai's Rating of Energy and Environmental Sustainability)

TREES is Thai's Rating of Energy and Environmental Sustainability, launched in 2010 by the Thai Green Building Institute (TGBI). This was initiated by the fact that the environmental and energy crisis is seriously increasing. The production of energy resources such as oil, coal, and natural gas is constrained, which reverses the demand for these resources as the demand is dramatically rising. This issue has affected natural resources production; besides that, it affects energy prices, which is an extra life expense for people in society. Meanwhile, renewable energy development is not able to develop rapidly enough to serve energy demands in the near future. Therefore, energy production mostly depends on resources that have a harmful impact on the environment. It is generally acknowledged that burning oil and coal provides a large amount of Greenhouse Gas, which is a cause of the Greenhouse Effect issue and threatens humanity's well-being. Critically, trespassing onto natural resources continues to occur in terms of accessing energy resources, and this threatening action affects both Marine and Terrestrial ecosystems. In addition, fuel transportation has a severe impact, such as fuel extraction, including pumping oil across the ocean level, which has a dangerous tendency to leak during transportation, which can massively damage the ecosystem. As described, TGBI has seen these threatening actions as an energy crisis that directly causes the current environmental crisis (Thai Green Building Institute, 2016b).

Moreover, TGBI considers building construction a crucial cause of energy and environmental issues due to the consumption of electricity such as lighting, electrical

equipment, air conditioning, and ventilation that are necessary to modern-day occupants in terms of responding to their activities, productivity, human comforts and well-being. Quality of life is a priority, and energy demand is needed in terms of maintaining an acceptable life quality level for occupants in the buildings. Nevertheless, it is undeniable that human activities have direct and indirect effects on social, economic, and environmental systems. Therefore, TGBI holds that balancing energy, occupants' well-being and environmental conservation should be considered appropriately. Furthermore, apart from human activities, buildings have a crucial impact on environmental problems; for example, built-up areas can cause flooding, the heat island phenomenon, excessive water consumption, excessive extraction of raw materials for building construction, excessive waste and pollution from building operations and the construction process, et cetera. With these facts, TGBI focuses on the quality of a sustainable building design approach that should be able to reduce environmental problems while maintaining occupant well-being and productivity with appropriate designs and technologies to balance the quality of life for humans and nature (Thai Green Building Institute, 2016b).

Generally, TREES rating systems are designed to suit varied building types, both new and existing buildings and primarily focus on new construction buildings or large renovations (Thai Green Building Institute, 2016b). Currently, TREES is divided into four categories, which are: -

1. TREES-NC (New Construction and Major Renovation)
2. TREES-PRE NC (Preparation of New Building Construction and Major Renovation)
3. TREES-NC/CS (New Construction and Major Renovation and Core and Shell Building)
4. TREES-EB (Existing Building: Operation and Maintenance)

Moreover, the TREES Assessment criteria that are used for evaluating the score of a particular building's performance are divided into eight sections, which are shown in *Table 4.1*.

Table 4.1 TREES Assessment criteria for evaluating a building performance

Section	Assessment Criteria
1	Building Management (BM)
2	Site and Landscape (SL)
3	Water Conservation (WC)
4	Energy and Atmosphere (EA)
5	Material and Resources (MR)
6	Indoor Environment Quality (IE)
7	Environmental Protection (EP)
8	Green Innovation in Design (GI)

Therefore, each section has various criteria and prerequisites that help the TREES experts evaluate a building's performance concisely. Notably, the proportion of a score under each criterion differs since it depends on each type of building assessment. Furthermore, a gained score is evaluated from each assessment section when there is a building performance assessment. The TREES expert will then use that score to identify the award levels: Platinum, Gold, Silver, and Certified. For instance, *Figure 4.2* is an example of the score proportions for TREES-NC, and *Table 4.2* shows the score range of each award level.

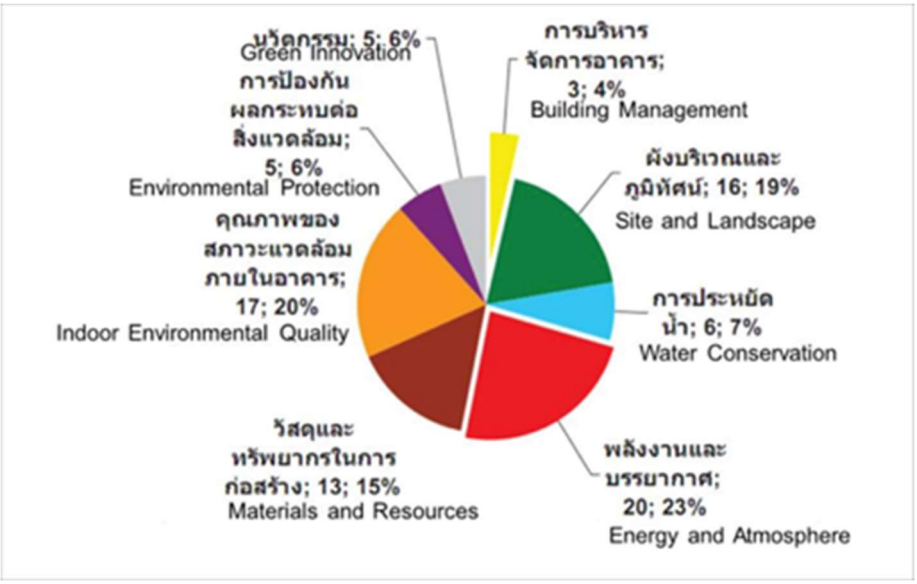


Figure 4.2 Example of the score proportions for TREES-NC building performance assessment from (Thai Green Building Institute, 2016b, p. 2)

Table 4.2 The score range of each award level for TREES-NC building performance assessment

Award Level	Score Range
Platinum	More than 60 points
Gold	46-60 points
Silver	38-45 points
Certified	30-37 points
All levels must pass prerequisite topics	9 prerequisite topics

The rationale for choosing TREES as one of the essential elements of RDF-T is that this study intends to investigate the capability of RDF-T in terms of being a new proposal of an alternative built environment design tool for the Thai context by applying it to a case study area in Thailand. TREES has the potential to fill the gaps in previous regenerative design frameworks in the aspect of being a Potential Assessment Tool, and it helps to strengthen the Performance Measurement section of a regenerative design project. This is in addition to the TREES assessment criteria, especially under section 2: Site and Landscape (SL) and section 7: Environmental Protection (EP), as these two sections have similar design requirements as the regenerative design approaches.

In detail, *Figure 4.3* shows the criteria topics under the Site and Landscape (SL) assessment section, which focuses on the avoidance of harmful environmental impacts using various strategies. For example, (1) Focusing on sustainable site planning with a reduction of negative impacts on greenfield areas, (2) Focusing on using local or native plants in the project site appropriately and using the native plants to shade the building with the consideration of managing an ecological open space to not less than 25% of the building footprint or 20% of the land area. Moreover, (3) Considering green roof or vertical garden design, (4) Preventing flooding by considering infiltration stormwater design, and (5) Focusing on reducing the heat island effects in the urban area, et cetera (Thai Green Building Institute, 2016b). Furthermore, *Figure 4.4* shows the criteria topics under Environmental Protection (EP) which focus on reducing pollution from the construction site, such as (1) Reducing pollution from construction by controlling soil erosion, managing excessive sediment release to prevent the impacts on water sources quality, and managing dust issues to prevent air pollution problems, (2) Waste management by managing debris or waste for recycling since waste problems can affect a landfill, and the implementation is preparing a clear recycling collection point to

efficiently manage waste, (3) Focusing on using low environmental impact products in fire suppression systems such as all the chemical that harm the Ozone layer, (4) Reducing the light reflection impact from buildings due to excessive light and temperature from a building causing a higher temperature in the urban area, which is one of the causes of the heat island effects, and (5) Installing meters for water treatment systems and electricity use which can help treat wastewater, et cetera (Thai Green Building Institute, 2016b). Likewise, the criterion under other assessment sections shares similarities with regenerative design approaches in terms of preventing harmful impacts on the environment and balancing the well-being of humans and nature for genuine sustainability.

Topic	Detail	Point
SL P1	Avoid inappropriate construction site	Prerequisite
SL P2	Reduce negative impact to green field areas	Prerequisite
SL 1	Locate project on the developed land	1
SL 2	Reduce using private cars	4
SL 3	Sustainable site planning	3
SL 3.1	Ecological Open Space not less than 25% of the building footprint or 20% of the land area.	1
SL 3.2	Plant 1 big tree per 100 m^2 of open space (do not relocate natural big trees other sites).	1
SL 3.3	Use local or native plants appropriately	1
SL 4	Infiltration of storm water and flooding prevention.	4
SL 5	Reduce Heat Island Effects in the urban area from project development	4
SL 5.1	Green roof or vertical garden	2
SL 5.2	Hardscape area received direct solar radiation not more than 50% of the total hardscape area.	1
SL 5.3	Place big native trees at the Western, Eastern, and Southern sides if the building. Native plants can shade the building efficiently and not make damage to the building	1

Figure 4.3 The originated criteria topics under the Site and Landscape assessment section from (Thai Green Building Institute, 2016b, p. 10)

Topic	Detail	Point
EP P1	Reduce pollution from construction Plan to prevent pollution and disturbance from construction.	Prerequisite
EP P2	Waste management Provide recycling collection area.	Prerequisite
EP 1	Low environmental impact products in fire suppression systems Non CFC, HCFC or Halon in fire suppression systems.	1
EP 2	Condensing unit/ cooling tower position Positions of condensing unit (compressor or cooling tower) shall be located far from the nearby area.	4
EP 3	External glazing Glazing visible light reflectance not more than 15%	1
EP 4	Control disease that involved with the building Comply with the Notice of the Department of Health, Ministry of Public Health of Thailand: Procedure to control Legionella in cooling tower of the building in Thailand.	1
EP 5	Install meter for wastewater treatment systems electricity use	1

Figure 4.4 The originated criteria topics under the Environment Protection assessment section from (Thai Green Building Institute, 2016b, p. 59)

Based on the information on the TGBI website, the number of buildings that received TREES certificates is 44 projects, and 61 projects are currently in the assessment process. *Figure 4.5* is an example of the score proportions of the DAIKIN Research and Development Centre in Thailand, which received a Platinum Green Building Award from TREES in 2017. Moreover, the example of the actual project that received the award from TREES called The Cheewa Panavet (Toyota Biodiversity and Sustainability Learning Centre in Thailand), used the concept of energy saving and environmental preservation that, in turn, used the TREES-NC criteria as a New Construction and Major Renovation of Thai Green Building Institute (TGBI) as a guideline for the design and development of the project that considered sustainable design as a priority to maintain a quality of life for humans and the environment.

This project aims to support a friendly-built environmental society. The Toyota company intends to use the Cheewa Panavet as a model of a green area that provides opportunities for younger generations to learn and acknowledge the importance of abundant biodiversity and that maintaining its quality with respect can support the certainty of ongoing life. This can lead to happiness in Thai society. The Chewa Panavet is combined with three words – Cheewa means “life”, Pana represents “forest”, and Vet represents “habitat”. The main functions of the Cheewa Panavet project are (1) Eco–Forest, (2) Toyota Biotope, which is the artificial habitat of living organisms as the area is home to animals, plants, and other living creatures that will help generate a

productive ecosystem, and (3) the Royal Commemoration Exhibition Building that exhibits and helps educate people on sustainability (Millikin, 2016).

Figure 4.5 Example of the score proportions of 'DAIKIN Research and Development Centre with Platinum Green Building Award'

4.1.3 Backcasting Technique

The first use of the Backcasting Technique was in the 1970s to analyse and plan for energy systems. Normally, it is proposed to analyse future scenario changes over 20 to 100 years. This technique has then been used to indicate broader issues in the sustainability field, i.e., buildings, land use, transport, and food. Hence, the Backcasting Technique is mostly related to sustainable development that requires the involvement of social structures in the process of change (Åkerman & Höjer, 2006; Anderson et al., 2008; Geurs & Van Wee, 2000; Green & Vergragt, 2002; Höjer & Mattsson, 2000; Mander et al., 2008; Robinson, 1990). Generally, the Backcasting Technique is the technique of forming desirable goals by creating a normative perspective of the future and then designing pathways back to the present to follow ways to reach the desired goals, which means today's decisions can facilitate changes in the future (Köves et al., 2013). Hence, change in these terms implies that a vision of the future can be feasibly achieved when there is planning from today that is capable of leading to that point.

The difference between Forecasting and Backcasting is that Forecasting provides prediction scenarios as a warning to prepare and adapt for upcoming scenarios that

might happen in the future, which can help in terms of planning or changing strategies to suit these future scenarios. In contrast, the Backcasting technique is not a prediction. Instead, it is the establishment of a formative future scenario that helps form the desired outcome in which the feasibility of the future occurrence depends on the current planning strategies that have the possibility to direct ways to achieve goals. At the same time, planning strategies possibly tackle undesired outcomes or reduce obstacles along the way before reaching the goals that the users create from the vision scenario and prepare implementation for these future outcomes (Köves et al., 2013). Therefore, preparing the scenario is a proactive strategy that can be adjusted to fit possible occurrences in the future (Huss, 1988; Palacios-Agundez et al., 2013; Wollenberg et al., 2000). Hence, it is more flexible when decision-making is based on the scenario (Peterson et al., 2003), and the planning scenario possibly provides a very helpful tool for addressing feedback from the cross-scale that can further facilitate discussions for the multiscale dimension (Zurek & Henrichs, 2007).

To simplify the use of the Backcasting technique as a planning scenario method, the Backcasting technique is mainly used in the sustainable development field (Miola, 2008; Quist, 2007; Wangel, 2011). As shown in *Figure 4.6*, the methodology of the Backcasting technique will examine backwards from desirable future results formed by stakeholders, identify the consensus pathways to achieve the goal, and consider alternative approaches to evade the undesired results in the future (Quist, 2007). Currently, the end-point of the normative future is set between 25 to 50 years, based on a timeframe that needs to be longer than 50 years and requires extra distance from the current point for the essential space of envisioning a different qualitative scenario of the future (Quist & Vergragt, 2006; Vergragt & Quist, 2011). Furthermore, the previous study claimed that most people could imagine the future in terms of the time range of approximately 20-50 years in relation to their lifespan or their children onwards from the present point (Robinson et al., 2011).

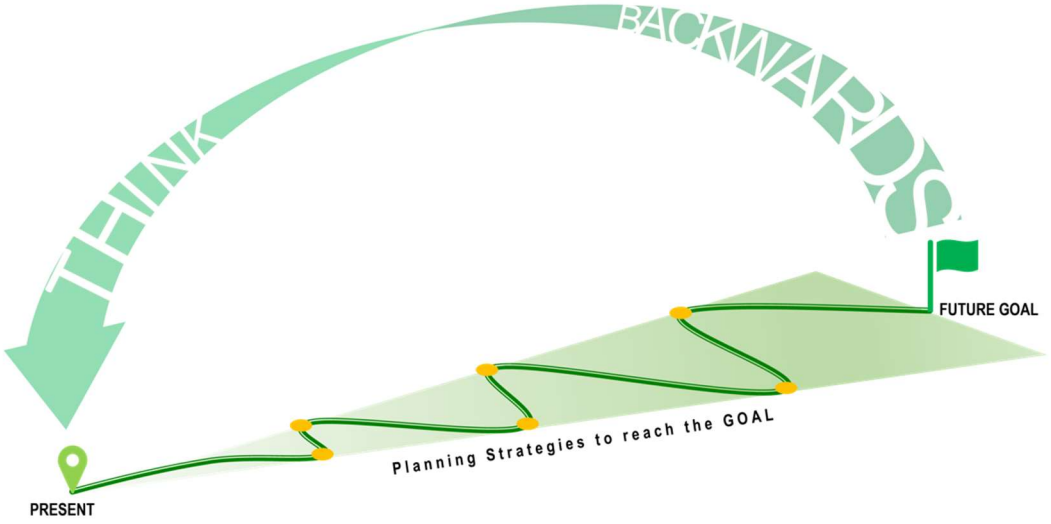


Figure 4.6 The methodology of the Backcasting technique

According to Robinson (1990), the Backcasting development process has six steps, which are: -

(1) Prescribing the scenario development purpose is determining the objectives of development, including describing the purpose of analysis, considering the temporal, spatial and substantive scope of analysis, and then determining the type and number of scenarios (Robinson, 1990).

(2) Determining targets, goals, and limitations is a step of setting goals and targets, examining limits or constraints for variable external factors and scenario analysis (Robinson, 1990).

(3) Explaining a current system is a description of the outline of physical consumption and production processes (Robinson, 1990).

(4) Specifying variable external factors of the Backcasting is developing a description of variable external factors to specify the variety of components that affect scenario analysis, and later, these factors will be used to lead the direction of the Backcasting process (Robinson, 1990).

(5) Processing the scenario analysis, including the developing scenarios; this step is divided into four semi-steps, which are A) choosing the scenario creation method, B) Analysing the future consumption and production processes, especially at the mid-

point and end-point, C) Improving the scenario(s), and D) Repeating as needed to acquire internal consistency (Robinson, 1990).

(6) Processing the impact analysis is synthesising the scenario results by combining an analysis of social, economic, and environmental impacts and then comparing the possibility of results with step 2 to recheck and repeat the analysis processes as needed to confirm consistency between goals, targets, and results (Robinson, 1990).

These six steps of the Backcasting technique are applied in several sustainable development projects to prepare for the guideline and development policy capable of providing credibility to stakeholders and ensuring the desired results that tend to occur in the future. A cautious estimation of scenarios has been carefully iterated before producing the direction to pursue the desirable result.

However, the following studies have developed and improved the Backcasting development process to suit the circumstances for an accurate result. Wangel (2011) has interpreted and distinguished the Backcasting technique into two approaches, which are (1) A result-oriented research Approach and (2) A participation-oriented creative Workshop Technique. The difference between these two approaches can be described in terms of the methodology that is needed when using the Backcasting technique as A Result-Orientated Research Approach, while the discussion of the participation process is inferior to the primary purpose of finding a suitable result. In contrast, A Participation-Orientated Creative Workshop Technique is the opposite of this due to the methodology of the Backcasting process being able to adjust towards better compatibility with the desired results after the participation process (Wangel, 2011). However, the participation process is essential for both approaches as it includes various points of view and knowledge that help the scenarios. At the same time, this process can encourage a consensus agreement or create space to discuss the conflicts to empower the community to establish social acknowledgement and capacity-building; this then impacts stakeholder approval to increase the validity of results portrayed through scenarios (Wangel, 2011). Likewise, previous studies illustrate that the integration of participation is a useful approach in scenario planning due to it being an essential tool that can facilitate the management of landscape sustainability. Since the participation of relevant stakeholders provides multi-sources of knowledge leading to accurate planning through the complexity of social-ecological processes (Whitfield et al., 2011). It is obvious that the participation process or workshop is an essential component of the

Backcasting technique for consensus policies, guidelines or the direction to achieve a desirable goal that is determined by stakeholders (Miola, 2008; Quist, 2007; Wangel, 2011).

As mentioned before, the participation of relevant stakeholders in the workshop process is crucial. It has been applied in various projects regarding the studies of the actual sustainable development projects, i.e. The Hungarian Backcasting experiment – design policy recommendations for reaching the desired future of sustainable employment in 2050 (Köves et al., 2013), The local participatory scenario planning for ecosystem management policies in the Basque country, Northern Spain in 2050 (Palacios-Agundez et al., 2013), and The resilient energy systems for a Japanese community to 2030 in Suita City, Osaka (Kishita et al., 2017). This study has learned from these projects and has summarised the workshop procedure into four essential steps, which are: -

1. Provide the topic and relevant fields of discussion.
2. Exchange perspectives among stakeholders and experts with regard to the topic and relevant fields.
3. Observe, collect and summarise data by the researcher/ observer/ project member.
4. Make a conclusion of desirable policies and guidelines for long-term practice.

Subsequently, this study intends to apply the Backcasting technique by adapting the basis and participation method of this technique to suit the direction and context of this study for the most valid results that can be used to summarise the research conclusion, including evaluating the capability of the RDF-T, which uses the Backcasting technique as one of the most critical elements to underpin the framework's credibility and usage.

4.2 The summary of the structure of the RDF-T

The RDF-T is based on the intention of this study to fill the gaps in existing regenerative design frameworks. It is supposed to be an alternative built environment design tool that combines the principle of regenerative design and development with two crucial elements – the TREES rating system and the Backcasting technique. The RDF-T is intentionally used in built environment design engagement to create a suitable built

environment design for the local community in a particular area in the Thai context. The area of study is presented in the next section below. Apart from the built environment design, RDF-T's implementation intends to create guidance for project development to continue maintaining the quality of the built environment design, including architecture, landscape, and local ecosystem.

Table 4.3 summarises the structure of RDF-T and briefly explains its elements for a clear understanding of the whole framework. In detail, this table has distinguished the role of the three elements of the RDF-T in this study's research methodology in terms of performing in the built environment engagement process. The regenerative design approaches and TREES requirements would be used in the built environment design charrette. Then, the Backcasting technique intends to be used in the development policy-making process. The following section below illustrates more information about the research methodology regarding the site selection.

Table 4.3 The summary of the structure of the RDF-T

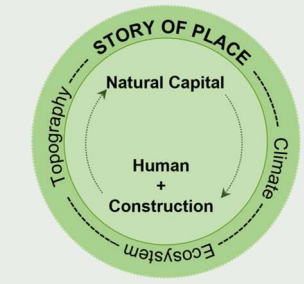
Analysing the gaps in the existing regenerative design frameworks

REGENERATIVE DESIGN FRAMEWORK FOR THE THAI CONTEXT (RDF-T)

Literature Review

REGENERATIVE DESIGN PRINCIPLE

PRINCIPLE: Human and Nature work together as partnerships in terms of regenerating an ecosystem for the benefits of whole living systems on their specific place.



Regenerative Design Conceptual Diagram

DESIGNING APPROACH: Taking natural function into an account and allowing nature to be a significant partnership in the design process by prioritising building design to be suitable with place's condition.

HUMAN ROLE:
Building Design (i.e., Eco-Friendly Design, Biophilia Design, Roof Garden Design etc.)
Landscape Design (i.e., Native plants garden, Edible Landscaping, Community wet land, Raised Beds and Container Garden etc.)

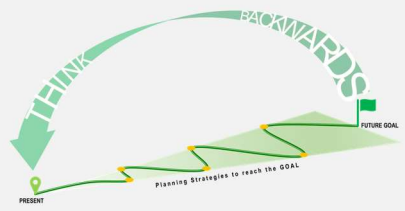
Natural Role:
Natural Function → source-sink-source (i.e., Natural filter, Nutrient absorption, Natural remedy etc.)

Before a design process, the selection of participants for creating an identical understanding of regenerative design principle is important. Furthermore, the selected participants should not be solely from a design field and occupants, but it should cover other experts in the ecological field. With their expertise could help the design team to focus more on the revitalising an ecosystem. Therefore, the participants can exchange their diverse disciplines among them for the most effective building design.

BACHCASTING TECHNIQUE

Backcasting is the technique of forming desirable results for the future. Especially use it in terms of the sustainability field.

METHOD: Backcasting entails looking back from a preferred future typically set by stakeholders and identifying the steps that need to be taken to achieve it, or alternatively, determine actions to avoid an undesired future (Quist, 2007).



Workshop is an important component of this technique for seeking consensus policies, guideline, or the way to achieve a desirable goal which determines from stakeholders.
Example of procedure:
1. Provide the topic and relevant fields of discussion.
2. Exchange perspective among stakeholders and experts with regard to the topic and relevant fields.
3. Observe, collect and summarise data by the researcher / observer / project member
4. Make a conclusion of desirable policies, guideline for a long-term practice.

Case Study:
- Designing Backcasting scenarios for resilient energy systems for Japanese community to 2030
- Hungarian policy recommendation for reaching a desired future of sustainable employment in 2050
- Scenario planning for ecosystem management policies in the Basque Country, Northern Spain in 2050
- Etc.

TREES

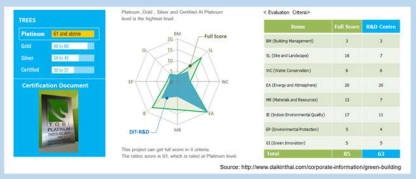
TREES is Thai's Rating of Energy and Environmental Sustainability by Thai Green Building Institute (TGBI). TREES rating system is designed suitably for various building types, both new buildings and existing buildings, and mainly focus on new construction building, or major renovation.

TREES is divided into 4 categories: -
-TREES-NC
-TREES- PRE NC
-TREES-NC/CS
-TREES-EB

TREES Assessment criteria is divided into 8 sections: -

1. Building Management (BM)
2. Site and Landscape (SL)
3. Water Conservation (WC)
4. Energy and Atmosphere (EA)
5. Material and Resources (MR)
6. Indoor Environment Quality (IE)
7. Environmental Protection (EP)
8. Green Innovation in Design (GI)

A total score which gained from each section is used to identifying the award levels **(Platinum, Gold, Silver, and Certified)**



Example of the score proportions of "DAIKIN Research and Development Centre with Platinum Green Building Award"

The number of buildings that received TREES certificate are 44 projects and 61 projects are in the assessment process.

In each section of assessment criteria, it has prerequisites and sub-specification that includes similar site intervention approaches in **"Regenerative Design Practice"**, of which could increase and improve biodiversity on site and surrounding.

Especially, in **"Site & Landscape and Environmental Protection section"**

Research Methodology

Apply in a built environment design charrette

Apply in a development policy-making process

Apply in a built environment design charrette

Case Study in Thailand

Design Workshop with stakeholders and experts

- Experiment with the RDF-T
- Creating a built environment design and development policy for the case study area. All the results are used to indicate a capability and limitation of the RDF-T
- Developing the RDF-T for further implementation

Analysing Data and Finding Conclusion

4.3 Regenerative Design and Site Selection

This study aims to introduce the concept of regenerative design and development to Thailand, an approach that remains relatively unfamiliar within the country. During this study's duration, there were no implemented projects in Thailand that utilised regenerative design principles or frameworks. This absence presents an opportunity to enhance understanding and adapt the RDF-T specifically for the Thai context. The RDF-T, still in its preliminary stages, could serve as an alternative tool for designing built environments, potentially improving the application of regenerative design in various Thai projects. Therefore, meticulous site selection becomes crucial, aligning with the study's criteria to effectively use the RDF-T for regenerating local ecological conditions and addressing environmental issues within the community.

As has been mentioned before, among Asian countries, Thailand has been facing severe urbanisation issues, including the transformation of urban growth, excessive energy consumption, the explication of waste that affects humans and environmental well-being, and the degradation of the ecosystem. These actions directly impact climate change, urban heat island and the greenhouse effect on a global scale (Friend et al., 2016). Friend et al. (2016) mention that each region in Thailand has been identified as sensitive to climate change. Therefore, investment and industrialisation around urbanisation must rely on the fossil fuel economy, including expanding petrochemical industries, coal-fired power production, and urban buildings that use individual transport. Therefore, there is a tendency that future urbanisation will face global difficulties (Friend et al., 2016). Thailand is in a new phase totally different from the previous history, in which it is facing rapid urbanisation, which is likely to reach 72% rapid growth by 2050. In addition, based on the studies, land use for agricultural productivity and forest areas has been changed for residential use and other purposes (Navanugraha, 1997; Sangawongse & Peterson, 1997; Sangawongse et al., 2005; Wara-Aswapati, 1991). Urbanisation issues in Thailand have been a cause of climate change, which must be considered in urban planning. Unfortunately, an awareness of urbanisation is not the main agenda for both the state and public sectors. Academics and researchers in the field of building the capacity of a new generation addressed that the change in Thailand's urban planning requires cooperation from the public and private sectors to aid awareness as to how urbanisation can affect climate change to reduce the risk that causes tremendous harm to people and the ecosystem (Friend et al., 2016).

In 2011, empirical evidence showed that Thailand had a severe flood issue. Many studies reveal that the transformation of urbanisation is the leading cause of floods (Friend et al., 2016; Rebecca, 2019)—the geography and topography of Thailand slope from the north down to the middle of the country. During the rainy season, the Chao Phraya River is Thailand's major river that bears water flows from the north. However, the transformation of urbanisation has destroyed the natural water systems of the country, meaning the Chao Phraya River cannot carry the overload flows, and the massive amount of water has directly caused flood problems for the whole country. Notably, the Northern part of Thailand is considered as a critical area that experienced regional sustainable development problems. The highland landscape is covered by forest, and it is a location of essential watersheds that flow through the Ping River Basin system, which has a catchment area of around 35,000 km^2 into the Chao Phraya River. The Ping River Basin is crucial for the rainy season, in which the water is stored in the downstream reservoir and irrigated for agricultural and commercial uses in the dry season to prevent drought problems (Lim et al., 2012). Previously, the basin area consisted of subtropical forests that later were changed into agricultural areas, which were related to social, political, and economic factors that affected the change in land use (Fox et al., 2012).

Except for the critical flood issues in Thailand, air pollution studies during the past five years in Thailand reveal that there has been a severe air pollution problem which is that the Particulate Matter sized 2.5 microns ($PM_{2.5}$) directly affects the environmental systems in Thailand, particularly in the northern and middle part of the country (Wongwatcharapaiboon, 2020) The cause of this problem is the traffic congestion that produces dust and black carbon; likewise, the biomass burning from agricultural sources has increased and accelerated the rise in air pollution that affects the well-being of local people and ecosystems (Squizzato et al., 2018). After searching for a case study, Chiang Mai City was selected to be a case study. First of all, Chiang Mai City is located in the north of Thailand. Chiang Mai City is a critical historic city that was the capital of the Lanna people (population in Northern Thailand). It was established in the 13^{th} century. *Figure 4.7* depicts the city centre, designed as a square surrounded by walls and double layers with a moat where water was irrigated from the nearby river. In the past, the area between the walls and the river at the east was likely a rice field as the main agricultural source of the Lanna area (Scheer & Scheer, 2002). Therefore, the map shows the local natural systems of Chiang Mai City; the city centre is in the middle, with the Chiang Dao

Mountain in the north, the Suthep Mountain in the west, and the Ping River in the east; these natural systems have been considered a crucial eco-corridor of Chiang Mai City since the previous period.

Chiang Mai City was built with the consideration of preventing flood risk. According to the morphology and topography, the city is located on a modest slope between the Suthep Mountain and the Ping River to drain water in the rainy season into the river system. Therefore, the natural rivers were critical for local people in terms of being the traditional systems supporting agriculture, communication, transportation, and a secure place (Ng et al., 2015). As shown in *Figure 4.7*, Chiang Dao Mountain and Suthep Mountain are significant natural water sources. The water from Chiang Dao Mountain flows through tiny natural creeks to Ping River, while the water from Suthep Mountain flows through a waterfall and natural streams restored at Fai Hin and Wiang Chet Lin as the old reservoirs of Chiang Mai City. Therefore, Huay Chang Khian Creek received the water from Suthep Mountain and flew directly to Nong Bua, the city's most extensive reservoir.

The Chiang Mai Old City study mentions that the Fai Hin, Wiang Chet Lin, and Nong Bua reservoirs were vital wetlands of the city as they stored water from the Suthep Mountain and surrounding natural streams during the monsoon season and irrigated the rice fields during the drought season (Charoenmuang, 2007). Unfortunately, the change in traditional system and degradation of the Fin Hin, Wiang Chet Lin, and Nong Bua reservoirs occurred during the colonisation of Siam (which was changed to Thailand afterwards) in the late 19th and early 20th centuries – at that time, Chiang Mai City was not yet part of Siam. The reign of King Rama V created significant changes to the political aspects and the structure of the country based on the modern technology of those times without consideration for the water-based management of the city (Phanthuwongpakdee, 2016, p. 131). With the effect of this manner, the traditional water system of the city was destroyed. The empirical evidence shows that Wiang Chet Lin wholly transformed into the main roads and area residential and commercial. Likewise, Nong Bua was affected by the urban transformation; however, the empirical evidence shows that some of Nong Bua's areas are vacant and belong to the private sector as awaited land for development. Therefore, a significant change of tradition system in aspect of urban planning, industrialisation development had become fruitful, and many railroads were built to connect the main cities of the country; these constructions

directly impacted the changes of natural waterways for transportation which recently become the mains roads of Chiang Mai city while a traditional waterway has been replaced and disappeared. Moreover, the conventional irrigation methods were replaced by greater systems that were initially intended to increase the production of rice. With regard to the changes, the rapid urbanisation and development of the floodplain, especially from industrialisation in the late 20th century, have been the causes of Thailand's flooding since then (Lebel et al., 2007; Phanthuwongpakdee, 2016).

The traditional systems in Chiang Mai, evolving over time, encompassed various facets that shaped the city's historical lifestyle. These included:

Water Management: The traditional approach to managing water involved using natural sources, reservoirs, and irrigation channels to aid agriculture and regulate water across different seasons, playing a pivotal role in sustaining the city's livelihood and farming practices.

Urban Layout and Infrastructure: Chiang Mai boasted a distinct urban design, featuring a central city area enclosed by walls and moats intended to mitigate flood risks. As these structures transformed and modern infrastructure emerged, the city's architectural scenery underwent substantial alterations.

Transportation and Communication: Traditional modes of travel, such as waterways, wooden boats, and carts, served as vital transportation and communication mediums. However, advancements ushered in by modernisation replaced these traditional methods with motor vehicles, railroads, and contemporary communication technologies.

Agricultural Practices: The traditional agricultural system relied heavily on the fertile lands encircling the city, predominantly used for cultivating rice fields and farming. With the city's progression, these lands transitioned into commercial and residential zones, catering to the burgeoning population and evolving economic demands.

Cultural and Social Dynamics: The traditional systems in Chiang Mai City encompassed cultural and social elements, embracing community interactions, local traditions, and a way of life rooted in the city's historical heritage.

These traditional systems underwent significant changes over time, owing to urbanisation, technological advancements, and societal shifts, thereby moulding the city's identity and reshaping its contemporary landscape.

The decline and rearrangement of the city's primary irrigation system brought significant changes to how locals lived, impacting transportation, farming, and communication. This shift saw the former waterways, previously used for irrigation and transportation, change into railroads and residential areas. Furthermore, traditional methods of travel, once reliant on wooden boats and carts, were replaced by motorbikes and cars. Simultaneously, lands that were once used for farming—historically rice fields—were transformed into shops and housing for the increasing local and immigrant population. These changes aimed to modernise the city in line with global standards and technological advancements, aiming to position it as a centre of progress. This transformation has notably impacted the local environment, leading to recurring floods expected to persist. Aside from flooding, the deterioration of water systems poses a significant challenge for Chiang Mai City, profoundly influencing its developmental trajectory (Charoenmuang, 2007; Phanthuwongpakdee, 2016).

This section illustrates the evolution of traditional systems in Chiang Mai City, showcasing their significant influence on the transformation that contributed to local environmental issues, as outlined below.

Alteration of Natural Waterways:

1. Degradation and Transformation: The historic water systems, notably the Fai Hin, Wiang Chet Lin, and Nong Bua reservoirs, underwent degradation and transformation during a period of modernisation. These reservoirs, pivotal for water storage and irrigation in the region, were repurposed into urbanised zones and road networks.

2. Replacement by Modern Infrastructure: The traditional water networks were supplanted by contemporary infrastructure, exemplified by the implementation of railroads and the interruption of natural water flow due to the development of roads and drainage mechanisms.

Urban Planning Revisions:

1. Altered Landscape Dynamics: The fundamental landscape and configuration of the region were reshaped owing to urban planning interventions. The conversion of reservoirs into urban and residential sectors significantly impacted the indigenous water management strategies.

2. Impact of Industrialisation: The swift urban expansion and industrial progress catalysed changes in land utilisation, resulting in the conversion of agricultural domains into commercial and residential precincts. Concurrently, the construction of roadways and infrastructure reconfigured the cityscape.

Impact on Local Socio-economic Fabric:

1. Disruption of Traditional Modalities: The waterways and urban infrastructure modifications disrupted age-old practices and norms among the local populace. This alteration affected conventional modes of transportation, communication, and livelihoods, particularly those reliant on water-based activities.

2. Environmental and Societal Implications: The reengineering of water management systems gave rise to recurrent flooding issues, significantly impacting inhabitants' daily lives. Furthermore, the transition from agricultural to urban zones led to a transformation in local lifestyles and economic activities.

In synthesis, the transformation of Chiang Mai City's traditional system engendered substantial changes in natural waterways, urban planning paradigms, and the socio-economic fabric of local communities, manifesting as landscape alterations, the remodelling of traditional practices, and the emergence of environmental and societal challenges.

Furthermore, the significant environmental impact is evident through recurring floods, which are expected to persist in the future. Beyond the issue of flooding, Chiang Mai City grapples with the deterioration of its water systems, exemplified by the degradation of water quality in the Mae Kha Canal over three decades (Nuanla-Or, 2016, p. 1). Addressing the escalating surface runoff problem necessitates bolstering infrastructure to mitigate flooding. Presently, the city predominantly employs waterways as drainage channels, often lined with concrete, to facilitate water conveyance and prevent surface erosion. However, while addressing flooding, this approach adversely affects the local environment and ecosystem, leading to diminished biodiversity and mutations in local flora and fauna (Nuanla-Or, 2016, p. 6).

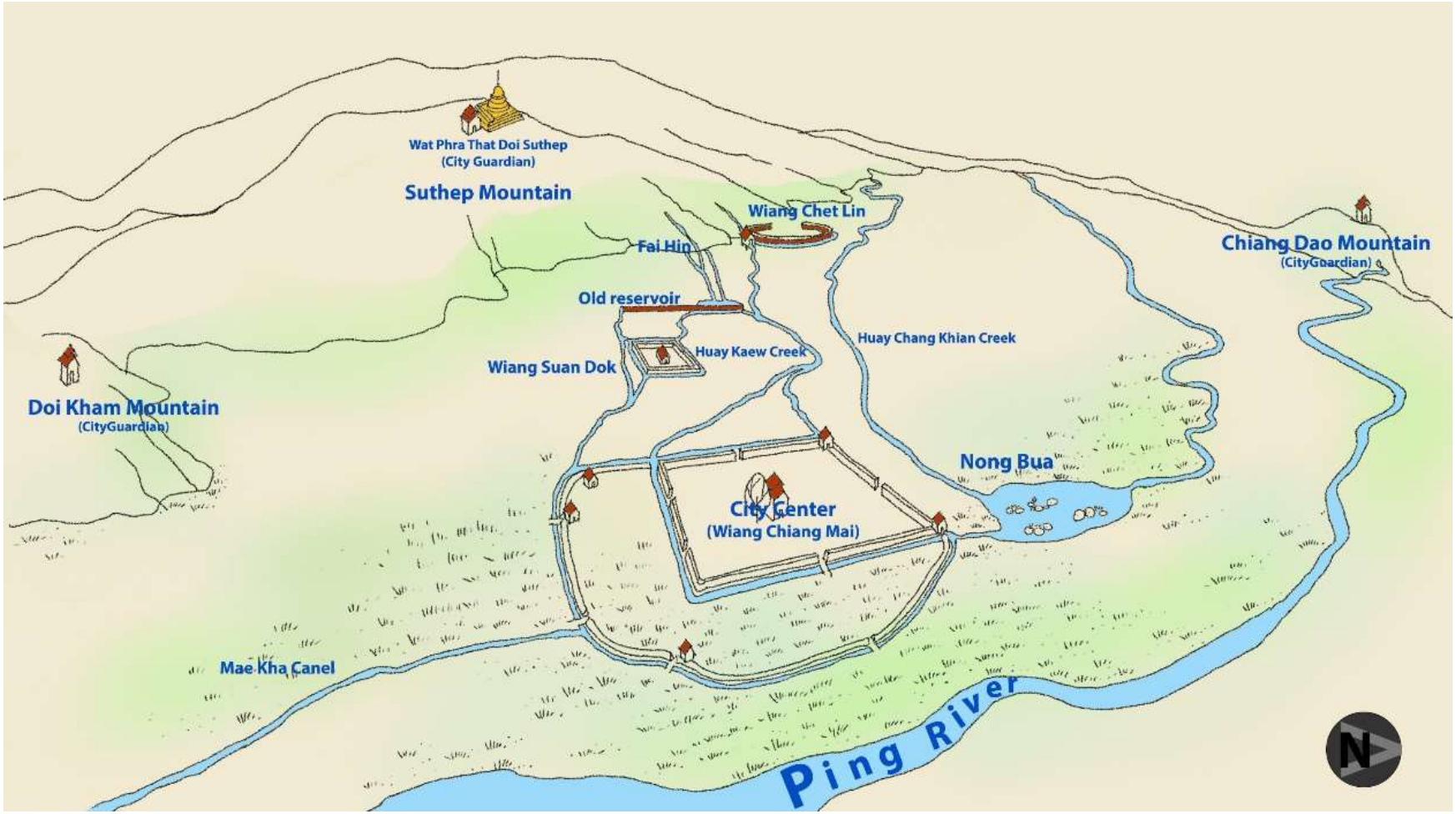


Figure 4.7 The map of the connection of Chiang Mai City's natural water systems management with the surrounding mountains (Applied from (Chiang Mai World Heritage, 2020; Scheer & Scheer, 2002)

Moreover, Chiang Mai City is one of the fastest-growing cities in Thailand (Kumar et al., 2016; Kusakabe et al., 2014). *Figure 4.8* shows the location of Chiang Mai City, which is 700 km from Bangkok, and "Mueang Chiang Mai District" is the city's centre. *Figure 4.9* shows the coverage area of 40.216 $km^{2,}$ which combines 14 sub-districts with a total population of 141,361 people. Therefore, Chiang Mai Municipality is considered as the 4^{th} most famous municipality in Thailand. Currently, Chiang Mai City is facing urban issues related to the transformation of cities, including sprawling and unplanned urban development, water and air pollution, local traffic congestion, and inferior waste management, which impact environmental degradation.

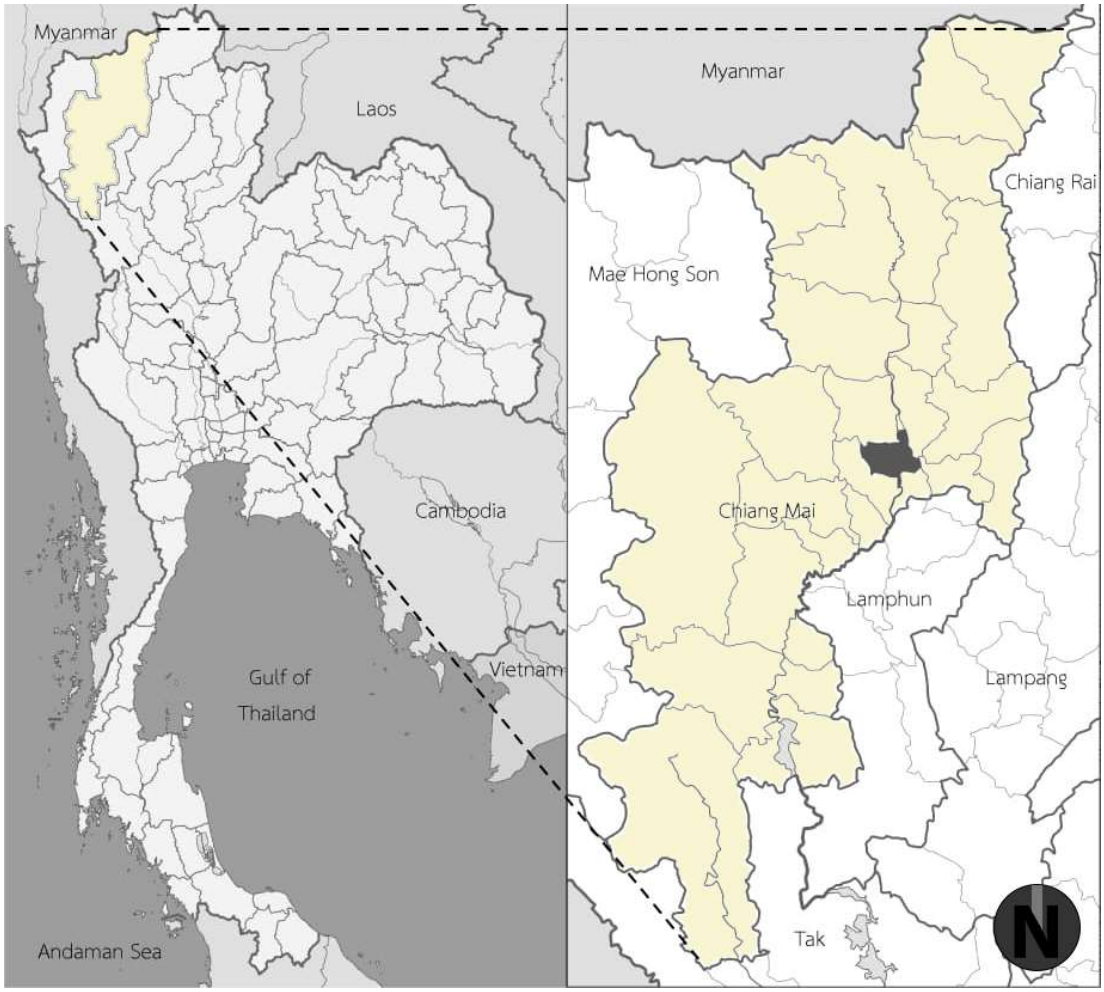


Figure 4.8 The map shows the location of Chiang Mai City (modified from (Satsue, 2018, p. 2))

The sprawling expanse of the urban area in a horizontal dimension interferes with the compact pattern of the city centre, as shown in *Figure 4.9.* Moreover, unplanned urban development lacks consideration for compatibility with current traffic management regulations and policies, which directly leads to local transportation

difficulties, such as rising traffic congestion, air pollution, insufficient local public transportation and pedestrian ways that are inconvenient for local people and tourists (Kumar et al., 2016). Besides, based on the land use and land cover statistics acquired from the GIS database, satellite images of 1952, 1977, 1989, and 2000 showed the accelerated change in urbanisation in Chiang Mai city. Therefore, the statistics illustrated the expansion of the urban area from 13 km^2 to 339 km^2 from 1952 to 2000, with the tendency to continuously increase (Sangawongse, 2006), as the land use of Chiang Mai city increased by 24% between 1989 and 2009 from an agricultural area to a transformed city (Lebel et al., 2009; Masud et al., 2016; Sangawongse, 2006; Sangawongse et al., 2011).

Subsequently, the degradation of nature leads to climate change, increasing flood risk. Empirical evidence shows a severe flood in 2011, which was ranked the highest in the world at that time, and records predicted that a similar amount of flooding would possibly occur again within 10 to 20 years (Gale & Saunders, 2013). In addition, the construction of the main ring roads and the changes to the Ping River bank and floodplain are referred to as the causes of the severe floods in current years (Jarungrattanapong & Manasboonphempool, 2016; Jompakdee, 2004; Lebel et al., 2009; Rigg & Ritchie, 2002). Furthermore, mudslides and flooding impact the greater area in Northern Thailand, including Chiang Mai City and other cities (Wood & Ziegler, 2008). The severe flood in 2011 caused damage of up to $45 billion, reflecting difficulty in water management. However, urbanisation development has both positive and negative effects on sustainability, leading to the climate change crisis (Rebecca, 2019). According to the Global Climate Index of Thailand, Thailand is one of the countries most affected by global climate change (Wibulpolprasert, 2016). It has been suggested that Thailand should create a heritage of flood flexibility to decrease the risks of climate change. Apart from this, Chiang Mai City should also apply the pattern of historical development to maintain its identity while reducing the risk of flooding issues (Rebecca, 2019).

Figure 4.9 The map of Mueang Chiang Mai District Area and Urban transformation (Picture retrieved from earth.google.com on 21st September 2022)

Furthermore, except for urban transformation and flood issues, the previous study shows that the population in Chiang Mai City is dangerously affected by $PM_{2.5}$ air pollution. The level of $PM_{2.5}$ in the city has exposed and exceeded the recommended standard level of $PM_{2.5}$ (10 μg/m^3) set by the World Health Organisation. Therefore, the world ranking obtained on 24 March 2019 showed that Chiang Mai city had the highest record of $PM_{2.5}$ level for 240 μg/m^3. The following year's record showed that on 15 March 2020, it reached the highest $PM_{2.5}$ level of 193 μg/m^3. The highest level of $PM_{2.5}$ in both years indicated that excessive $PM_{2.5}$ levels severely affected the local population's health. Furthermore, the record data of the Thai Pollution Control Department revealed that the local population continuously faced dangerous levels of $PM_{2.5}$ in 2019 and 2020 for more than 44 days and 37 days, respectively. Mostly, the high concentration of $PM_{2.5}$ levels in Chiang Mai City is from pollution in urban areas, open agricultural burning, congestion of transportation, and transboundary smog from surrounding countries (Jarernwong et al., 2021). This is because the topography of Chiang Mai City is in the shape of a basin surrounded by steep mountains that trap and affect the climatic and airflow circulation, leading to air pollution distribution (Mostafanezhad & Evrard, 2021).

With regard to experimenting with the capability of the RDF-T, this study searched for a particular area with the most potential for being the case study. Interestingly, in 2019, there was a project named “GREEN BOOK” for the 2021 public policy for greening Chiang Mai, which started from 33 civil society networks and independent organisations that intended to improve the quality of local environmental issues in the Chiang Mai Municipality area. The main focus of this project aimed to build an ecology corridor to re-establish a connection between local people in Chiang Mai City and Chiang Mai’s main ecosystem network, which are Suthep Mountain and the Ping River, as these two natural elements are the biggest natural resources for feeding Chiang Mai city from the past until now (Jai Bann, 2019). In addition, the research of the GREEN BOOK project showed that the Chiang Mai Municipality area currently has 18% of the green area, which is 7.44 km^2 out of 41.09 km^2 of the whole area (Jai Bann, 2019). Therefore, the GREEN BOOK project considered that the challenge of future development in Chiang Mai City is: -

1. Air Pollution and Smog Problem ($PM_{2.5}$)
2. Rapid Urban Development Problem and the Loss of Green Area
3. The increasing of city temperature (Urban Heat Island)

Thus, the GREEN BOOK project focused on three crucial ambitions that need to be achieved in 2021: (1) Increasing green areas and a healthier ecosystem for Chiang Mai City, (2) Solving urgent environmental problems in Chiang Mai City, such as air pollution and the smog problem ($PM_{2.5}$), a loss of green areas from urban development and the urban heat island phenomenon in Chiang Mai city, and (3) Searching for a suitable prototype of an environmental design in a green area which should be compatible with the place and local people (Chiang Mai World Heritage, 2020; Jai Bann, 2019).

Regarding the three main ambitions of the GREEN BOOK project, this study highlights the possibility of applying RDF-T, based on a principle of regenerative design and development approaches in response to creating green infrastructure to reduce air pollution, the smog problem ($PM_{2.5}$), and the urban heat island phenomenon (Akbari, 2005; Vaz Monteiro et al., 2019), to improve Chiang Mai city's environment. Furthermore, applying the Backcasting technique and TREES requirement can produce an appropriate policy for the environmental development plan of Chiang Mai City (Quist, 2007; Thai Green Building Institute, 2016b). Based on the study's ambition, it intended to use the RDF-T in terms of solving and reducing accelerated urban transformation and flood issues. Then, this study aims to introduce RDF-T as an alternative built environment design tool for local design practitioners.

After studying and acknowing the dramatic environmental problems of Chiang Mai City from previous studies, including the information mentioned in the GREEN BOOK project, there was a potential site that the GREEN BOOK project needed to improve as it was a place full of historical value and used to be a crucial natural system of Chiang Mai City in the past decades and this place is called "Nong Bua". In this manner, this study considered this opportunity to select Nong Bua as a potential case study for experimenting with the RDF-T.

4.3.1 Case Study Area: Nong Bua, Chiang Mai City, Thailand

The Chiang Mai World Heritage Initiative team (CMWHI) is one of the GREEN BOOK project contributors who is urging Chiang Mai City to be a world heritage site, and now Chiang Mai City has been placed on the tentative list for UNESCO (Jai Bann, 2019). In 2020, the CMWHI team planned for environmental development within the nominated boundaries of Chiang Mai City. The study had a chance to exchange the idea of developing Chiang Mai City's environment with the CMWHI, and the team was interested in applying the RDF-T to the Nong Bua area. As shown in *Figure 4.10*, this area

has value to Chiang Mai City for its historical significance, as it used to be one of the seven sacred places of the city for religious worship. Therefore, it was a critical wetland that received natural water from Suthep Mountain before being released to other natural canals to feed the city and local people (Charney, 2011).

Chiang Mai City, meticulously planned to navigate flood risks, has seen significant changes during its urban evolution and industrialisation, notably since the colonial era of King Rama V. Unfortunately, this progression has witnessed the destruction of invaluable natural water systems, including the irreplaceable Nong Bua. The loss of this crucial wetland has profoundly impacted the city, triggering recurring flooding crises and hampering irrigation during droughts. The expansion of transportation networks, oblivious to water management considerations, further exacerbated the situation. With roads and ground surfaces constructed at varying levels, the monsoon rains inundate these pathways, unable to efficiently drain excess water into the local sewer systems. Consequently, the city grapples with recurrent flood woes and escalating water contamination.

According to Chiang Mai City's old map and previous studies shown in *Figure 4.10*, Nong Bua disappeared around 1904 due to urban transformation (Satsue, 2018), and nowadays, most of the Nong Bua area has become a residential area, commercial area, and part of Chiang Mai Rajabhat University's campus. Besides, *Figure 4.11* reveals that the freeform figure that is shown in green is vacant land awaiting development with an approximate area of 41,248 m^2. The CMWHI noticed the importance of Nong Bua and aimed to regenerate and develop this area to represent the old Nong Bua image, which was full of diverse ecology (Charney, 2011; Chiang Mai World Heritage, 2020). Moreover, with funding support from the Chiang Mai Provincial Administrative Organisation, the CWWHI intended to provide a new green area for Ching Mai City, which was also the intention of the GREEN BOOK project (Jai Bann, 2019).

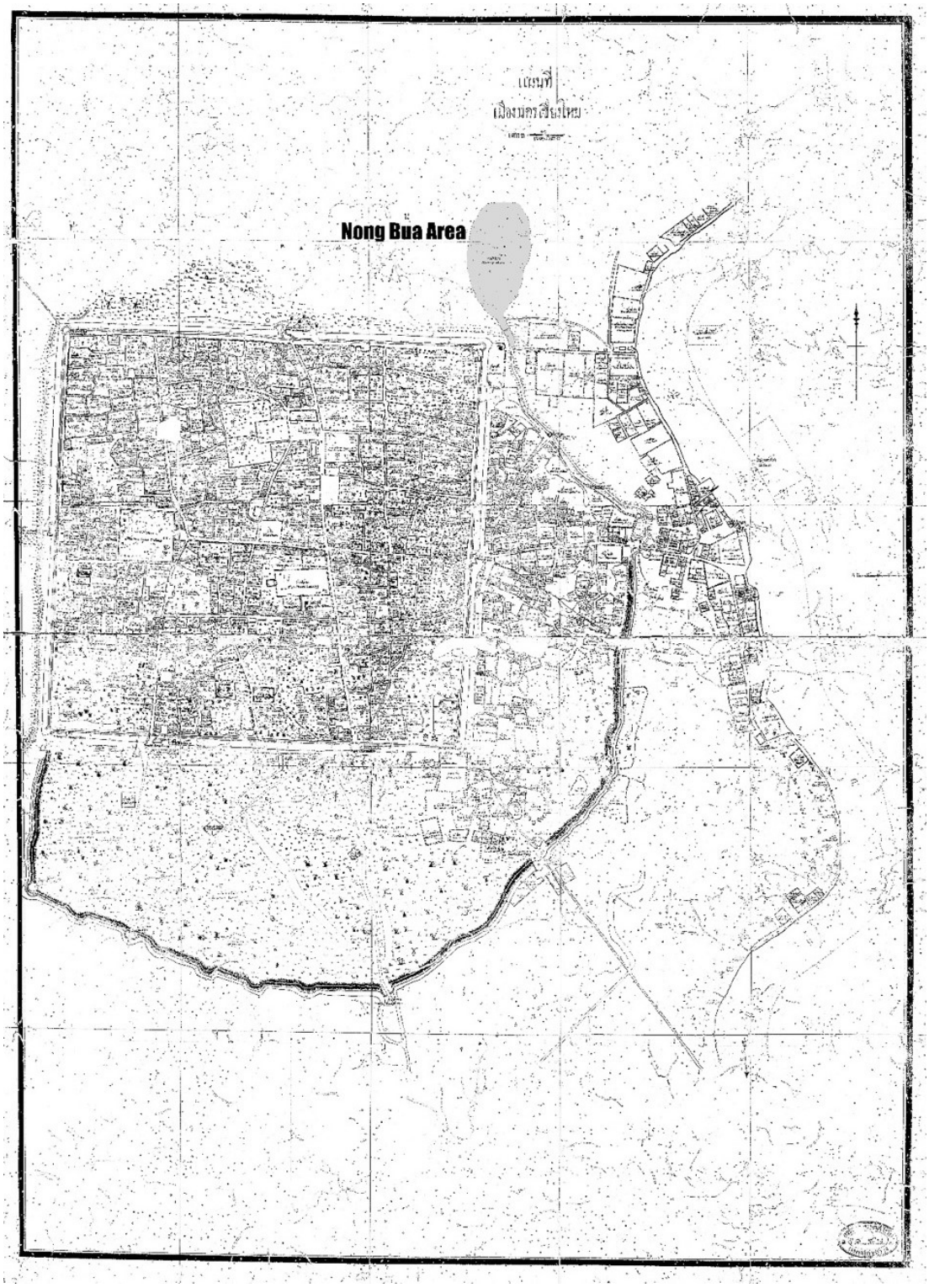


Figure 4.10 The old map of Chiang Mai City in 1893 (Modified an original picture from The Payap University Archives (Satsue, 2018, p. 173))

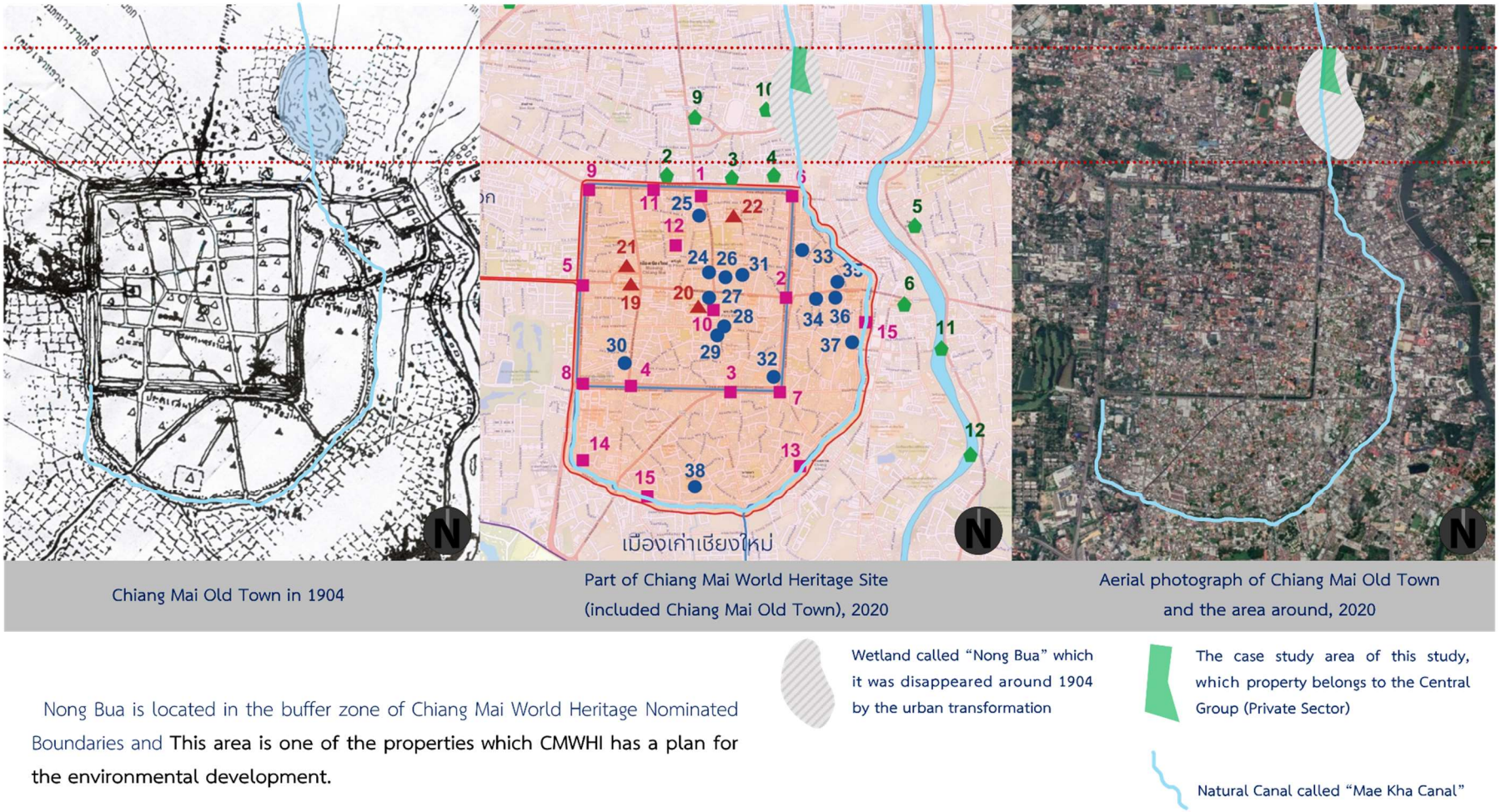


Figure 4.11 The map shows a transformation of the Nong Bua area between 1893 and 2020 (Pictures from (Chiang Mai World Heritage, 2020; Satsue, 2018, p. 198)

Figure 4.12 shows the location of Nong Bua, with an approximate area of 41,248 m2, which lies approximately at latitude 18° 80', longitude 98° 99', and altitude of 305.74 meters. The North of Nong Bua is near the south side of Muen Dam Phra Khot Road; the East is near the west of Rural Road Chiang Mai 2041, and the west of Asadathorn Road; the West is near the west of Chang Phueak Road; the South is near the north side of Maneenopparat Road. The Nong Bua area connects with the critical surrounding areas, such as Chiang Mai Old Town, Chiang Mai Rajabhat University, Chiang Mai Municipal Stadium, Jing Jai Market, Mueang Mai Market, Pa Phaeng Temple, and surrounding natural water systems which are Huay Chang Khian Creek, Mae Kha Canal, and Ping River, which are natural resources affected by the disappearance of the Nong Bua wetland. This transformation has interrupted the waterways, which leads to flooding issues. *Figure 4.13* depicts an aerial photograph of the Nong Bua area retrieved from the GIS database. It shows that this piece of the old Nong Bua area is vacant. This area is next to the main roads leading to the other important spots of Chiang Mai City. Regarding the physical attributes of this area, it is similar to a low basin, which is lower than the surface of the roads. With unconsidered water management, during the rainy season, excessive stormwater from the road flows through this area, causing flooding and leaving standing water that later causes water pollution and disease.

Referring to the existing regulation and design practices of Chiang Mai City, all developing areas must follow the third revision of the Chiang Mai Comprehensive Plan, which divides land use into eleven zones, as shown in *Figure 4.14*. *Figure 4.15* shows that the Nong Bua area is located on land number 4.18 in the red zone, which is a high-density residential area. The Comprehensive Plan states that a high-density residential area is for the use of commercial, residential, tourist attractions, government institutions, and public facilities – for the other purposes of land use is permitted to not over 15% of the whole area, which applied the regulation in the red zone. Besides, the design practices are indefinite; however, the design shall prioritise the impact on the local environment and community (*The Third Revision of the Chiang Mai Comprehensive Plan*, 2010, p. 22). With respect to the existing regulations, this study concerns it as crucial information that potentially supports the built environment design process of the Nong Bua area.

Figure 4.12 The connection between the Nong Bua area and the surroundings (Retrieved from the GIS database on 21st September 2020)

Figure 4.13 The Aerial photograph of the Nong Bua area (Retrieved from GIS database on 21st September 2020)

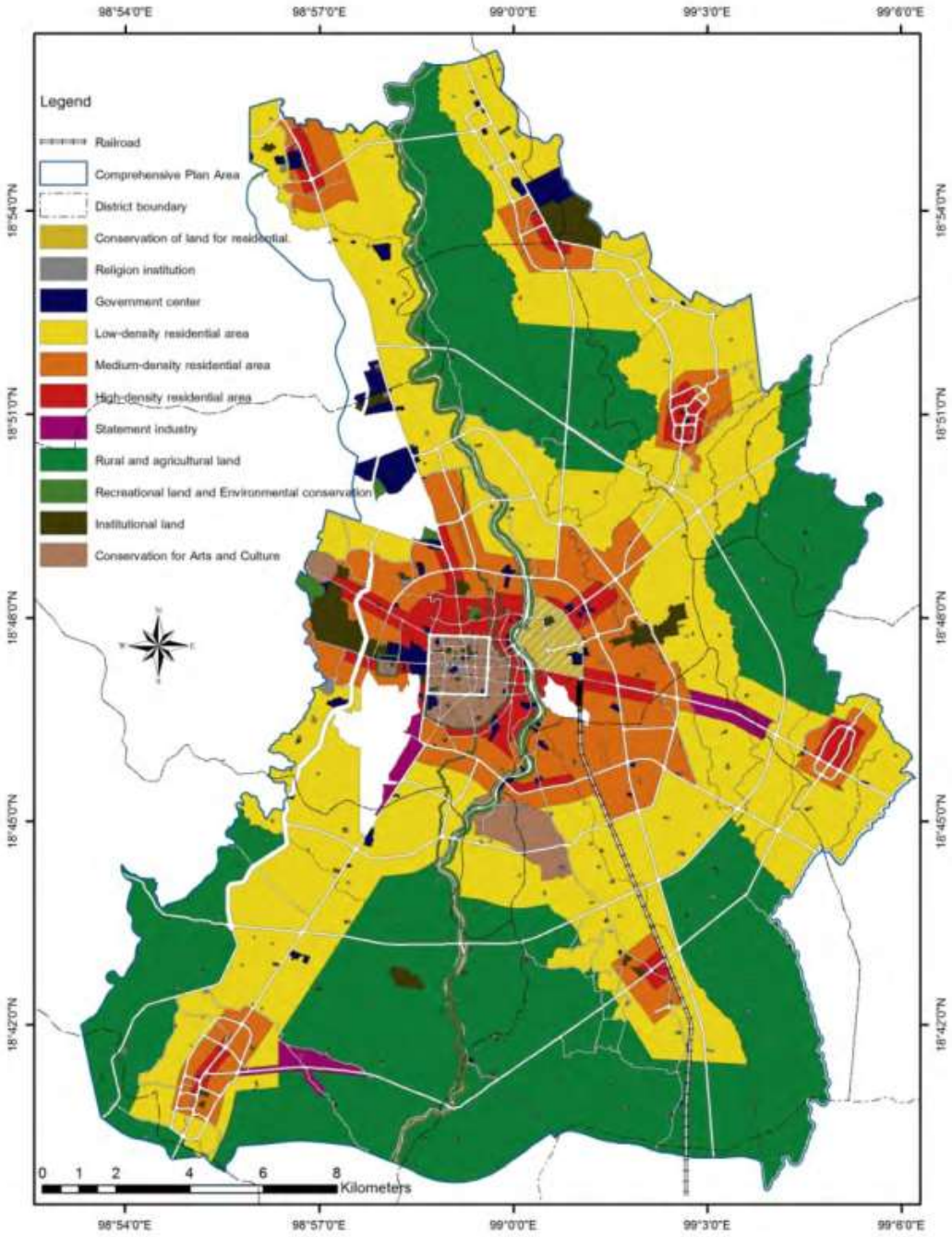


Figure 4.14 The Chiang Mai Land Use Mapping in the Third Revision of the Chiang Mai Comprehensive Plan (*The Third Revision of the Chiang Mai Comprehensive Plan*, 2010).

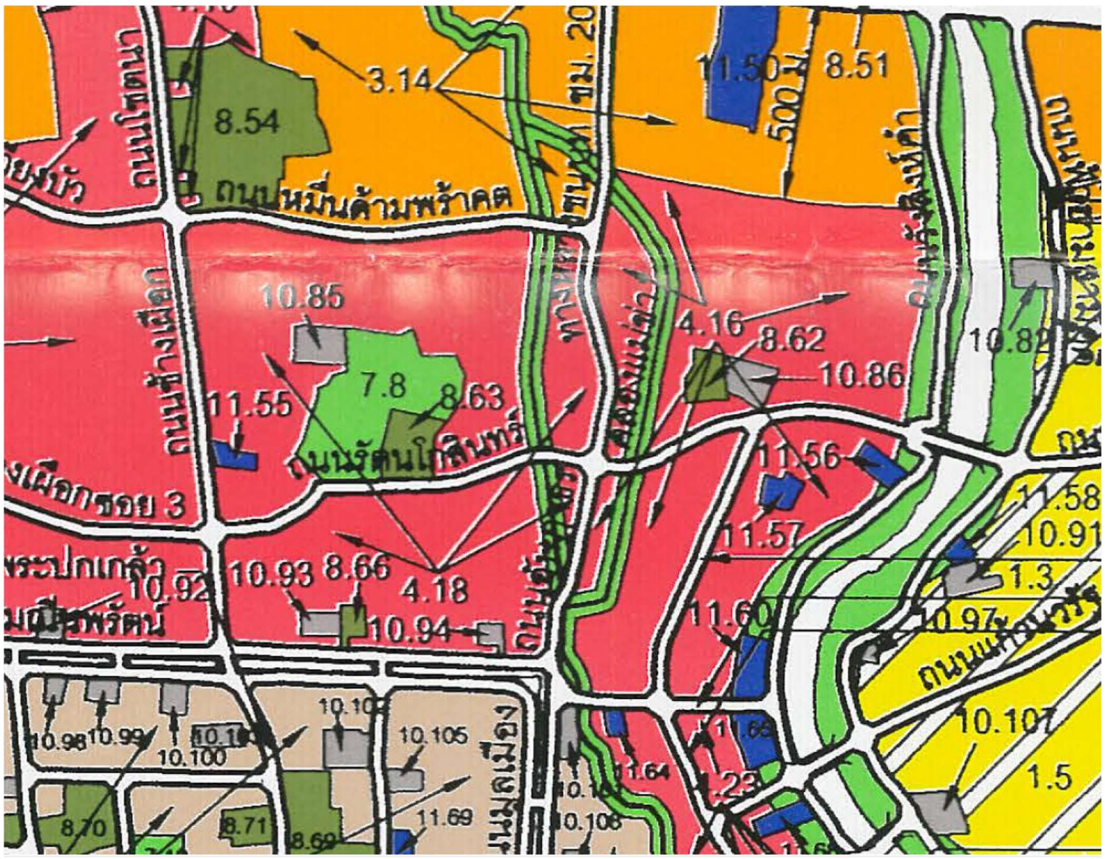


Figure 4.15 The Location of the Nong Bua area on land number 4.18 in the red zone (*The Third Revision of the Chiang Mai Comprehensive Plan*, 2010).

The challenge was that this property belonged to a private sector company called the Central Group. However, with the assistance of the CMWHI, this study offered a proposal that explained the aims and objectives of this regenerative design for the built environment in the Nong Bua area to the property owner.

1. To apply the RDF-T to be adjusted for a built environment design and re-establish the local ecosystem with policies that suit the context of the Nong Bua area and surroundings.

2. To create a shared understanding among the relevant participants in a built environment design process for studying and acknowledging the spatial site's physical and historical value and use it to compare the difference in the social function between the past and present. Therefore, this built environment design process can encourage and strengthen the awareness of environmental problems.

3. To provide an opportunity for participation in the built environment design and development guideline-making process. To enhance the interdependent

relationship between humans and nature while considering the needs of a property owner and suitability for the local community and further development of Chiang Mai city.

4. To use an initial built environment schematic design and green policies as an explanation of the environmental development plan in the report to UNESCO and provide this initial built environment design to the property owner. Later, it will probably be used in the actual building and environmental development for the Nong Bua area and be a guideline for other places.

5. To use the obtained data from the regenerative design for the built environment in the Nong Bua area to support the study of the RDF-T in terms of finding the conclusion for the research.

Furthermore, the CMWHI team contacted the Central Group to exchange ideas and discuss the possibility of the development of this area by inviting them to participate in a 3-day workshop with the other relevant participants such as the community architects, landscape architects, TREES specialist, local people, Chiang Mai historical expert, ecologist, and botanist, using the RDF-T to lead the workshop. This provided an excellent opportunity to experiment with RDF-T and observe the whole process to collect the data, analyse the results and summarise the conclusion of this study. Therefore, the details of the 3-day workshop will be explained in the next part.

Chapter 5

Testing the RDF-T in a case study area

5.1 The Examination of the RDF-T

According to the previous chapters, existing regenerative design frameworks and the Backcasting technique require the relevant stakeholders to engage with the process as a crucial methodology for underpinning the accuracy of the design result to the RDF-T (Kishita et al., 2017; Köves et al., 2013; Palacios-Agundez et al., 2013). This study aims to manage a 3-day built environment design engagement process to testify to the RDF-T's capability through the case study experiment. In detail, this chapter attempts to apply the RDF-T in an actual case study, which is the Nong Bua area in Chiang Mai City, Thailand, in terms of contributing to a built environment design that suits the local ecosystem and community for the holistic benefit of humans and nature.

A 3-day built environment design engagement is based on previous regenerative design engagements that applied LENSES and Perkins+Will framework to their projects. The first day is mainly used for site visiting as the story of a place can provide a better understanding for stakeholders about the current conditions of the place. Then, the next day is for the built environment design process; it should be 1 to 2 days, depending on the site's scope, scale, and complexity. Finally, the last day of the engagement process is for the built environment policy-making process in which this study uses the Backcasting technique for supporting and finalising the consensus guideline or policy that all stakeholders create together in terms of contributing to the future success and

maintenance of the suitable ecosystem for the project site and surrounding community. The following parts will explain the deeper details of the research methodology implemented in the built environment design engagement process.

Investigating the use of the RDF-T is the most influential part of this study. This is because the findings can show the RDF-T's capability to respond to the research questions insofar as identifying its success or failure as an alternative built environment design tool for the Thai context. Moreover, the findings of this study can potentially be developed further and promote regenerative design and development among Thai design practitioners. In addition, the RDF-T can be repeated in other developing areas, as it can be another built environment design tool compared to different mainstream sustainable design approaches. Therefore, it perhaps increases more choices for design practitioners and relevant experts in regard to choosing a design tool to create better conditions for the Thai ecosystem to re-establish genuine sustainability.

5.2 The Engagement Process: A 3-Day Workshop on Built Environment Design and Development guideline-making Process

Existing regenerative design frameworks illustrate that one of the most effective methods is to gather stakeholders who are involved in the developing place to participate in the regenerative design workshop process. Regarding their different backgrounds of knowledge, they can exchange thoughts and ideas among themselves and use these notions to stimulate and understand the story of a place, which is the main factor of the regenerative design approach that can design maximum benefits for both the ecosystem and humans (Miller, 2012). Therefore, the RDF-T elements include a Backcasting technique, which is well-known as a tool in the sustainability field for creating a policy and strategy to accomplish the desired goal (Quist, 2007). Likewise, this technique requires an engagement process as a critical approach to gather participants for brainstorming, setting the desired goal and paving a way to obtain that goal (Quist & Vergragt, 2006).

This study focuses on investigating RDF-T in the Nong Bua area. This study grasped the research question of how RDF-T impacts Nong Bua's built environment design process and what the RDF-T's limitations and contribution plan of this research for supporting future studies. In addition, this study aims to use the outcome to examine a suitable regenerative design practice for the Thai context and policy guidance for the built environment in this area for further development.

Normally, the workshop day lasts for 1 to 3 days; it depends on the scope and scale of the development project and whether RDF-T has applied workshop patterns from the previous regenerative design frameworks as such LENSE and Perkins+Will (Cole et al., 2012; Hes et al., 2018; Plaut et al., 2012). A site visit mostly takes up the first day. The following day should be for the design development process, which should take 1 to 2 days, depending on its complexity. Then, the other day should be for regenerative development guidance or relevant policy-making processes. Therefore, for an appropriation of the workshop's length and activity, this study deliberated with the CMWHI team about the workshop pattern led by the TRD-F for consensus agreement and management, including the survey questions used in the workshop related to the evaluation of the capability of the RDF-T and suggestion in regards to developing this framework further which later this study can use the obtained data to analyse and find the study's conclusion. The details below will precisely explain all the procedures in the RDF-T workshop.

5.2.1 Stakeholder and relevant participant selection criteria

Referring to established regenerative design studies and Backcasting technique procedures, a diversity of stakeholders and participants is required in the engagement process. This is because their different backgrounds of knowledge and expertise are able to provide different perspectives on a case study area (Kilroy, 2014; Miller, 2012). Therefore, in the engagement process, they can exchange ideas and deliberate on a consensus agreement for a built environment design and development guidelines that suit their decision and local conditions. Moreover, these different ideas can help them further recheck and enhance the precision of the results. Existing regenerative design frameworks suggest that the example of potential participants is green design specialists, including architects and landscape architects, ecologists, botanists, green technology specialists, property owners, local people in the community, local authorities, historians, et cetera. However, the number of participants in the engagement process depends on how it relates to the scope and scale of the case study area, which the project team needs to examine carefully for appropriateness (Cole et al., 2012; Hes et al., 2018; Plaut et al., 2012).

5.2.2 Built environment design workshop and guideline-making process

According to the relevant studies and deliberation with the CMWHI team, this study arranged a 3-day workshop to experiment with RDF-T and the length of the workshop was adapted from the current regenerative design framework's studies mentioned in the previous section and based on the agreed-upon decision that this study considered to be a suitable time length and a selection of participants for the workshop from the scope and scale of the case study area with the CMWHI team who have the most knowledge about this area. In addition, the CMWHI team was the project leader, gathered the relevant stakeholders, and provided the necessary materials for the workshop.

Moreover, the workshop invited all stakeholders who had been involved with Nong Bua, such as a property owner, the CMWHI team, community architects, landscape architects, TREES specialist, local people, Chiang Mai historical expert, ecologist, and botanist to participate in this 3-day workshop. Before moving on to the next part, *Figure 5.1* illustrates a summary of this study's methodology used in the 3-day workshop on a built environment design for the Nong Bua area. This summary reveals the correlation between the methodology and research questions to summarise a comprehensive aspect of the accurate conclusion.

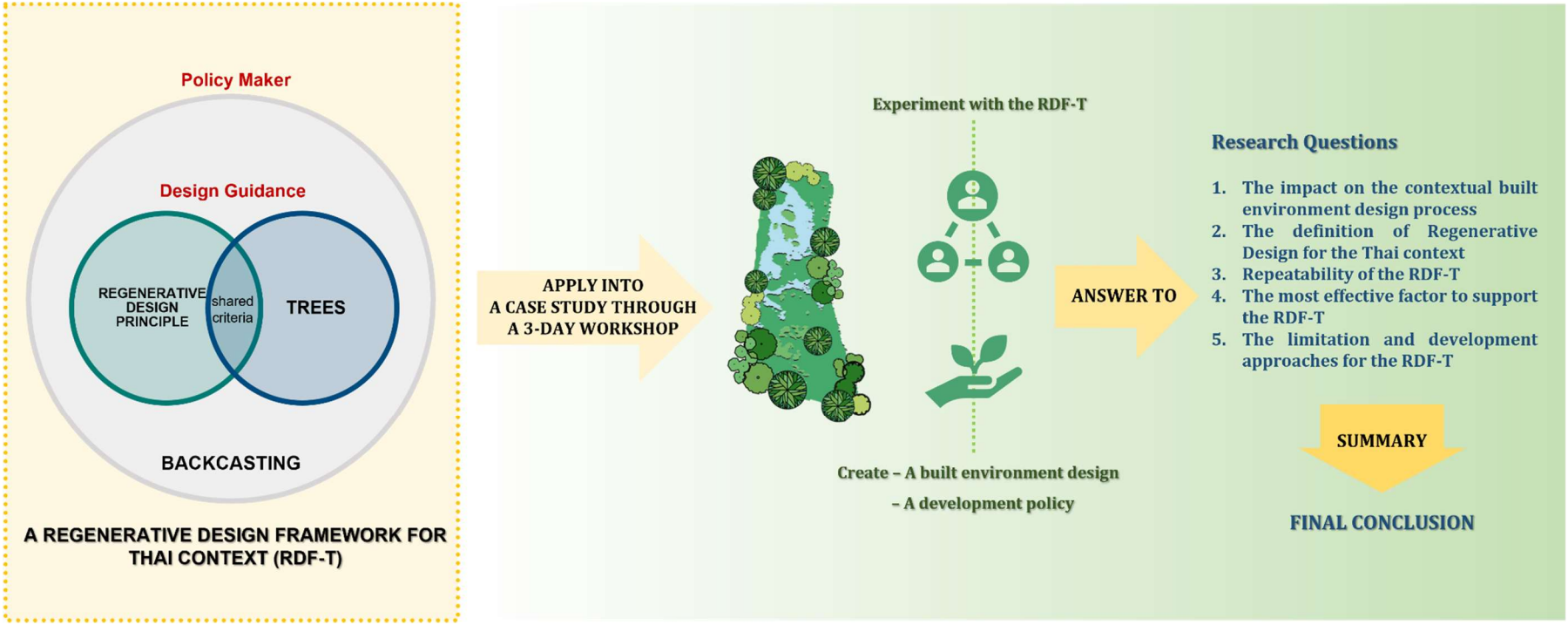


Figure 5.1 A Summary of the methodology of this study

5.2.3 Engagement Goal

This study arranged and explained the RDF-T to the CMWHI team to create a shared understanding before explaining it to the other participants again. When the built environment design workshop started, this study led all participants to consider the goal of engagement since this helped lead the team to focus on the crucial factors which established an efficient workshop. Furthermore, the awareness of the engagement goal could instigate a pattern of activity that would be allocated for the workshop days.

For this workshop, the engagement goal was an initial built environment design schematic and regeneration guidance to maintain the ecosystem's quality in the case study area. By means of this, the activities that would be allocated in the workshop days were a built environment design charrette based on regenerative design approaches, TREES, while using the Backcasting technique in a brainstorming process among the participants to produce a consensus agreement on ecological regeneration guidelines as a regulation to follow when it comes to an actual construction stage.

5.2.4 Workshop Activity Observation

This study has mainly focused on qualitative data collection, and during the workshop process, this study asked for consent from all participants to record their voices, pictures, and videos. Therefore, one CMWHI member noted each activity for accurate observation and comprehensive data collection. On the first day of the workshop, the first session was an introduction to the RDF-T and a discussion towards all the activities to create identical understanding among participants. The recording techniques were taking notes, voice, video and picture recording. Following the afternoon session was a site visiting activity; notes-taking, video and picture recordings were used for this activity.

On the second day, the activity was a built environment design process, which mainly proceeded the activity in a meeting room. Then, the recording techniques were notes-taking, voice, video and picture recording. Likewise, the last day of the workshop was a built environment guideline-making process, which used notes-taking, voice, video and picture recording to observe. This study examined the raw recordings as supportive materials that would later be used in data analysis, and thematic analysis was examined as a suitable way of analysing these raw data for this study.

5.2.5 A 3-Day workshop contents and activities

A 3-day workshop on the built environment design and development guideline-making process gathered the relevant stakeholders who are related to the case study area to participate in the workshop to exchange their thoughts and design a built environment paradigm for the case study area. At the end of the workshop, the participants had to brainstorm to create built environment guidance for the case study area for further development. The participants in the workshop were from the CMWHI team, property owner, community architects, landscape architects, TREES specialist, local people, Chiang Mai historical expert, ecologist, and botanist – the total number of participants was 17 persons. *Table 5.1* shows the name list and role of the participants, which later, their expertise was crucial and stimulated the quality of the workshop and provided accuracy of a built environment design outcome.

Table 5.1 The participant list

Organisation	Name	Role
CMWHI	Anonymous	Head of the CMWHI team
	Anonymous	The CMWHI team
	Anonymous	The CMWHI team
	Anonymous	The CMWHI team
Central Group (property owner)	Anonymous	Project Manager of Central Group
Jai Ban Studio	Anonymous	Community Architect
Homsuk Studio	Anonymous	Community Architect
	Anonymous	Community Architect
Faculty of Architecture, Chiang Mai University	Anonymous	Landscape Architect
	Anonymous	Landscape Architect
	Anonymous	Architect and TREES Specialist
Faculty of Fine Art, Chiang Mai University	Anonymous	Chiang Mai historical expert
Doi Suthep Nature Center, Faculty of Science, Chiang Mai University	Anonymous	Ecologist
	Anonymous	Botanist
Greenery.Beauty.Scent	Anonymous	Local people
	Anonymous	Local people
Ruk Chiangmai Urban Community network	Anonymous	Local people

Therefore, this study had a mixture of qualitative and quantitative research data collection, which mainly focused on qualitative data collection as this study planned to collect the data in the workshop that required the participation of the stakeholders. During the workshop event, the agenda of the study was distributed, including the explanation of a procedure in the workshop. Notably, there was a request for permission to record voices, videos, and pictures of the participants during the activities in the workshop that would be later used in a thematic analysis process. *Table 5.2* shows the contents and activities of a 3-day workshop on the built environment design and development guideline-making processes. In addition, during each activity, this study used questions related to the research aims and objectives, as shown in *Table 5.2*, to stimulate the participants' thoughts for the most comprehensive outcome. Furthermore, at the end of the workshop, this study prepared a survey for the participants, in which the number of responses from participants would potentially support the authenticity of the results, and later adapted the suggestions to strengthen and support the study results and further develop the capability of RDF-T.

Table 5.2 The contents and activities of a 3-day workshop (TRDF is a previous terminology of this study)

Day	Content and Question
1	**Morning session (2-3 hrs.)** Q1:What do you think about the current sustainable design (eco-friendly design /Green design)? Q2:What kind of elements of humans and nature can encourage the built environment design? • The Explanation of Thai Regenerative Design Framework (TRDF) • Discussion on "The work with nature (built environment & ecology)" by Jai Bann Studio, Community Architects • Lecture "TREES principle (Thai's rating of energy and environmental sustainability)" by Mrs Pimsiri Thovichit, TREES Specialist **Afternoon session (2-3 hrs.)** • Site visiting (the case study area is called Nong Bua in Chiang Mai, Thailand. Currently, this area belongs to The Central Group) to create a shared understanding. • Lecture on the "History of Place" by the Chiang Mai Historical expert Q3:What are the pros and cons of a case study area? and How can you use those pros and cons of this area in terms of enhancing the ecological system? • Group discussion "Story of place" (Old/New place's condition, Natural capital flows, Place's potential)
2	**Morning session (2-3 hrs.)** • Continue to discuss the place's potential (owner's aim, the local community's aim) / pros and cons of the place. Q4:What kind of built environment design do you want to build on a case study area? Q5:How can you use the natural flows on site to contribute to an architecture and landscape design? • Discuss and find the possibility of built environment design on the place **based on the regenerative design principle and TREES requirement.** **Afternoon session (2-3 hrs.)** Q6:Can you design a schematic design of the built environment for a case study area which could revitalise an ecosystem on site and the Mae Kha canal based on the regenerative design principle and TREES requirement? • Group discussion and design "schematic design of built environment" (architecture and landscape design) **based on the regenerative design principle and TREES requirement**
3	**Morning session (2-3 hrs.)** • Summarise a shared understanding of the schematic design of the built environment to set it as the desired goal to achieve Q7:What are the key factors that should be considered in the development of policy and guidance to achieve the desired goal for the built environment in a case study area and Mae Kha canal? • **Use the "Backcasting technique" to set the policy/guidance to achieve the desired goal.** **Afternoon session (2-3 hrs.)** • Summarise the results of the workshop. **Survey Question** Q8:Are you satisfied with the proposal for the Thai Regenerative Design Framework (TRDF)? Q9:In your opinion, what is regenerative design for the Thai context? Q10:Do you have a suggestion for the development of the Thai Regenerative Design Framework (TRDF)? • Feedback for the Thai Regenerative Design Framework (TRDF)

A 3-day workshop called Environmental Regenerative Design: Case Study Nong Bua, Chiang Mai, was held on 28-30th September 2020 at the Social Research Institute, Chiang Mai University, in collaboration with Chiang Mai World Heritage Initiative Project (CMWHI). The total number of participants in the workshop was 17 people. They were the CMWHI team, property owners, community architects, landscape architects, TREES specialists, local people, Chiang Mai historical experts, ecologists, and botanists. As shown in *Figure 5.2, Figure 5.3,* and *Figure 5.4,* all participants were fully engaged throughout the 3-day workshop.

First Day of the Workshop: there was an initial explanation of the RDF-T, including its elements to all participants as shown in *Table 5.1* of the participant list mentioned above to provide an identical understanding of the RDF-T for urging the flow of the workshop process, then started the workshop with a question that stimulated participants' thoughts towards current sustainable design, such as eco-friendly design, green design, and crucial elements of humans and nature that potentially encourage the built environment design.

After that, there was an activity that asked the participants to share their ideas and exchange their experiences about the Nong Bua area based on their backgrounds of knowledge. This process identified several aspects of Nong Bua that were slightly new for some participants, i.e. the difficulty of land management in regards to restricting the land from outsiders who caused harm to the area, the history of the Nong Bua in terms of the transition of the landlords. Regarding exchanging knowledge about Nong Bua at the initial stage of the workshop, the participants could use the acquired data to compare with the site's current condition when they visited Nong Bua as a following activity of the first day.

The site visiting activity was in the afternoon session; the participants were invited to visit the Nong Bua area to explore the current condition of the place. The empirical evidence showed that the Nong Bua area was a vacant land that the property owner solely used as a parking lot on the day the Jing Jai market opened. Apart from this, the Nong Bua area was affected by the urban transformation in which the old reservoir disappeared entirely, and the construction of the surrounding road created a different level between the roads and Nong Bua that, in the rainy season, this caused a flood and polluted water problems in the area. Therefore, the odour of water pollutants from the Mae Kha Canal affected the Nong Bua and surrounding communities.

During this activity, the site visiting activity urged the participants to discuss and share their knowledge about the Nong Bua area, and this process potentially highlighted the pros and cons of this area, including the potential of the site to develop as a green area for Chiang Mai City. Therefore, the discussion about the Nong Bua area could be linked to the connection with the surrounding community and local ecosystem, and these aspects would stimulate the participants' understanding of the story of this place. The understanding of this place's story would have a great deal of impact on the built environment design and guideline-making process in the following workshop days.

Second Day of the Workshop: It was prepared for a built environment design activity that asked the participants to share their ideas about their desire for a built environment that they needed this place to be. In the beginning, there was a discussion about a regenerative design approach and TREES requirement that could help the participants in terms of using these techniques as a tool for designing a built environment that the participants thought most suited the Nong Bua area and the surrounding community. The story of place that the participants learnt from the site visiting day effectively prompted the built environment design process. The participants understood the current condition of the place and mapped the natural flows of the past and present story together. Interestingly, during the discussion about the flows in this area, Chiang Mai historical expert, botanist and ecologist shared their knowledge of aspects of local beliefs and emphasised the importance of the Nong Bua as it was a crucial reservoir of the city. Therefore, they suggested other participants focus on re-establishing and increasing diversity of biodiversity in the area as a priority in the built environment design, which they thought was a supportive factor that potentially regenerates an abundance of the ecosystem to the Nong Bua area and local environment.

This process helped reveal a more explicit story of the place that led the participants to use this story to consider the most suitable built environment design for the Nong Bua area. The discussion and agreement revealed that most participants needed this place to be the "Ecotourism Centre". Notably, during the built environment design process, community and landscape architects had a significant role in leading the other participants to understand the design process and encouraging them to use their speciality to apply to the built environment design. During the design brainstorming, they designed two schematic designs for the Nong Bua area, in which all the function programmes of the designs related to ecological support, historical support,

community's benefit, and owner's benefit. Therefore, the participants applied the regenerative design approaches and TREES requirements within both schematic designs. The results of the second day of the workshop were two schematic designs that would be used as a target goal, which required policy or development guidelines to achieve it. The built environment guideline-making process continued on the third day of the workshop. This study obtained the critical results that are essential for further analysis at the end of the day.

Third Day of the Workshop: It was for the built environment guideline-making process. This activity mainly used the Backcasting technique to lead the whole process. At first, the participants agreed to focus on the two obtained schematic designs from the previous day of the workshop as a target goal. Then, through the built environment guideline-making process, they planned a possible pathway to achieve their desired goal. During this activity, the participants shared their ideas about relevant factors that could support or be an obstacle when it comes to the actual construction. Based on participants' backgrounds of knowledge, there were plenty of ideas about ways to develop the Nong Bua area to achieve the goal – these ideas linked to several factors such as local governance structure, community's participation, ordinances/regulations adjustment, additional studies about Nong Bua, and transportation. Therefore, the participants decided to consider the regenerative design approach and TREES requirement to adjust to the development strategy for the Nong Bua. They believed this guideline was potentially useful and practical for regenerating the fruitfulness of Nong Bua and the local ecosystem.

The discussion during this activity was an open conversation, and many topics differed from the main agenda at some point. However, the Backcasting technique that was used to lead this activity had the potential to direct the participants to recognise the main focus of the discussion. As mentioned earlier, the Backcasting technique is a normative scenario approach that is used chiefly in the Sustainable planning field to plan the linkage between the future and present, and this linkage has the possibility to form the direction to achieve the desired goal by thinking backwards from the future back to the present (Miola, 2008; Vergragt & Quist, 2011). Within this approach, the participants could create consensus-built environment guidance for developing the Nong Bua area, which has been categorised into several subjects in regard to generating the ecosystem in the Nong Bua area and the surrounding environment, including the suggestion to use

this study's results as an example of future work in creating other green areas for Chiang Mai City. More precise details and explanations will be mentioned in the following sections.

Figure 5.2 The 1st Day of A 3-day workshop on Environmental Regenerative Design: Case study Nong Bua, Chiang Mai

Figure 5.3 The 2nd Day of A 3-day Workshop on Environmental Regenerative Design: Case study Nong Bua, Chiang Mai

Figure 5.4 The 3rd Day of A 3-day Workshop on Environmental Regenerative Design: Case study Nong Bua, Chiang Mai

In addition, before the end of the 3-day workshop, this study prepared a survey for participants to evaluate the workshop led by the RDF-T. The survey was designed based on the findings in the literature concerning the discovered gaps that affected the capability of the existing regenerative design frameworks, as mentioned in the previous chapters. Therefore, this study intends to investigate the ability of the RDF-T that developed by adapting the notion about regenerative design principles and practices with the Backcasting technique and TREES. Then, the survey required the participants' feedback and suggestions for assessing the RDF-T's potential and the 3-day workshop procedure, as shown in *Table 5.3*. This study believed the survey results could be helpful, and all the collected survey was analysed after finishing the 3-day workshop, which led to the data analysis process as the next step of this study.

In elucidating the terminology employed in the survey conducted during a comprehensive 3-day workshop, as delineated in *Table 5.3*, the Thai Regenerative Design Framework (TRDF) was initially utilised. However, this investigation has subsequently revised the nomenclature to the Regenerative Design Framework for the Thai context (RDF-T) for terminological precision. This updated terminology has been consistently applied throughout each chapter for the sake of scholarly coherence and uniformity.

Table 5.3 The example of the survey that would be prepared for the participants before the end of the workshop

Question	Satisfaction				
	1 very unsatisfied	2 unsatisfied	3 neutral	4 satisfied	5 very satisfied
1. Are you satisfied with the proposal of the Thai regenerative design framework?					
1.1 Regenerative design principle					
1.2 TREES					
1.3 Backcasting technique					
2. In your opinion, what is the regenerative design for the Thai context?					
3. The suggestion for the Thai regenerative design framework					

The following sections present an analysis result of the engagement process after applying the RDF-T, from which the results lead to answers that can indicate the success and limitations of the RDF-T for further development and the conclusion of this study. The explanation started from the main results collected during the workshop by separating them into two categories: (1) A built environment design for the case study area, and (2) A built environment guideline for the case study area. After that, this study will summarise the examination results of the RDF-T from obtaining the materials collected at the end of the workshop. These include the survey of satisfaction on the RDF-T, and the suggestions of the workshop's participants. Including an additional

interview and an online focus group, this study considered using a Delphi method to support the study's primary results. All raw obtained data lead to an accurate conclusion for this study to investigate the ability and repeatability of the RDF-T. Therefore, the summary of results can help strengthen future use of this framework.

5.3 A Built environment design for the case study area

This part analyses the ultimate designs of the built environment from two schematic designs that the participants in the workshop discussed and created, forming a built environmental design based on the regenerative design principle and TREES requirement applied to the Nong Bua area as *Figure 5.5, and* this is the original figure of two schematic designs of the built environment in the case study area. Refer to the obtained data, this study has summarised the design details into four categories, which are (1) Building type, (2) Theme, (3) Main user, and (4) Function program that has indicated a detail of each function in terms of supporting the ecology, historical value, community, and owner's benefit. To simplify all details of these two schematic designs, this study has created sketches based on the original figure of the schematic designs and summarised all information in the tables shown in *Figure 5.6* and *Figure 5.7* as schematic design 1 and 2, respectively.

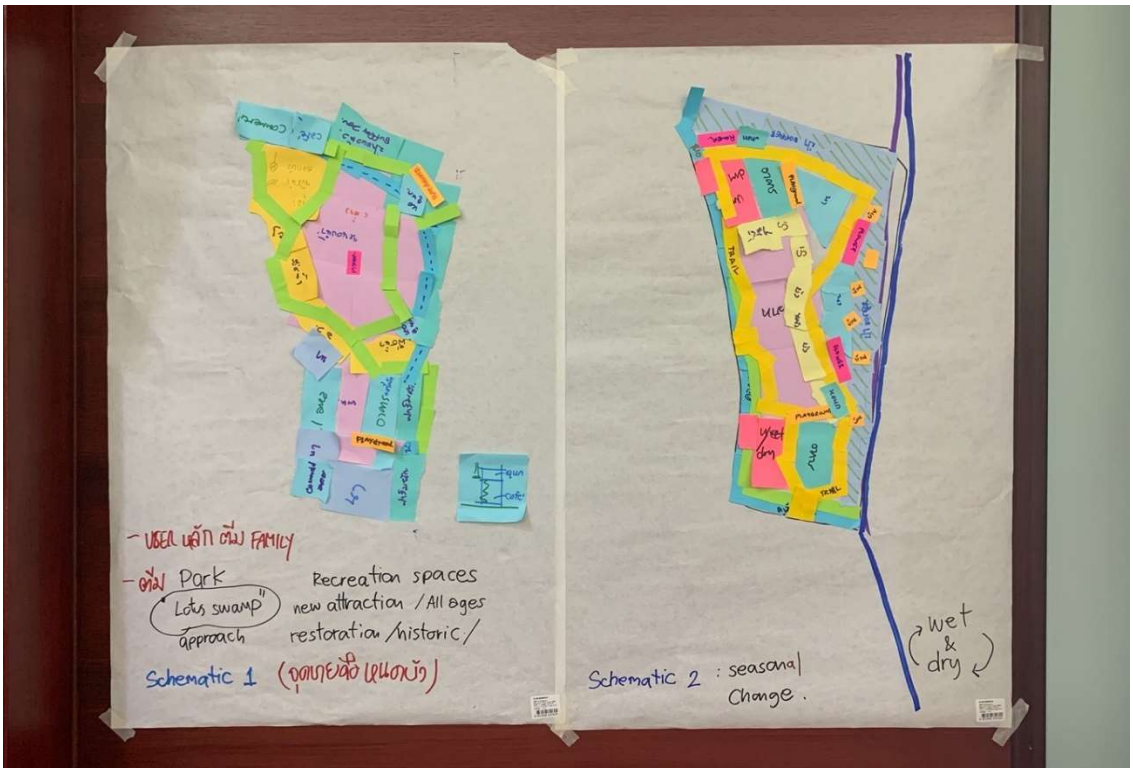


Figure 5.5 Schematic Designs of the built environment in the Nong Bua area

5.3.1 Schematic design

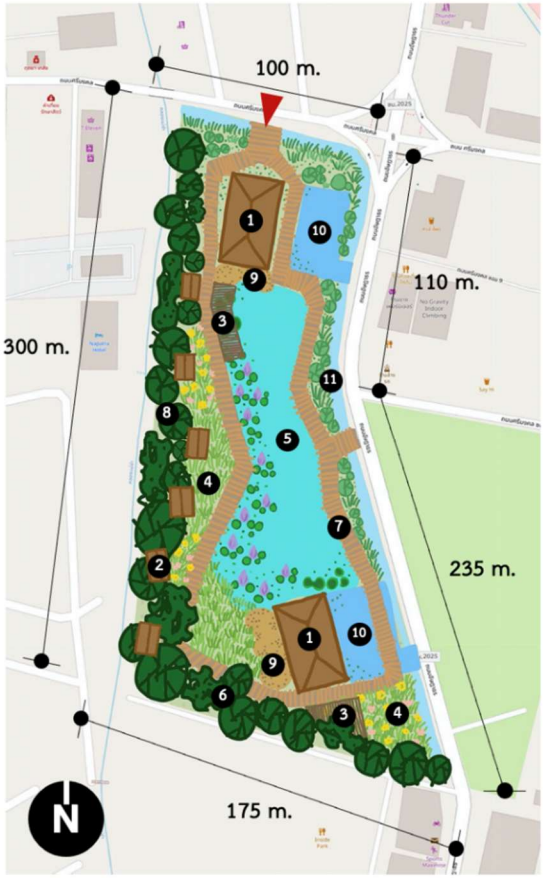
Schematic design 1, as shown in *Figure 5.6,* illustrates that the building type of built environment design is an "Ecotourism Centre", while the theme of this design is a "Lotus Swamp" and prefers to target a group of "family" as the main user of this project. Therefore, the function programs of this design are divided into two parts: (1) Building design (2) Landscape design. The building design part includes a Commercial Building (including a Natural learning zone as an indoor playground, Restaurant, Museum and Exhibition zone), a Café, a Lanna-style residential section for tourists, and a Bird watching tower. In the landscape design part are Rice fields, a Lotus swamp, a Vertical Forest/ Buffer Forest, a Natural trial, an Urban farm (an area for harvesting vegetables and containing a chicken coop), a Natural learning zone as an outdoor playground, and Bird Island. Importantly, each function of this design has been designed to support the Ecology of the place, History of the place, Community's benefit, and Owner's benefit – depending on the appropriateness of use and purpose of each area as shown in different colours with more details as depicted in the table of *Figure 5.6.*

Likewise, schematic design 2, shown in *Figure 5.7,* reveals that the building type of built environment design is an "Ecotourism Centre", in which the design's theme is "Seasonal Change" and prefers to target "Tourists and Local people" as the main users of this project. When comparing this schematic with schematic design 1, this design's function programs are divided into two parts: (1) Building design and (2) Landscape design. The function areas in the building design are a Commercial Building (including a Natural learning zone, Restaurant, Café, Recycling learning zone, Museum and Exhibition zone, Rental residents (Treehouses for tourists), and a Bird watching tower. Meanwhile, there are Rice fields and a Native flower garden, a Lotus swamp, a Vertical Forest/ Buffer Forest/ Edible Forest, a Natural trial, an Urban farm for seasonal native vegetables, a Natural playground, a Wet and Dry area, and Bioswale in the landscape design part. Similar to schematic design 1, each function of this design has been designed to support the Ecology of place, History of place, Community's benefit, and Owner's benefit – depending on the appropriation of use and purpose of each area as shown by the different colours and in the table of *Figure 5.7.*

Building Type	Theme	Main User	Function Program				
			Building	Ecological Support	Historical Support	Community's Benefit	Owner's Benefit
			1. Commercial Building				
			• Natural learning zone (Indoor playground)				
			• Restaurant				
			• Museum and Exhibition zone				
			2. Café				
			3. Lanna style residential (for tourist)				
Ecotourism Centre	Park "Lotus Swamp"	Family (All ages)	4. Bird watching tower				
			Landscape	Ecological Support	Historical Support	Community's Benefit	Owner's Benefit
			5. Rice field				
			6. Lotus swamp				
			7. Vertical forest / Buffer forest				
			8. Natural trial				
			9. Urban farm (Vegetable and Chicken coop)				
			10. Natural learning zone (Outdoor playground)				
			11. Bird Island				

Main Entrance

Figure 5.6 Schematic Design 1



Building Type	Theme	Main User	Function Program				
Ecotourism Centre	Seasonal Change	Tourist and Local people	**Building**	**Ecological Support**	**Historical Support**	**Community's Benefit**	**Owner's Benefit**
			1. Commercial area				
			• Natural learning zone				
			• Restaurant				
			• Café				
			• Recycle learning zone				
			• Museum and Exhibition zone				
			2. Rental resident (Tree houses for tourist)				
			3. Bird watching tower				
			Landscape	**Ecological Support**	**Historical Support**	**Community's Benefit**	**Owner's Benefit**
			4. Rice field and Native flower garden				
			5. Lotus swamp				
			6. Vertical forest / Buffer forest / Edible forest				
			7. Natural trial				
			8. Urban farm (Seasonal native vegetable)				
			9. Natural Playground				
			10. Wet and Dry area				
			11. Bioswale				

Main Entrance

Figure 5.7 Schematic Design

Accordingly, this study has simplified the two schematic designs to the architecture site planning shown in *Figure 5.8* and *Figure 5.9* in the following section, revealed the detail design of each schematic and indicated the function programs that likely support the ecology, history, community, and owner of the place. However, both of these schematic designs are slightly different in detail, and the sorted results show the capability of the regenerative design approaches and TREES requirement that participants have used as a tool in the built environment design process. Therefore, these primary results respond to the research question by illustrating how the RDF-T impacts the Nong Bua Built environment design process, which the results show as the two schematic designs of the built environment.

5.3.2 The critical components and function programs in the schematic designs

The results illustrate that the building type of these two schematic designs is an "Ecotourism Centre", which has a different theme and focuses on serving a diverse group of users. However, most of the function programs are designed to support the ecosystem by following a regenerative design approach and TREES requirement. At the same time, the proportion of landscape design is slightly more considerable than that of architectural design. This place is designed to be an Ecotourism Centre that intends to use a built environment design to maintain and enhance the quality of the local ecosystem by preparing the area for nature to grow and regenerate an abundance of places to be green areas for humans and natural habitats for other organisms. Moreover, several function programs in the architecture design have supported the importance of maintaining the quality of the ecosystem and using them as places to educate the users about the environment whilst possibly responding to the needs of humans.

With regard to regenerating an ecosystem and encouraging historical value, these two schematic designs have designed a “Lotus swamp”, which in Thai means "Nong Bua", to imitate the image of the old Nong Bua and represent the aspect of Chiang Mai city's wetland as a reservoir in the rainy seasons that benefitted agriculture in dry seasons. Thus, it was an important place for Chiang Mai City according to its use as a sacred swamp of the city (Charney, 2011). Therefore, these two schematic designs plan to grow native plants around the area, using them as a natural filter to filter debris, waste, and pollutants from stormwater runoff before draining into the constructed wetland and infiltrating into groundwater. Moreover, the native plants are compatible with the local

climate and topography and are likely to have simple maintenance. Furthermore, in a part of landscape design, these two schematic designs have applied other regenerative design approaches in the Nong Bua area, such as Edible landscaping, Wetland construction, Wet and Dry areas, Bioswales, and Stream Daylighting. An example shown in *Figure 5.8* and *Figure 5.9* consists of regenerative design approaches that are applied to a built environment design: -

Native plants: The native plants are the main vegetation used in the Nong Bua area. They are used as a buffer to prevent stormwater runoff, thus filtering the sediment and debris before absorbing the water to the ground level. Therefore, the roots of the native plants are vigorous and grow well in the local typology and climate. Then, the roots can dig deep into the ground and grasp the soil tightly while maintaining its condition and being a natural remedy to help regenerate the local ecosystem (Kilroy, 2014). *Table 5.4* shows examples of the native plants listed by the participants in the workshop.

Edible landscaping: Both schematic designs have created edible landscapes that choose seasonal vegetables to plant in the Nong Bua area, such as Broussonetia kurzii, Ficus lacor Buch, and Gymnema inodorum, to be the community's food bank and feed the animals that live in this area. Apart from providing food, massive trees will be used as a vertical forest/buffer forest, which possibly protects against noise pollution around the site, furthermore being a source of fresh air to create a healthier microclimate. It also helps reduce the heat in the air that causes the urban heat island problem for the city. Additionally, this forest can be a habitat for other organisms that live and breed in this area (Kilroy, 2014).

Wetland construction: The Nong Bua area was an important natural swamp of Chiang Mai city that disappeared over time by urbanisation (Satsue, 2018). There is a wetland design to uphold the historical value of the place, and this wetland construction will be built over the same land as it was once a part of the old Nong Bua. As mentioned previously, "Nong Bua" in Thai means "Lotus Swamp"; therefore, the main vegetation planted in this wetland are several breeds of local lotuses.

Bioswales: There are bioswales in the built environment design, and the purpose is to use the bioswales to slow the stormwater runoff from the streets around the site and use the native plants for capturing debris before infiltrating into the soil to recharge the groundwater (Kilroy, 2014). Therefore, native planting alongside can prevent

massive sediment or waste that comes with stormwater before flowing to the wetland in the Nong Bua area.

Stream daylighting: A design for stream daylighting in a built environment design will link with a natural canal (Mae Kha canal) next to the site. Even though the construction of the stream daylighting cannot wholly solve the Mae Kha canal's water pollutants, it still has the potential to increase the oxygen in the water from aquatic animals while allowing the natural bacteria to seize nitrogen to maintain the water quality (Kilroy, 2014). In addition, the participants intend to use the stream daylighting design as an example of natural water pollution management for Chiang Mai City.

Wet and Dry area: The result in the second schematic design shows that the wet and dry area is next to the bioswales and stream daylighting. This design intends to use this multifunctional area to receive excessive stormwater filtered through the stream daylighting and bioswales area in the rainy season and then flows to the wet and dry areas. Due to the typography of this area being lower than the surrounding area, the wet and dry areas can be a mini reservoir to reserve the water for further use in the dry season. Based on a discussion during the workshop, there is a possibility that the flow of the water might carry the seeds of plants or local wildflowers into the Nong Bua area, and so the wet and dry area has the potential to become a plant field. Whether water plant fields in the rainy season or meadows in the dry season, this mixture of plants can increase the biodiversity of this place.

Pervious pavement: As shown in both schematic designs, the material of the trail around the wetland is timber. The sidewalk material around the area is a modular paving block or natural ground. Since these materials' surfaces allow water infiltration, using pervious surfaces as a filter is the most effective way to help reduce the pollution from stormwater runoff, such as grease, solids, and oil, before absorbing it into the ground level (Kilroy, 2014).

Likewise, the TREES requirement has been applied in building and landscape design during the built environment design process. The most considered factors that follow the TREES requirement are Green building preparation, Reducing the negative impact on greenfield areas, Sustainable site planning, Infiltration of stormwater and flooding prevention, Reducing pollution from construction, and Using natural light in the building. The combination of design with regenerative design approaches is shown in the site planning of the two schematic designs. The design principle of these two elements

has the same criteria regarding reducing harmful impacts on the environment while regenerating the quality of the ecosystem. The finding of these results shows that the built environment design of the Nong Bua area potentially contributes to the ability of the regenerative design principle and TREES as essential elements of the RDF-T in order to successfully generate the built environment design for the case study area.

The results shown in the built environment design are based on the shared understanding of the participants who experimented with these two elements in the design process. Interestingly, the participants' consensus aims to develop the Nong Bua area as a new green space that suits the Thai context, and they would like to use this place as an example of a green development project in Chiang Mai City. With this regard, the primary results imply that the RDF-T and its elements were valuable and practical for the workshop.

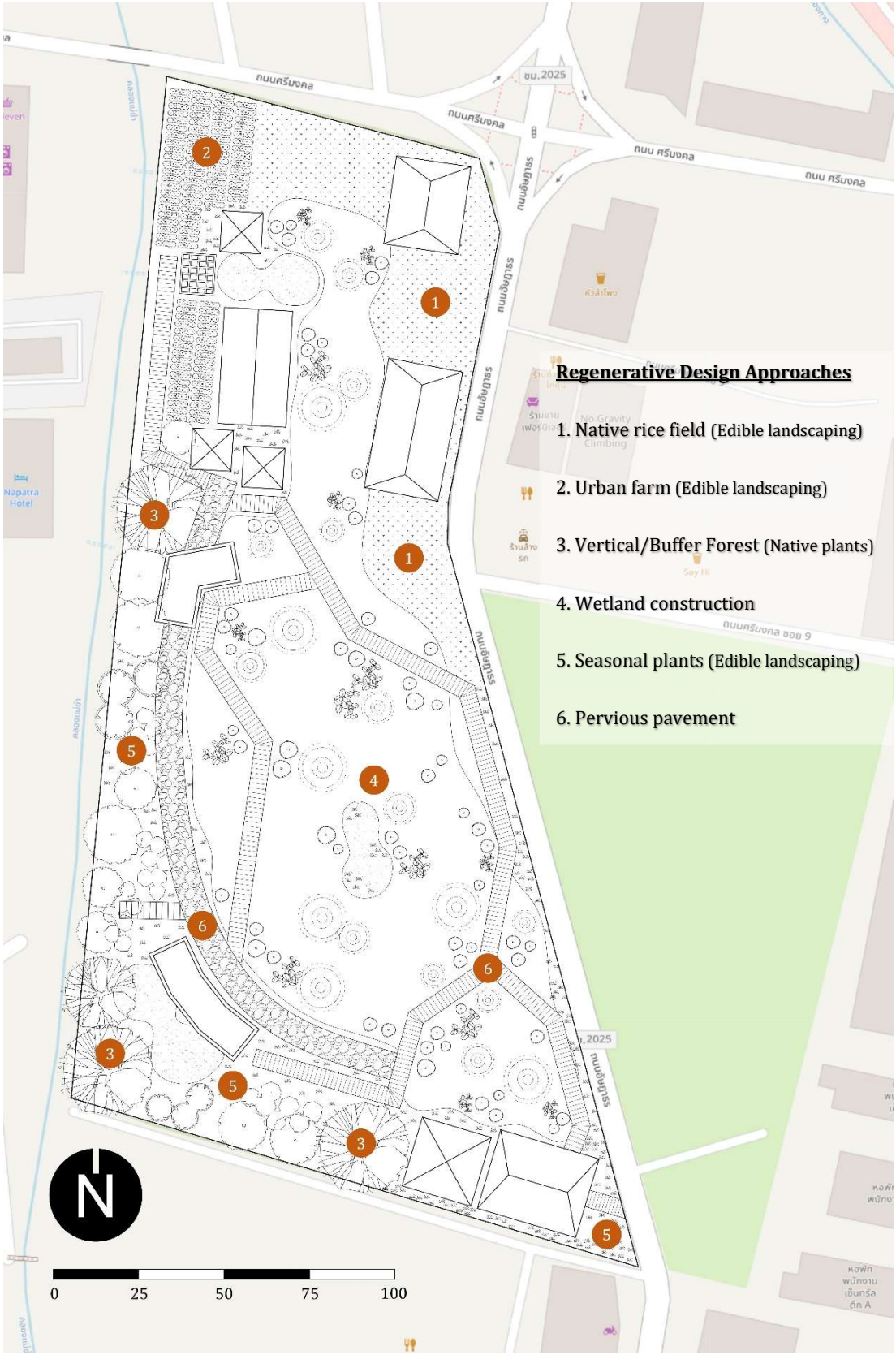


Figure 5.8 Regenerative Design Approaches in Schematic Design

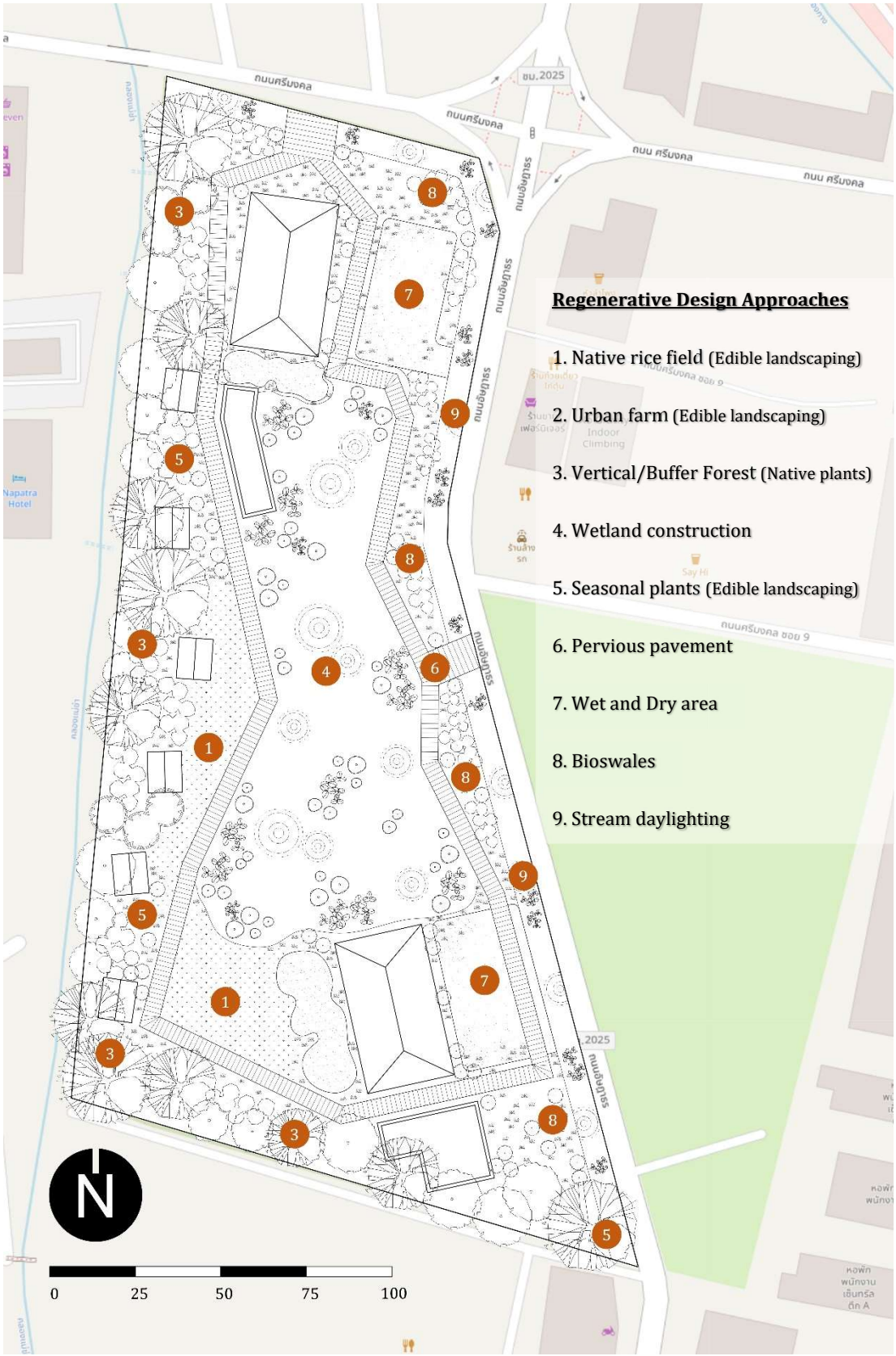


Figure 5.9 Regenerative Design Approaches in Schematic Design 2

Table 5.4 The list of the native plants in the built environment design of the Nong Bua area

Type	Native plants
Big tree	Earleaf acacia Neem Tree Jujube Monkey pod tree Golden shower tree
Small plant	Sunn hemp Tagetes erecta Peacock flower Pagoda flower White crane flower Nymphaea lotus Cannaceae Greater Galangal
Wild plant	Sulfur cosmos Murdannia giganteum Cogon grass Silver cock's comb Dancing ladies ginger Convolvulaceae
Seasonal plant	Melastoma malabathricum Ruellia tuberosa Asian pigeonwings Schoutenia glomerata fairy petticoat tree
Edible plant	Broussonetia kurzii Ficus lacor Buch Gymnema inodorum

5.4 A Built Environment Guideline for the Case Study Area

This part uses a thematic analysis approach to transcribe and reduce the raw data from recorded voice clips and videos, including pictures of the whole process during the 3-day workshop. This study used the NVivo 12 program to search for word frequency from an original recording of the built environment guideline-making process on the last day of the workshop for accurate built environment guidance analysis, *Figure 5.10*. Transcribing can narrow down the data and reveal crucial points that lead to a summary of the main agenda of the built environment guidance. Subsequently, this study has categorised a Nong Bua environmental development guideline into five sections: -

1. Community to City Cooperation
2. Regulation adjustment
3. Transportation
4. Additional research about Nong Bua
5. Environmental design for the ecosystem

Figure 5.10 A Word frequency of built environment guideline for the Nong Bua area

5.4.1 Community-to-City Cooperation

1. Set up a meeting with all relevant state authorities and stakeholders to build cohesive understanding and negotiate for cooperation, i.e., a discussion with the Chiang Mai Municipality Office about the city's water system. Inform and deliberate with the Old Town Subcommittee on the procedure and suitability of the development project in the Nong Bua area.

2. Invite the 7th Regional Office Fine Arts, Chiang Mai to investigate its suitability before starting the development as the Nong Bua area is an important historical place in Chiang Mai city.

3. Make an announcement that the Nong Bua area is a buffer zone in the nominated area of the Chiang Mai World Heritage Initiative Project for awareness and to produce beneficial incentives for the Local Community and Chiang Mai City.

4. Illustrate an original boundary of the whole Nong Bua area to encourage local people who live in this area to be aware of shared ownership.

5. Create cultural mapping to increase the value of this area and Community and encourage Chiang Mai people to visit this area. i.e., using a tree pathway to connect the city's crucial nodes to create an interaction between humans and the surrounding area through Nong Bua.

6. Reintroduce the History which mentions the Lotus (Bua) in Chiang Mai Old Town moat to reuse those lotus species in the Nong Bua built environment project to connect and support local businesses that sell lotus products.

5.4.2 Regulation Adjustment

1. Recheck the public works and town and country planning regulations ordinances and propose the Nong Bua built environment project to the Chiang Mai Municipality Office for approval and deliberating with the Old Town Subcommittee for an appropriate developing process.

2. Proposing the adjustment of public works and town and country planning regulations and ordinances, which affect the green area development.

3. Proposing the commitment among stakeholders who are involved with the Nong Bua area, all of whom are from local authorities, private sectors, and the

Community, since the procedure of law and regulation adjustment requires time. i.e., creating public participation for the arrangement of a measure and practice for the long term and containing effectual usage for the whole of Nong Bua's boundary based on historical evidence.

5.4.3 Transportation

1. Ask for permission to share a parking lot in Jing Jai market as the main parking area for the Nong Bua built environment project.

2. Ask for cooperation from important places in Chiang Mai city to be pick-up and drop-off points for people visiting Nong Bua. This strategy can help increase accessibility and connect with the surrounding area by possibly reducing traffic congestion around the Nong Bua area.

3. Cooperate with public transportation such as the city bus and Grab (a mobility service provider) to increase accessibility and reduce traffic congestion around the Nong Bua area.

4. Encouraging a pedestrianised walk-through cultural mapping and tree pathway that grows native plants in-between node to node leading to the Nong Bua area.

5.4.4 Additional research about the Nong Bua area

1. Researching original data and extra details of Nong Bua for a comprehensive study and deep understanding of this area.

2. Providing a stage for elders who have experiences with the Nong Bua area to share and exchange knowledge.

3. Study a natural water system of the city, such as the Mae Kha Canal, which flows through the Nong Bua area. Moreover, deliberate with the Chiang Mai Municipality Office about the treatment and refreshing of the water quality.

4. Study the surrounding ecology, such as birds, trees, and others, to consider these factors as design support tools and transformation indicators in the Nong Bua area.

5.4.5 Environmental design for ecosystem

1. Offering an opportunity for a local designer to participate in the Nong Bua built environment project.

2. Propose the Nong Bua built environment project to participate in TREES and LEED to elevate this project to achieve international standards.

3. The Nong Bua built environment project should apply for EIA (Environmental Impact Assessment) approval, as most large projects have this approval. Furthermore, the Nong Bua built environment project should apply for HIA (Heritage Impact Assessment) as it has historical value, and this project is possibly a role model for other similar development projects.

4. The construction of the Nong Bua built environment project should start by designing a master plan and dividing the construction phases. Thus, knowing a total construction period depends on a management plan strategy, and that will make it easier to manage this project's other systematic plans. Furthermore, the community should be notified during the construction to inform them of upcoming processes.

5. A construction process should start with swamp construction to encourage local people to participate in the hand-digging process, followed by a local ceremony, such as the consoling water spirit (Riak Kwan Nam). These activities can gather people to interact with the area and participate in the project. A record of the activities can later be used to exhibit in the museum.

6. Deliberate with the relevant authorities for a suitable approach to derive water from the other resources to fill in the newly constructed swamp. The amount of water evaporation for practical usage should be considered for a constructed wet and dry area that would be used as a reservoir in the rainy season.

7. Use the Nong Bua built environment project as a water management model, such as the bioswale construction. Native plants can be utilised to filter debris from stormwater runoff, and the newly constructed Nong Bua can help filtrate water pollutants at some level before releasing them to a natural canal. Furthermore, this approach can be a role model for Chiang Mai City to consider it as one of the solutions to solve the water pollution in Mae Kha Canal and others.

8. For the Nong Bua built environment project, it is unnecessary to build extra-large buildings. However, the building space should be between 2,000 and 5,000 m^2, the height should not be over 12 m, and in case there is a lack of space, a designer should consider building a basement instead of adding the building's height as well as examining the proportion of hardscape and soft scape in this developing area.

9. Before having a constructed forest in the area, there should be a proper level of forest and density of the native plants which will be used in this area. i.e., planting Bushwillow as it was found the most in this area in the past. Therefore, if there is a need to ball plant the trees from another area to be planted in Nong Bua, there must be an approval certificate.

10. Focus on a design strategy and planting management to avoid a negative effect on existing trees in this area.

The primary results of the study reveal, in terms of the built environment design schematics and the built environment guideline for the case study area, potentially implies the capability of the RDF-T in regard to leading the built environment design engagement and successfully produce the results that respond to the research aims and objectives. Primarily, the results are used to respond to the research questions that concern the impact of the RDF-T on the Nong Bua and reveal the essential factors as shown in the built environment guideline that this study distributed these findings for the further development of the Nong Bua area. At the same time, the findings strongly stimulate the development of the RDF-T further. The exquisite details of the assessment of the RDF-T and development are shown in the following chapter.

Chapter 6

Assessment of the RDF-T's Effectiveness

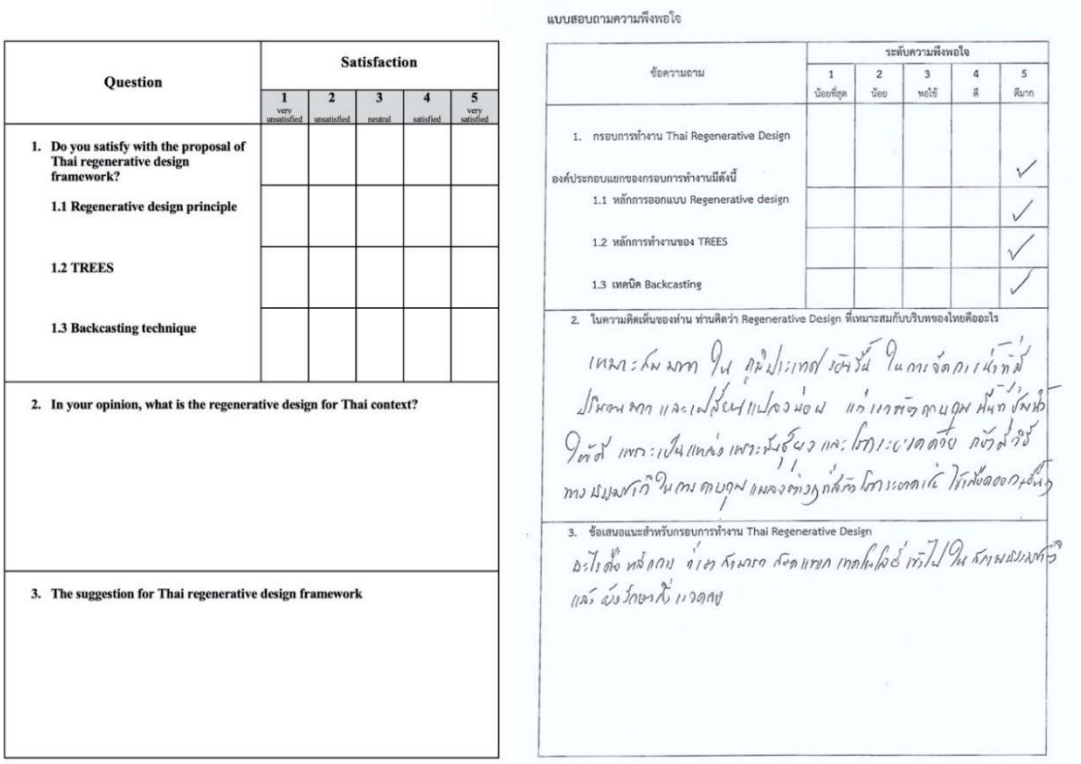
6.1 A Primary summary of results of the RDF-T examination

As mentioned previously, this study aims to investigate the ability and repeatability of the RDF-T by applying it in a 3-day workshop on Environmental Regenerative Design: Case study Nong Bua, Chiang Mai, Thailand. Apart from the results collected from the built environment design process and the built environment guideline-making process, this study has collected the survey and suggestions of 13 persons out of the total number of 17 participants in the workshop to investigate the ability, repeatability and limitations of this framework for the appropriate development of RDF-T. *Figure 6.1* is an example of the survey questions shown in English before being translated to Thai when used in the workshop.

Furthermore, this study has analysed a 5-point Likert scale of satisfaction on the RDF-T and its elements. It has illustrated the results in the graphs shown in *Figure 6.2* and *Figure 6.3*. Moreover, this part will also explain the limitations and development of this framework by translating all the suggestions from the survey in the Thai version into English and using the program NVivo 12 to help analyse the keywords to simplify a comprehensive conclusion. The analysis of the results is shown below.

In providing explication, the terminology featured in the survey conducted during a comprehensive 3-day workshop, as depicted in *Figure 6.1* and prevalent in most figures within this chapter, initially incorporated the Thai Regenerative Design Framework,

denoted as TRDF. Subsequently, in the pursuit of terminological precision, this research has modified the nomenclature to the Regenerative Design Framework for the Thai context, abbreviated as RDF-T. This revised terminology has been consistently applied across all chapters to ensure scholarly coherence and uniformity.



Question	Satisfaction				
	1 very unsatisfied	2 unsatisfied	3 neutral	4 satisfied	5 very satisfied
1. Do you satisfy with the proposal of Thai regenerative design framework?					
1.1 Regenerative design principle					
1.2 TREES					
1.3 Backcasting technique					
2. In your opinion, what is the regenerative design for Thai context?					
3. The suggestion for Thai regenerative design framework					

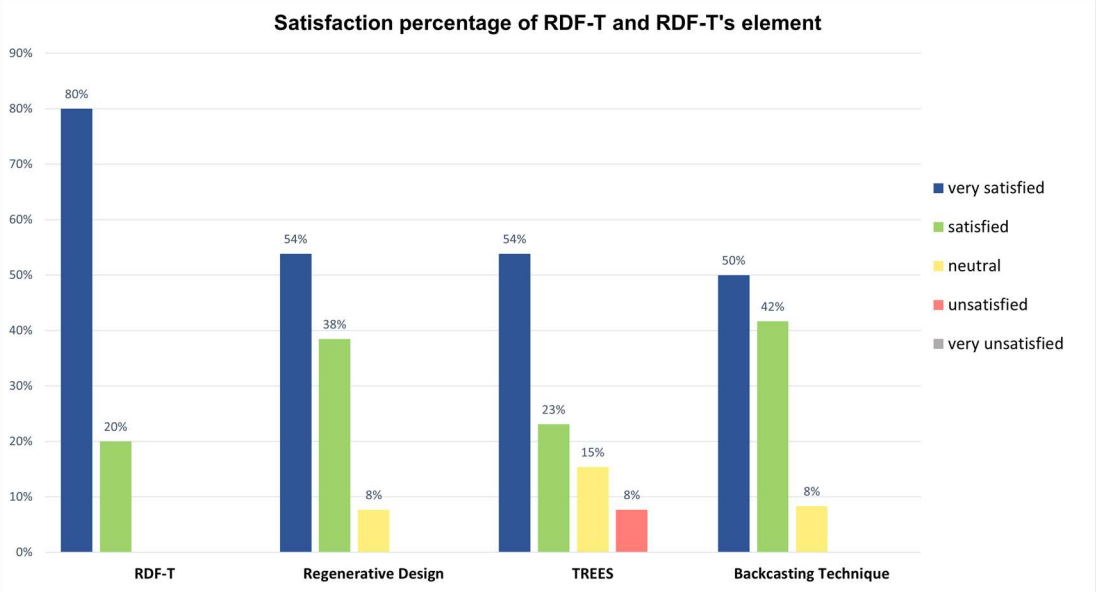
Figure 6.1 The survey questions of satisfaction and suggestions for the RDF-T

6.1.1 The 5-point Likert scale survey of Satisfaction in the RDF-T

Figure 6.2 shows the graph that illustrates the results of a 5-point Likert scale survey of satisfaction with the RDF-T and its elements, which was collected from 13 out of 17 participants. The graph reveals that the high percentage of 80% of the participants in the workshop were “very satisfied” with this framework. Likewise, a majority of the participants were “very satisfied” with its elements, as the results show 54%, 54%, and 50% for the Regenerative design principle, TREES, and Backcasting technique, respectively. Moreover, the second-highest percentages of the participants’ satisfaction with this framework and its elements are at the “satisfied” level as the graph depicts 20% for the RDF-T, and 42%, 38%, and 23% for the Backcasting technique, Regenerative design principle and TREES respectively. However, 15% of the participants felt “neutral” towards their experience of using TREES, and 8% of the participants were “unsatisfied”.

According to the graph, TREES has higher percentages at the neutral and unsatisfied levels when compared with the other two elements.

To simplify the overall picture of satisfaction in the RDF-T, *Figure 6.3* shows the graph of this framework's average satisfaction score and its element calculated from the 5-point Likert scale. There are score ranges from 0.00 to 5.00 that help indicate a level of satisfaction – as the results reveal, the score of this framework and each element are in the score range of the "very satisfied" level. The scores are 4.80, 4.46, 4.23, and 4.42 for the framework itself and for the Regenerative design principle, TREES, and Backcasting technique, respectively.



Number	RDF-T	Regenerative Design	TREES	Backcasting Technique
The number of respondents	10	13	13	12
The total number of respondents	13	13	13	13
The total number of workshop participants	17	17	17	17

Figure 6.2 The graph of an average satisfaction score of the RDF-T and its element

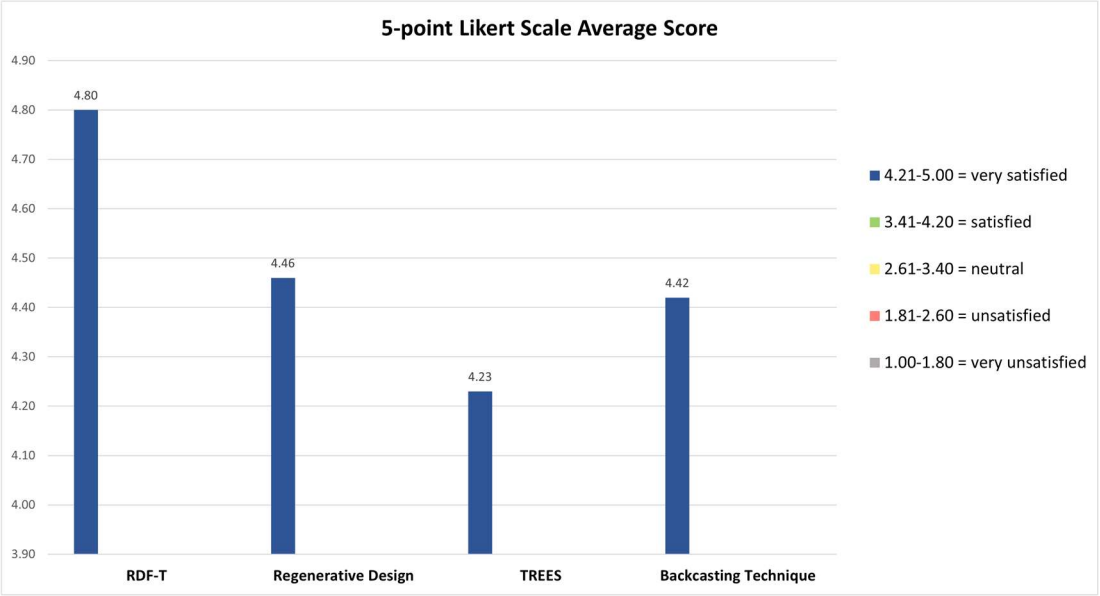


Figure 6.3 The 5-point Likert scale survey of satisfaction in the RDF-T and its element from the workshop's participants

6.1.2 The Suggestions for the RDF-T from the workshop's participants

Figure 6.4 A Word frequency of the suggestion to the RDF-T

Figure 6.4 shows the word frequency of the suggestions and feedback for the RDF-T. The group of these words is based on the thoughts of the workshop's participants,

which represent the crucial points that lead to the further development of this framework. The suggestions' details are divided into nine sections, as shown below.

1. Combine the principle of environmental technology that helps protect the environment with the RDF-T.

2. Consider the RDF-T's comprehensive elements, such as the Cost and Management system aspect.

3. Propose that the RDF-T considers a governmental structure change, a public works protocol, and town and country planning regulation adjustment to support a regenerative design development area.

4. Consider a study of soil and water in a developing area and combine the local people's way of life and beliefs of the Thai and adapt them to the RDF-T.

5. Propose this study to consider and possess a quality index, such as the Biodiversity Index, which is a comparison criterion of water quality which can indicate an increasing percentage of green space and the quality of the ecosystem. Moreover, to compare the condition of the place to see a difference before and after the development when the regenerative design approaches have been applied in the built environment design process.

6. Prepare additional knowledge about human behaviour in green spaces for Thais to have more awareness to maintain and enhance a greater quality of the Thai ecosystem during the workshop process.

7. Future workshops require cooperation from more authorities, such as the Local Authorities, Civil society, and General people in different areas of Chiang Mai City.

8. Propose this framework to clearly define Regenerative Design for the Thai context for cohesion.

9. Develop and strengthen the framework's efficiency by studying the lacking aspects of the latest workshop.

6.1.3 An Additional interview about the repeatability of the RDF-T

The survey results for RDF-T have led to an analysis of its capability and repeatability for future usage. Primary analysis has implied that this framework has the

potential to be reused in other developing areas and built environment design workshops. However, with the limitations of the study's period and the sole application of this framework to the Nong Bua area, the evidence that could help prove its performance might be inadequate. Subsequently, this study intends to examine and research results to strengthen a final conclusion. Consequently, the Delphi method was considered a supportive approach that possibly helped discover the additional findings. Then, this study requested an additional interview with the same group of participants about the repeatability of this framework. This study interviewed the participants individually by inviting them to respond to the same sort of question via a video interview, telephone interview, and email interview, depending on the participants' preferences.

The respondents were 12 out of 17 from the previous workshop. The recording of raw data from the interviews shown below is categorised by the participant's expertise from each career as they shared their thoughts towards the repeatability of the RDF-T. The details of the interview questions and answers are shown below.

Question: Do you think a 3-day workshop led by the RDF-T has the repeatability to be applied in other developing areas to create green spaces and regenerate an ecosystem?

Respondents: from the CMWHI team, TREES Specialist, Owner of the case study area, Community Architects, Landscape Architects, Ecologist, and Civil Society, forming a total of 12 persons.

CMWHI team (4 persons): The whole workshop process is capable of being applied to other areas in Thailand. Especially the Backcasting technique, which is a pro of this framework; likewise, it is possible to use this technique in other projects because most developing projects in Thailand do not invite many stakeholders from relevant sectors for a discussion process. This workshop has shown that the Backcasting technique is important in rechecking a project's completeness, such as with laws and regulations. Therefore, this technique can help narrow down a whole discussion into crucial points when civil society has held a public participation event to listen to the community's thoughts. Generally, there are many ideas in this kind of meeting, and sometimes, a debate goes too far and does not relate to the main agenda. However, a suggestion for this framework is to consider an expert selection criterion since experts will provide complete and robust results. On the other hand, if members who participate in a workshop are not experts, that can also affect the workshop process.

TREES Specialist (1 person): Actually, it can be applied to all areas – nevertheless, how the result will turn out depends on cooperation and information. Thus, an area owner must participate in the workshop, which can make it work.

The owner (1 person): It is possible to apply this framework to other developing areas.

Community Architect (2 persons): The workshop process led by the RDF-T can be applied to ecosystem development projects and other green spaces. However, it should be adjusted and designed for clear processes and details, including selecting an appropriate stakeholder that suits a selected area.

Landscape Architect (2 persons): It is possible, but the possibility of applying to a real area depends on the participants in a workshop who should work in a relevant field of designing an ecosystem and green areas as they can use knowledge from the workshop to apply it to a real developing area. For example, in the latest workshop, the Central Group was interested in this concept and had a real area that awaits development. Furthermore, many architect groups who work with green areas can use this design concept of the RDF-T with the green designs of their architecture firms.

Ecologist (1 person): It is possible to apply this framework to other areas. The next workshop should have asked for cooperation from more sectors, such as local government, civil society, and the general public members.

Civil Society (1 person): It was a good workshop that allowed all sectors to participate in the process. It was especially a meeting place for civil society and the private sector (property owner). I hope there will be this kind of workshop again in the future.

After the interview, this study used the program NVivo 12 to help summarise and search for the word frequency of the answers from the respondents, as shown in *Figure 6.5*. The summary of the interview results in *Figure 6.5* indicates that the previous workshop led by this framework was practical. Moreover, this RDF-T workshop has the possibility to be repeated in other developing areas in terms of creating green spaces and regenerating an ecosystem. Interestingly, the analysis reveals that the Backcasting technique is an important tool in the engagement process. Furthermore, the feedback on the Backcasting technique has highlighted that this technique can be applied in other

projects, in regard to leading to effective discussion for policy planning and being used to recheck the validity of each agenda for the development of the projects.

Figure 6.5 A Word frequency of the answer from an additional interview with the participants in a previous 3-day workshop that led by the RDF-T

To summarise, examining the RDF-T shows that this framework can generate a built environment design and guidelines for the development of the case study area, and each element has a distinctive role in the engagement process. Significantly, the Regenerative design principle and TREES are important in creating a built environment design in which all participants have been involved, as shown by the two schematic designs. Therefore, according to the results shown in built environment guidelines for the Nong Bua area, the Backcasting technique is a potential tool that helps direct the discussion to aid the participants in focusing on the main agenda of the policy/guideline-making process for an effective result.

Moreover, the supporting evidence, such as the 5-point Likert scale survey of satisfaction in the RDF-T, suggestions from the participants to the RDF-T, and an

additional interview, demonstrates that most of the participants are very satisfied with this framework and its elements. However, there is a need to adjust some factors of this framework to make it more efficient – i.e., an adjusted selection criterion of stakeholders, and a clearer explanation of the whole process led by the RDF-T. With these concerns, this study has reconsidered the lacking components in this framework, and the development of this framework is explained in the section below.

Therefore, in regards to reflecting on the research aims and objectives, at this stage of the study, illustrate the evaluation of the repeatability and limitations of the RDF-T, including the most effective element of RDF-T in terms of underpinning the valid outcome. Therefore, the results urge this study to continue to use the findings as material to support further development and relevant studies. The following section shows the development of the RDF-T that adapted the additional interview results to improve the RDF-T's capability, possibly extending the framework's credibility and accuracy for future usage.

6.2 A Development of the RDF-T

To increase the possibility of suggesting the RDF-T to other groups of users, this study has considered the results and suggestions for this framework from the previous workshop as essential material to improve its capabilities since several details were lacking and overlooked in the previous workshop. Examples include a strict selection criterion of stakeholders, a more precise explanation of procedure in the engagement process, a simplification of the framework, and an additional underpinning component to support the framework, et cetera.

This study has analysed all aspects of the primary results and developed this framework, as shown in *Figure 6.6*. This flow chart shows the crucial factors extracted from the results summary and the suggestions for the RDF-T that need extra consideration, such as (1) Cooperation, (2) Governmental Structure, (3) Regulation Adjustment, (4) Cost and Budget, (5) Management Plan, (6) Technology, (7) Soil and Water, (8) Way of life and Belief, (9) Human Behaviour in Green Spaces, and (10) Biodiversity Index. Subsequently, these components, which were lacking in the previous workshop, have been added to this developed framework and have been categorised into five aspects: (1) Consideration of the Stakeholder, (2) Clarify TREES prerequisite, (3) Clarifying the Regenerative design principle, (4) Additional information, and (5) Ecosystem quality indicator. Based on the results from the previous workshop, these

aspects require more consideration for the complete development of the RDF-T. The development of this framework reveals that it is necessary to define Regenerative design for the Thai context and to expand an acknowledgement of this framework by creating a Manual of regenerative design for the Thai context that can strengthen users' understanding of the RDF-T.

Subsequently, this study has summarised the findings for making the RDF-T easier to understand and raise awareness of applying this framework in further built environment design projects in different Thailand regions. Then, to simplify the core idea of the RDF-T, this study has established a definition of a Regenerative Design for the Thai context:

"It is an instruction to regenerate the abundance of Thailand's Ecosystem whilst applying the common regenerative design principle and approach along with Thai's belief and way of life for the built environment building and landscape design, including development guidance for proper use in the Thai environmental context".

Therefore, to create a better understanding of the RDF-T, as shown in *Figure 6.7*, this study has added significant factors into each element of this framework (Regenerative design, TREES, and Backcasting technique) to guide users to consider these factors during future engagement processes for a comprehensive built environment design and development guideline. Subsequently, to testify to the results of the development version of this framework, this study decided to create "A Manual of a Regenerative Design Framework for the Thai context" to use the manual as a communication tool that possibly promotes the RDF-T to local practitioners, which this ambition related to the research aims and objectives to propose the RDF-T in terms of being a tool for revitalising a local ecosystem and strengthening the well-being of humans, nature, and the local community.

The manual will explain the definition of a Regenerative Design for the Thai context, including a basis for utilising the RDF-T, the procedure of the engagement process, worksheets of questions and checklists that help stimulate the participants' thought during a workshop, implementation after the engagement process, and a suggestion for comparing the biodiversity quality pre and post-the-built environment design. However, before summarising the ultimate conclusion, this study needs to evaluate the efficiency of this manual to prove its quality and repeatability in terms of providing users with a clearer understanding of this framework. It is necessary to assess

this manual by inviting the same group of participants from the previous workshop to attend an online focus group to investigate the efficiency of a manual of RDF-T since this group of participants was familiar with and directly had experiences with the RDF-T through the 3-day workshop and the additional interview process. Ultimately, this study needs to use the results from an online focus group to underpin the accuracy and quality of the final conclusion of this study. The details of the online focus are illustrated in the next section.

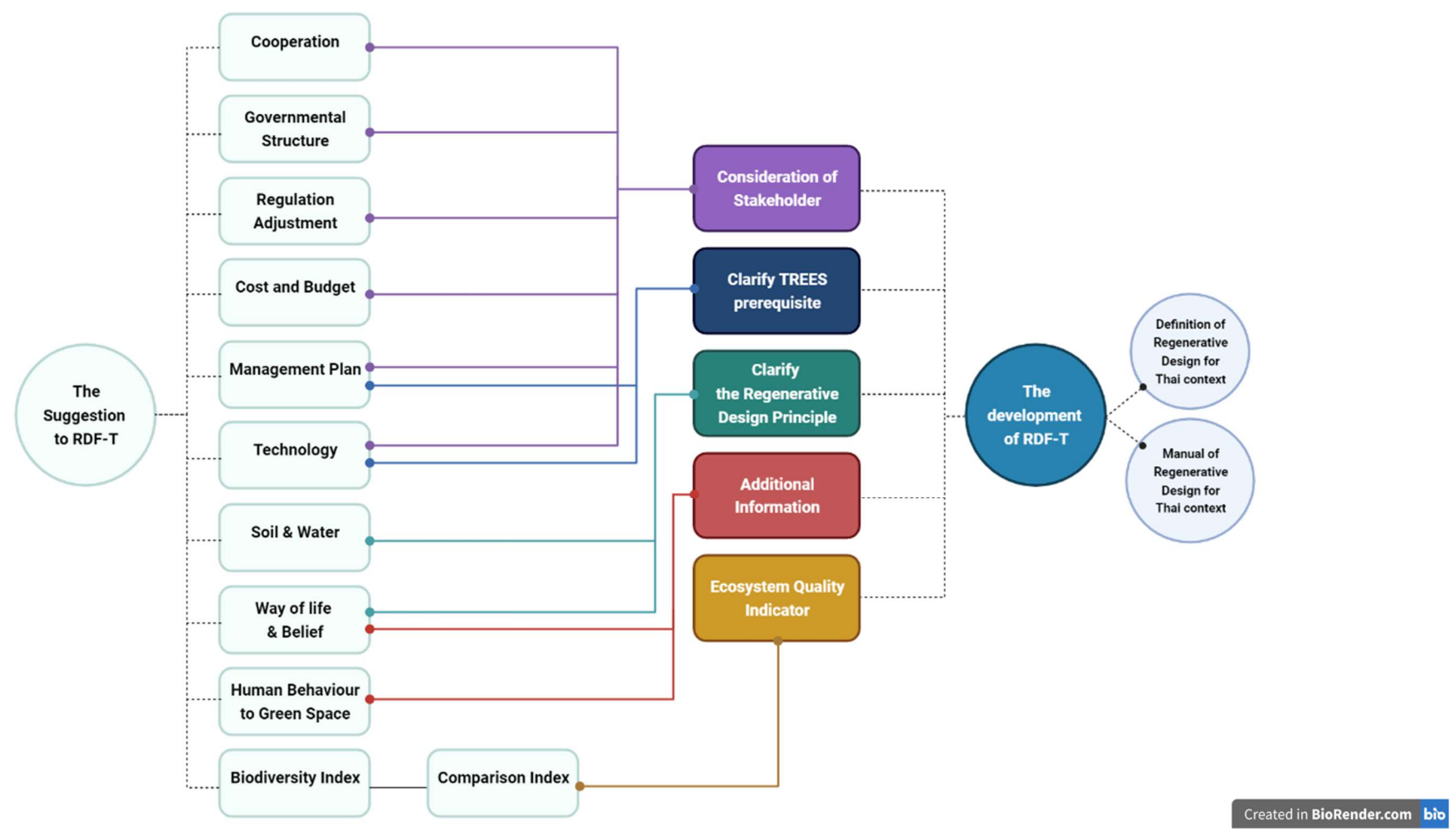


Figure 6.6 The flow chart shows an analysis of RDF-T development that extracted the crucial factors from the suggestion of the RDF-T by categorising it into 5 aspects that require consideration for the complete development of the framework.

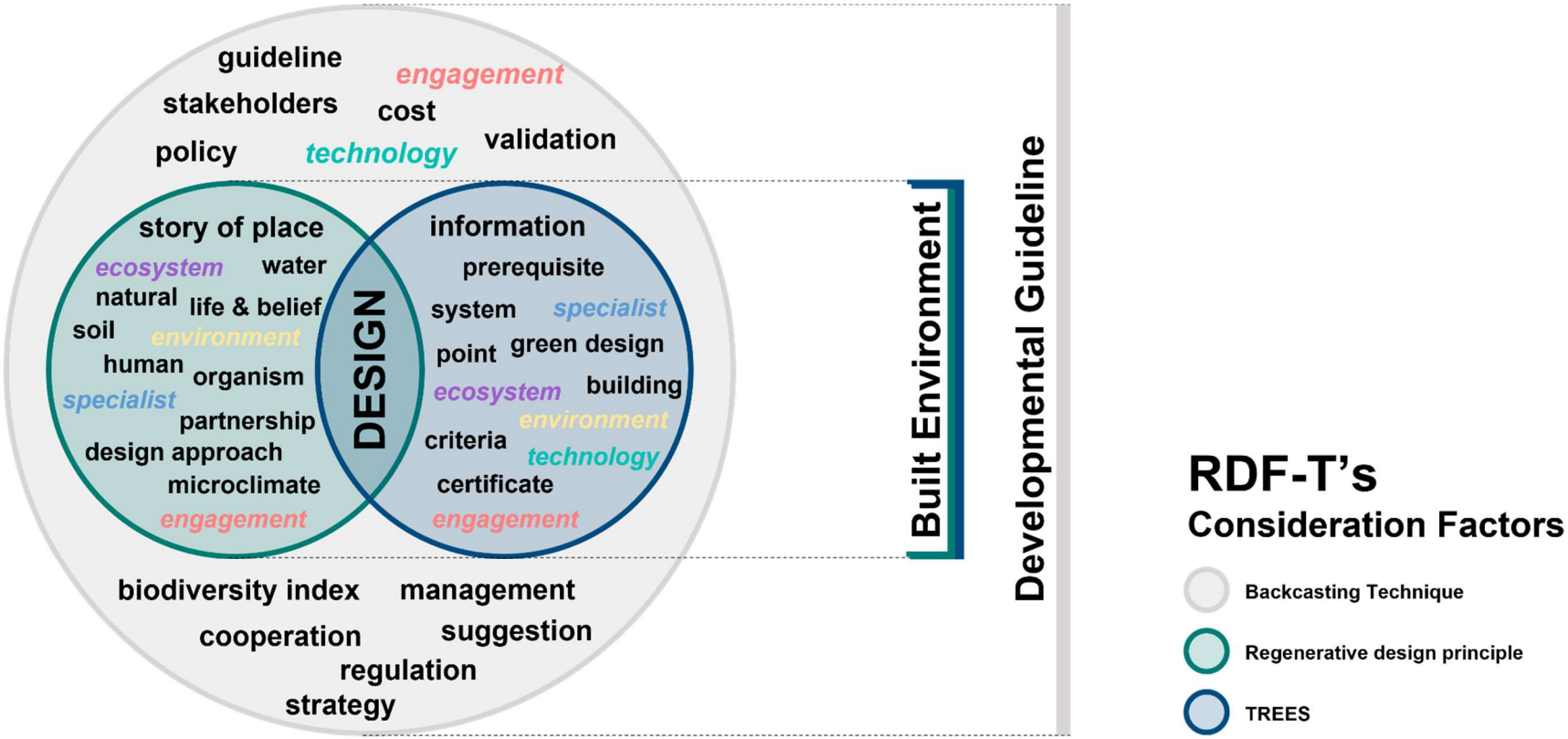


Figure 6.7 A diagram of the significant factors in each element of RDF-T that should be considered in the engagement process for a comprehensive built environment design and developmental guideline

6.2.1 An Online focus group and suggestions for a manual of RDF-T

The online focus group evaluated a manual of RDF-T that was held after the analysis process. This study then investigated the efficiency of this manual by inviting the same group of participants from the previous workshop to attend an online focus group via Zoom under the topic "The Updating of the Nong Bua Development Project and The Feedback on a manual of a Regenerative Design Framework for the Thai context".The invitation letter and a manual of RDF-T in Thai were sent to all participants two weeks before the online focus group meeting since the participants needed time to read and review the manual. Importantly, this study mentioned to the participants that this manual was a draft and was solely used as a part of this study. *Figure 6.8* and *Figure 6.9* shows examples of the manual's cover and contents in Thai.

On the online focus group day, 13 out of 17 participants from the previous workshop who attended were the CMWHI team (4 persons), property owner (1 person), community architects (2 persons), landscape architects (2 persons), TREES specialist (1 person), local people (1 person), an ecologist (1 person), and a botanist (1 person). At the beginning of the online focus group, this study asked the participants for permission to record the video of the focus group in order to transcribe the recording and use the results to analyse and develop the study further.

After asking for permission for the video recording, there was a slide presentation of the RDF-T when applied in the Nong Bua area to remind the participants of the previous workshop. This study then prepared questions to ask for the participant's opinions in order to use these questions to lead an open conversation and urge the participants to discuss their thoughts independently. The questions in the online focus group are shown below:

1. After the last workshop, how do you proceed with or develop the conclusion of Nong Bua built environment design and guidance?

2. Did you have a chance to participate in other built environment design workshops about the Nong Bua area? If you have attended other workshops, please share your experiences.

3. Do you understand the principle and how to use a manual of RDF-T?

4. Do you think this manual is functional and practical for use?

5. Does this manual and the RDF-T suit the Thai context?

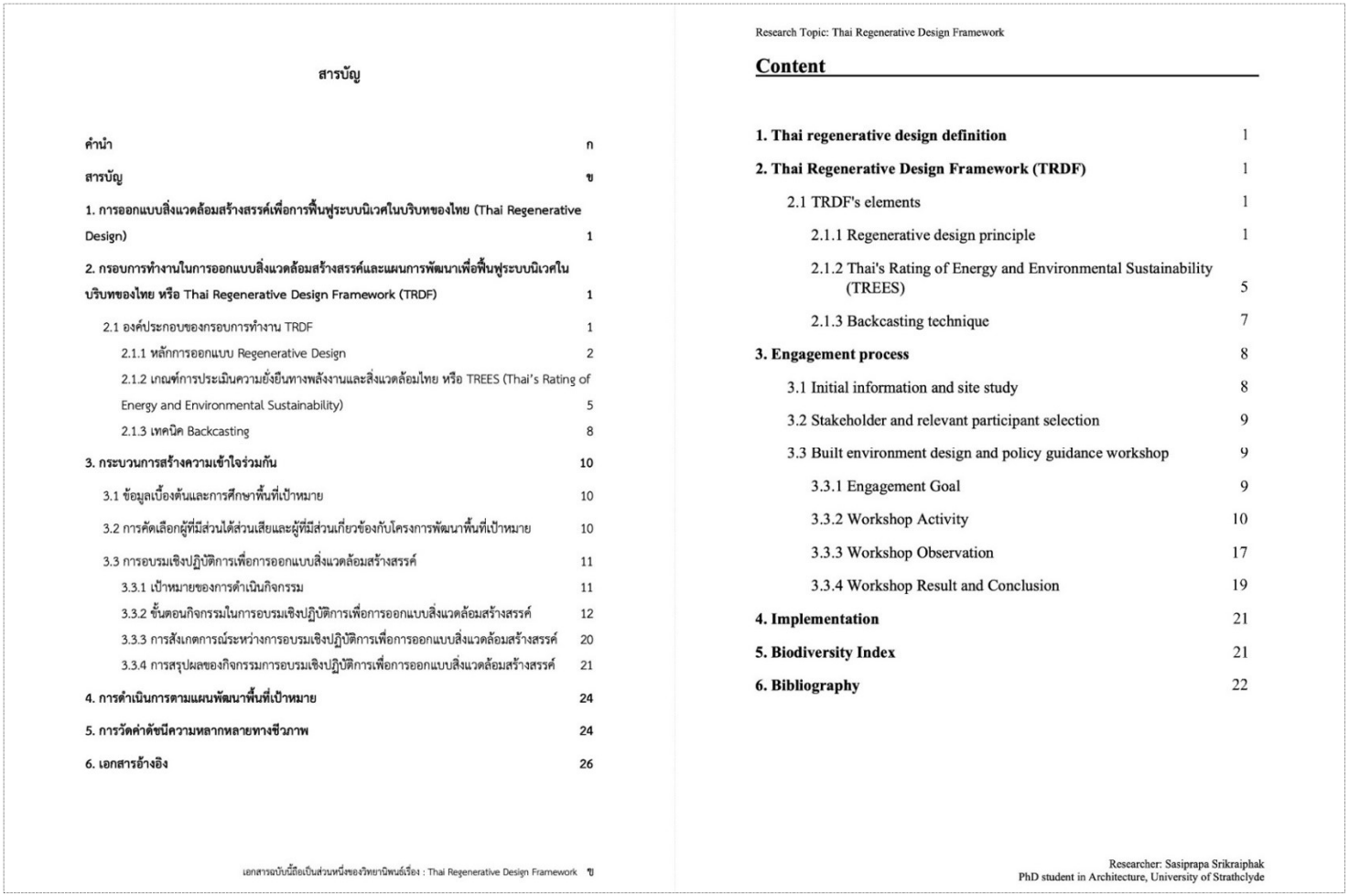
6. Can the RDF-T be applied to other built environment design workshops in Thailand?

7. Do you have any suggestions for the RDF-T?

In detail, the first two questions were meant to ask for Nong Bua Development project updates. The first question was for the CMWHI and property owner of the Nong Bua area, since the CMWHI has been in charge of this area from the beginning, regarding their aim to propose this area as a buffer zone of Chiang Mai World Heritage site to UNESCO. Therefore, the results of the previous workshop event that they cooperated with this study were used and adjusted in their project due to the built environment design in the buffer zone area being one of the green development plans of their Chiang Mai World Heritage Initiative Project. Likewise, the first question was also for the property owner as since this area is private property, the owner has the right to know and can decide on the development of their property.

Then, the second question was for the rest of the participants, as this study needed them to share whether or not they had the chance to attend other built environment workshops, as this data is essential to analyse any comparisons to the RDF-T. The following questions asked for feedback on the manual of the RDF-T. Intentionally, this study aims to investigate how practical this manual is and the repeatability of this framework for future built environment design projects. Then, this study used these questions during the online focus group to lead conversations and encourage participants to share and discuss their ideas. During the discussion process, it turned into an open conversation, which sometimes led to other things unrelated to the questions. However, the whole discussion was about the built environment design development of the Nong Bua area, the feedback on a manual of the RDF-T, and significant suggestions for this study.

Figure 6.8 A Cover of a manual of Thai Regenerative Design Framework (Shown in the previous title of this manual)



สารบัญ

Content

Researcher: Sasiprapa Srikraiphak
PhD student in Architecture, University of Strathclyde

Figure 6.9 The Contents in a manual of Thai Regenerative Design Framework in Thai and English versions (Shown in the previous title of this manual)

The results of this online focus group have been divided into three categories, as shown in *Figure 6.10*. The results show that there are three main points of the discussion that this study has gained from the online focus group.

1. A 3-day workshop is practical and effective. Therefore, the previous workshop led by a new methodology is a good start for built environment design for Chiang Mai City.

2. The manual is slightly hard to read. The suggestion is to make it concise and easier to read for user-friendly guidance.

3. In terms of the repeatability of this framework, it is possible to apply it to other places in Thailand. However, more distinctive factors should be considered while using this framework in different places, which should be explained in the manual. Therefore, some of the participants asked, "What is Thai in this framework?" and suggested that an explanation of this framework would be more precise if there were a change to the framework's title, which should be "Regenerative Design Framework for the Thai Context (RDF-T)" instead of "Thai Regenerative Design Framework (TRDF)" as they thought the title "Regenerative Design Framework for Thai Context (RDF-T)" is more specific in terms of explaining its use in a particular context.

On account of this, this study has found that in the title "Thai Regenerative Design Framework (TRDF)", the word "Thai" itself possibly leads people to refer to "Thainess" that could represent other aspects of "Thai" differently from the proposal of this study, such as political dynamics which have affected changing "Thainess" through time in regard to the meaning of Nation, Monarchy, and Religion (Sattayanurak, 2005). In contrast, this study aims to create this framework for the Thai context that intends to describe "Thai" in terms of indicating a specific place to which this framework can be applied in a built environment design process. As a consequence, this study has reconsidered the framework title based on the participants' suggestion and additional study by changing it to "Regenerative Design Framework for the Thai context (RDF-T)" since this framework title has a clear explanation per se in terms of proposing a built environment tool for a contextual design. Subsequently, the manual's title was changed to a manual of Regenerative Design for the Thai context (RDF-T).

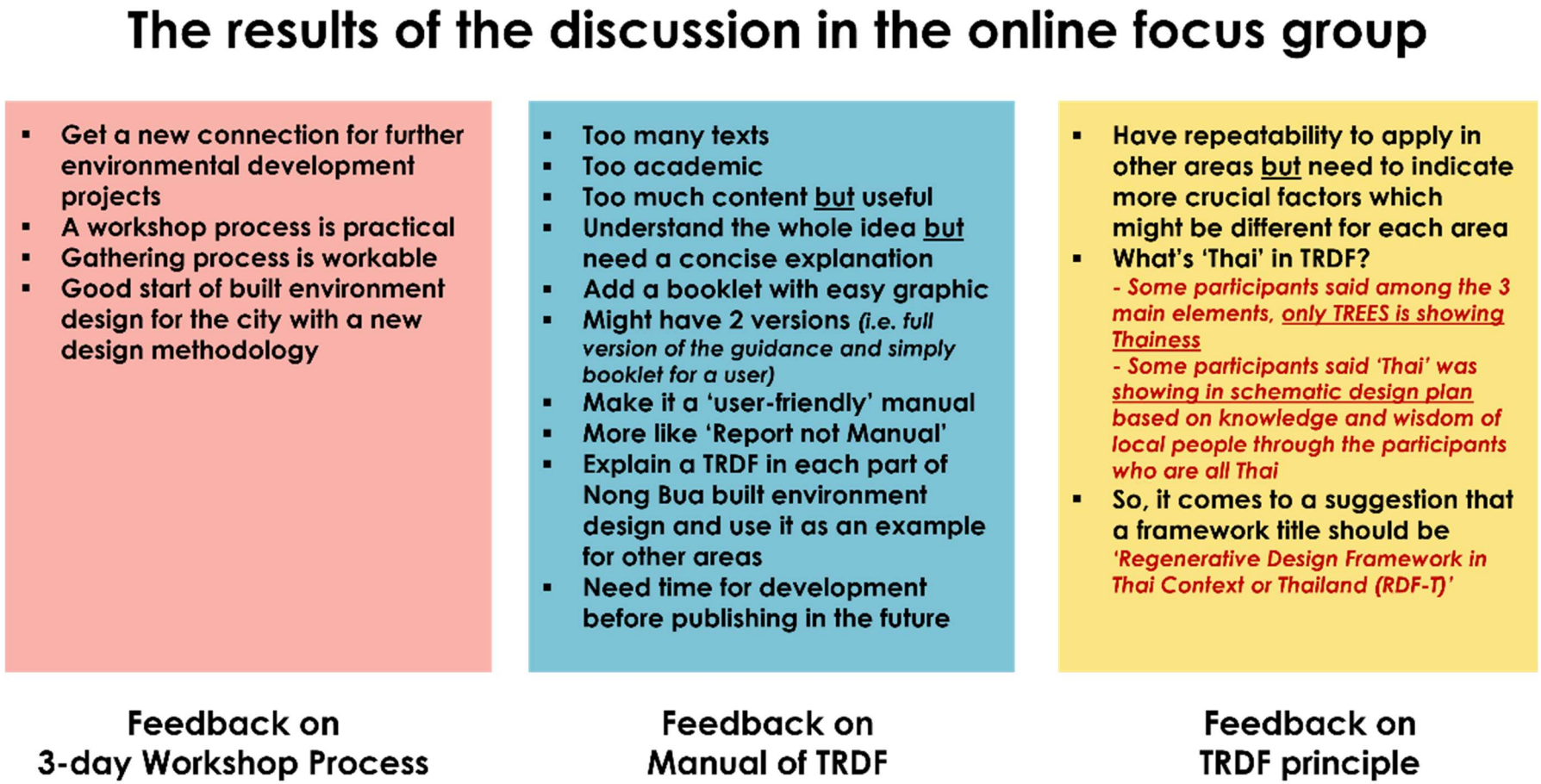


Figure 6.10 The results of the discussion in the online focus group (Shown in the previous title of this manual)

After examining and evaluating all of the data within the three main points of the online focus group's results, another important finding was a supportive element to strengthen the capability of RDF-T in terms of underpinning a specific contextual design and answering the question "What is Thai in this framework?". As shown in *Figure 6.11*, an adjusted diagram added a supportive element into RDF-T and inputted significant factors in each element of this framework that can be used as consideration factors in future engagement processes. This study finds that to underpin the completeness of RDF-T in terms of being an alternative contextual built environment design tool, especially for the Thai context, "Thai Socio-Ecological Characteristics" are essential to support this framework when combined with the other three elements (Regenerative design principle, TREES, and Backcasting technique). Thai Socio-Ecological Characteristics cover Culture, Belief, Way of Life, Religion, Ceremonies, Tradition, Governance structure, Local community's character, Socio-economics, and Socio-ecology. These characteristics imply a story of place in a specific area of the Thai context, which examines both the stories of humans and nature as having an equal role in the design. The basis of the regenerative design principle holds that it is vital to thoroughly understand the story of place for a suitably built environment design that benefits all living organisms which live in the same ecosystem (Hes & Coenen, 2018; Hoxie et al., 2012; Mang & Reed, 2012).

The diagram shown in *Figure 6.11* shows that the Thai Socio-Ecological Characteristics element intersects with the other three elements of the RDF-T. In the intersectional area, some similar factors exist, such as environment, stakeholder, ecosystem, life and belief, et cetera. These factors are essential in the fundamental elements of RDF-T and must be examined in the engagement process for a comprehensive built environment design and developmental guidelines. Therefore, these findings potentially imply the importance of Thai Socio-Ecological Characteristics to the built environment design process for the specific area in the Thai context to acknowledge the story of the place and use it to support the other two elements of RDF-T (Regenerative design principle and TREES) in the design process to distinguish a contextual built environment design that possibly has different details. Thus, the design based on the character of its place can fully benefit the local community and ecosystem.

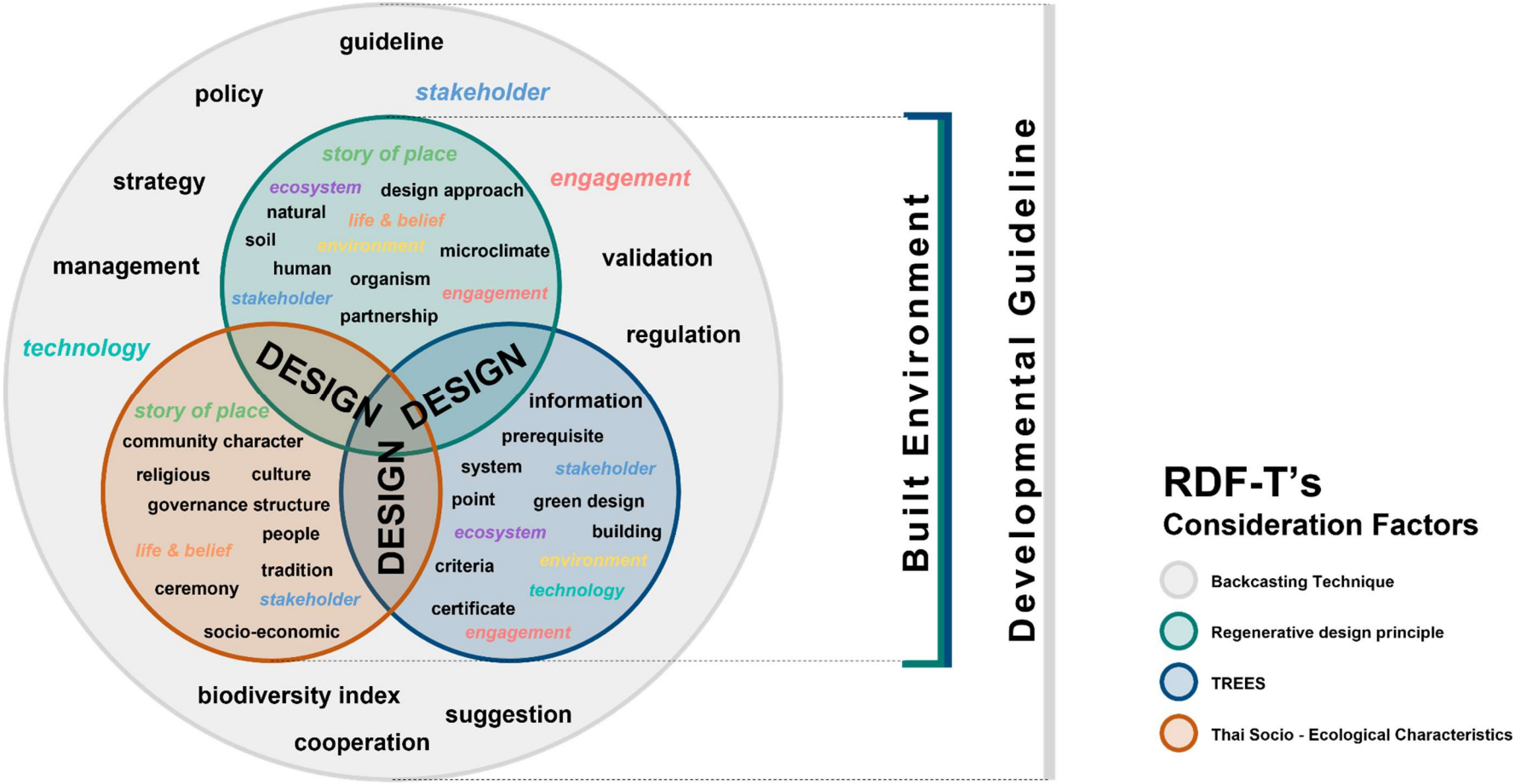


Figure 6.11 An Adjustment of a diagram of the significant factors in each element of RDF-T that should be considered in the engagement process for a comprehensive built environment design and developmental guideline.

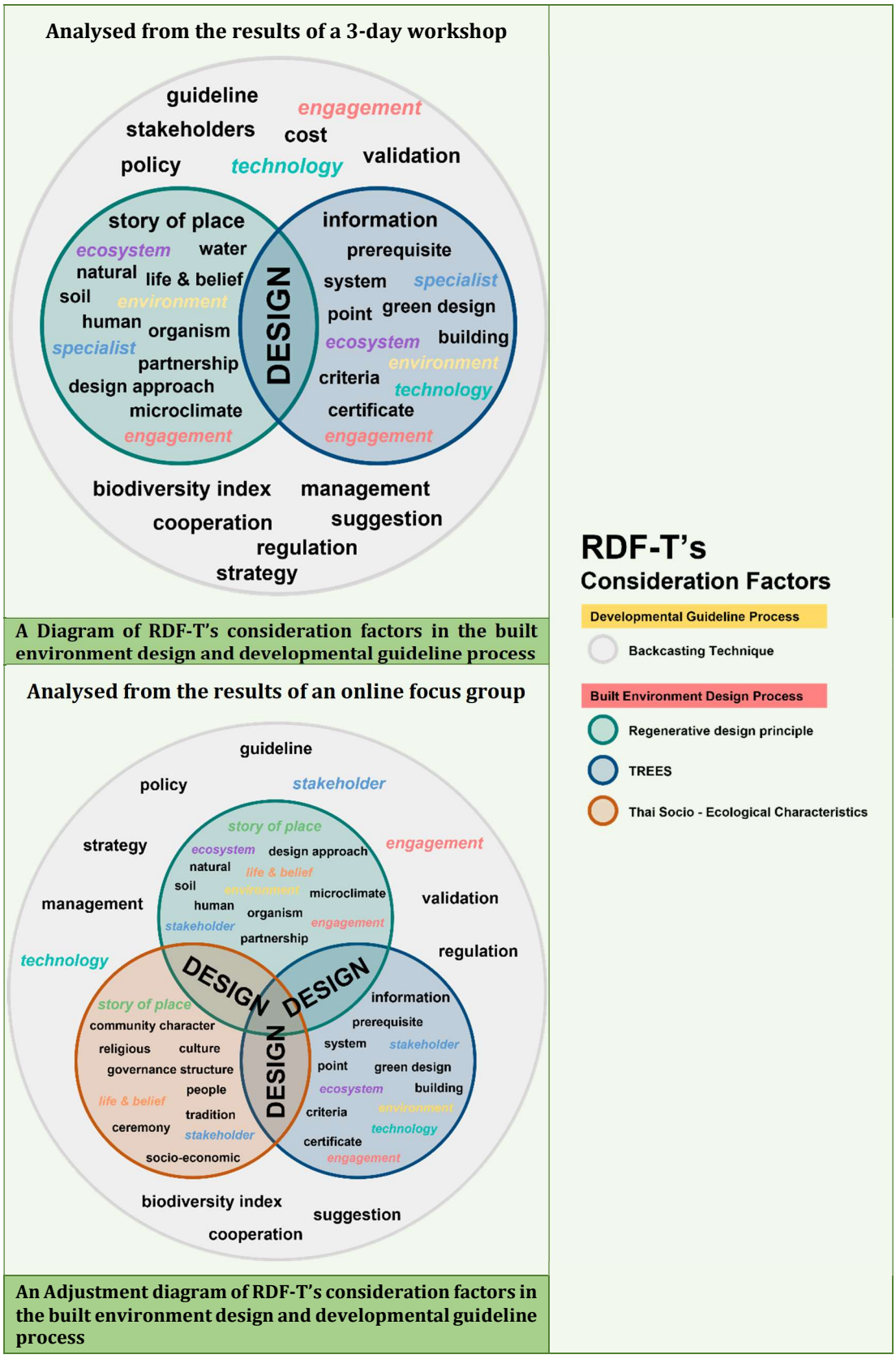
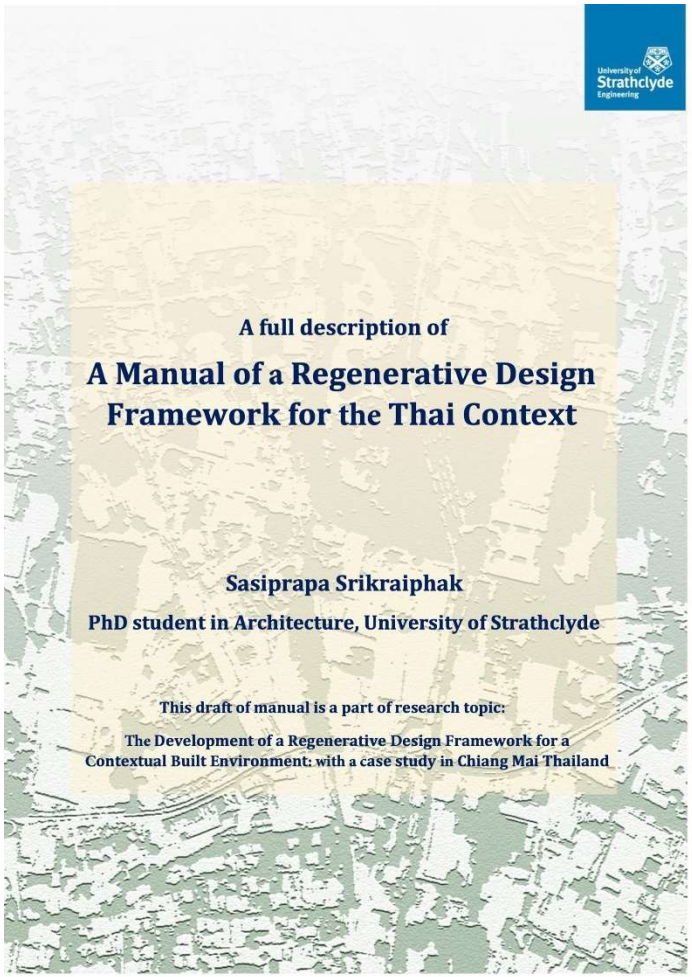


Figure 6.12 A Comparison of RDF-T's consideration factors diagram between the results of a 3-day workshop and the online focus group

To summarise, *Figure 6.12* shows a comparison of RDF-T's consideration factors diagram that was developed from the results of the 3-day workshop compared with the developed version from the online focus group in which there is a continued elevation of RDF-T that has inserted additional consideration factors in each element of this framework based on the results acquired from each stage of the study. With this respect, the findings through all stages of this study can strengthen the capability of this framework to be applied in future contextual built environment design and policy planning workshops. Nonetheless, the addition of Thai Socio-Ecological Characteristics aspects in the RDF-T affects the previous structure of this framework because it is a new crucial element that combines with the existing three critical elements (Regenerative design principle, TRESS, and Backcasting technique) that were the main structure of the RDF-T before the final findings. Consequently, this important discovery has led to the conclusion that the study has slightly adjusted a new RDF-T structure to suit better the Thai context.

Due to the changing RDF-T's structure, this study intends to develop the manual of the RDF-T to be more accessible and effective based on the latest findings, which leads to the recently adjusted version of the manual. It has been arranged concisely while containing all the essential information that possibly helps distribute a better understanding of using the RDF-T to future users who intend to apply this contextual built environment tool in their projects. In addition, except for a full description of the manual, this study has created a more concise version of the manual that summarised the overall contents in the full description version into a brief explanation that uses infographics to help explain the ideas and critical information of the RDF-T to the reader to aid their understanding in a short period of time. However, there is a need to use the full description of the manual along with the quick version since the full description version contains all of the information and helpful worksheets that are supporting materials for effective contextual built environment design engagement. *Figure 6.13* shows the covers of the full description version and the quick version of the manual of the RDF-T. Noticeably, both versions of the manuals are drafts that will be used as one of the final conclusions of this study. For further development, if there is any chance of applying this framework in a diverse built environment project, the additional findings will be added to the manuals for a robust RDF-T. The drafts of these manual versions are shown in Chapter 7, with more details and explanations.



A full description

A quick version

Figure 6.13 A Full description version and a quick version of the manual of RDF-T

Chapter 7

Reflection and Refinement of the RDF-T

7.1 A Development of RDF-T manual

This study has developed the manual of the RDF-T with regard to promoting the RDF-T to design practitioners; the contents in the manual were created from a 3-day workshop on the built environment design in the Nong Bua area. This study found the potential of the RDF-T in terms of being an alternative built environment design tool from the workshop and the feedback of the workshop, including an additional interview and online focus group with the participants. The findings imply that the RDF-T can be applied in the built environment design projects in different contexts in Thailand. Promptly with the suggestion from the participants, this study has developed the manual to be more accessible and practical for creating a more precise understanding for the user.

This study has created two versions of a manual RDF-T: A full description of a Manual of RDF-T and A Quick Manual of RDF-T. As previously mentioned, the two manuals are the initial version that needs to be revised and adjusted further when the RDF-T is possibly applied in developing projects in other regions of Thailand, which this study considers the application of the RDF-T in diverse projects is the most effective way to improve the accuracy and comprehensive of this framework. The difference in the condition of each place and the various groups of participants potentially provide novel aspects regarding the capability of the RDF-T. Then, the findings in each project can

potentially be valuable material in further improving the quality of the RDF-T manual before publishing the complete version to a larger platform.

The reason for creating two versions of the manual – apart from the suggestion of the online focus group's participants – is that the adjustment of this manual intends to help users understand the whole idea and each procedure to create an effective contextual built environment design and guidance that the RDF-T leads for the holistic benefit of all. Moreover, this study has discovered that a full description in the manual is necessary in terms of explaining the overall idea and details precisely in each procedure of an engagement process led by RDF-T. Moreover, it helps users understand every dimension of this framework when they need to apply it in their own built environment projects. Therefore, this manual version has been adjusted to be more concise. It has explained the information intensively, focusing on crucial information that is important for application in built environment design processes. Therefore, the quick manual version can help users understand a brief of the RDF-T in a short period. Nevertheless, users who prefer to use this framework in their built environment design projects should look for more details in the full description manual for more understanding and alongside other helpful materials to use in the engagement process.

The following section will illustrate the pattern and contents in A full description of a manual of the RDF-T, including materials that will be useful in the built environment design and guideline-making process. Then, there is a depiction of A Quick Manual of the RDF-T that briefly summarises the critical procedures of the RDF-T for users' quicker understanding.

7.2 A full description of a manual of RDF-T

7.2.1 A Description Regenerative design for the Thai context

Regenerative design for the Thai context is an instruction to regenerate the abundance of Thailand's Ecosystem whilst applying the common regenerative design principle and approach along with Thai beliefs and way of life for built environment building and landscape design, including development guidance for proper use in the Thai environmental context.

7.2.2 Regenerative design framework for the Thai context (RDF-T)

The RDF-T is a tool for a built environment design and planning that suits the Thai Socio-Environment in terms of responding to regenerating an abundance of ecology and sustainably maintaining the way of life of a local community by encouraging local people to consider natural functions as a crucial factor in designing with nature for the holistic benefit of human and other organisms in the ecosystem. At the same time, RDF-T is designed to be applied in the stakeholder engagement process, all of whom should be relevant to the target place. The engagement aims to produce built environment design and green development guidelines to prepare for the actual implementation based on the regenerative design for the Thai context principle and a consensus among the stakeholders.

7.2.3 RDF-T's elements

RDF-T combines four essential elements: The regenerative design principle, Thai's Rating of Energy and Environmental Sustainability (TREES), the Backcasting technique, and Thai Socio-Ecological Characteristics. Each element has its role in the engagement process. A combination of them can stimulate effective results and be presented in the form of built environment design and green policy guidance for ecosystem development.

Regenerative design principle

The term 'regenerative design' was developed by John Tillman Lyle, who saw the connection with the regenerative agricultural concept of Robert Rodale. Initially, it was developed for agricultural land use, known as permaculture. According to Bill Mollison, the co-originator of permaculture at The Permaculture Research Institute, permaculture is a philosophy and method to design sustainable settlements for humans to use land that is connected with plants, animals, water, soil, and microclimate and to create a productive community that is ecologically harmonious. With these practical approaches, Lyle saw the possibility of adapting these ideas into the whole system that could maintain life since 'regenerate' means to 'create again'. The definition of regenerative design is the replacement of a recent linear flow system with cyclical flows at sources that have been utilised in other places and would then return back to the sources. Within this operational process, the use of materials in a regenerative system provides continual replacement throughout its operation (Lyle, 1994; Maria-Angeliki Zanni and Robby Soetanto and Kirti, 2013).

The regenerative design principle emphasises work between humanity and nature as a design partnership in terms of regenerating an ecosystem for the benefit of whole living systems in their specific place. A designing approach is to understand "A Story of Place". Understanding "A Story of Place" is crucial for the greatest benefit to humanity and nature. This is because a story of a place can help stakeholders understand the place's physical status, topography, microclimate, pros and cons, the relationship between the ecosystem and community, and the way of life of local people, including the socio-cultural community as these factors affect the development of a built environment. Regenerative design requires stakeholders who are related to the place to be from many fields, such as property owners, local people, community architects, landscape architects, ecologist, botanist, local authority, historian (if the place has a historical value), et cetera. Their different backgrounds can help them understand the story of a place in diverse dimensions. At the same time, they can exchange their knowledge in a discussion for effective built environment design, which responds to the needs of the majority of the people in the community and provides benefits for all, both humans and other organisms who share the same ecosystem. *Figure 7.1* shows a conceptual diagram of regenerative design.

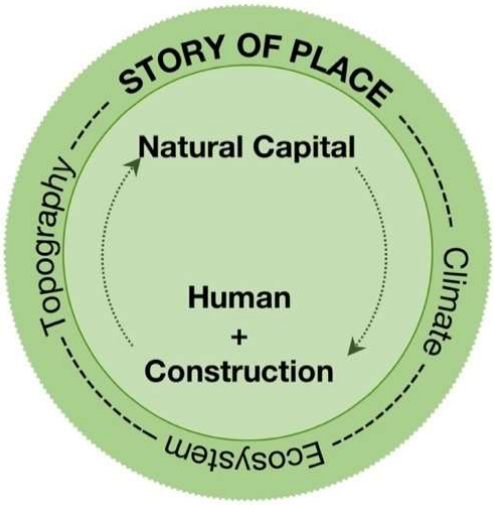


Figure 7.1 Regenerative Design Conceptual Diagram

Therefore, *Figure 7.2* shows that the regenerative design approach will consider natural functions and allow nature to be a significant partner in the design process by prioritising building design to be suitable for place conditions. Hence, the regenerative design principle focuses on the roles of humanity and nature that help to support a built

environment compatible with all living organisms (Cole, 2012b; du Plessis, 2012; Lyle, 1994; Mang, 2001; Reed, 2007; Van der Ryn & Cowan, 1996).

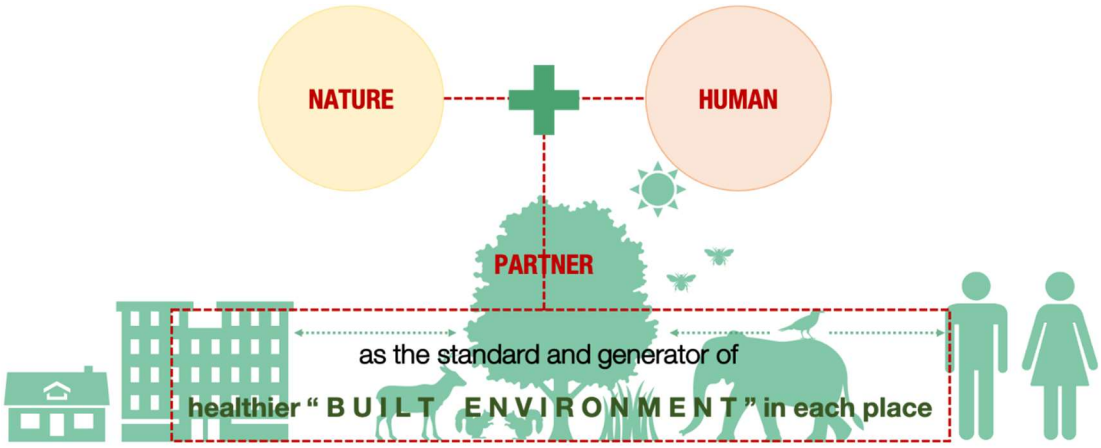


Figure 7.2 A relationship between human and nature in a built environment design process

The human role in building design is performed in methods such as Eco-Friendly Design, Biophilia Design, Roof Garden design, et cetera. Landscape design can include Native plant gardens, Edible Landscaping, Community wetlands, Raised Beds, and Container Gardens, et cetera. (Kilroy, 2014). Nature's role will consider using natural functions effectively, such as tree leaves and roots being a natural filter, nutrient absorption, and natural remedy for greywater before infiltrating into the ground level, et cetera (Kilroy, 2014). The example of regenerative design approaches below shows the combination of human and nature's role in built environment design.

Regenerative Design Approaches for Site Invention

1. Construction/ Restoration Stream daylighting
2. Construction/ Restoration Wetland
3. Using native plants
4. Designing a vegetated buffer
5. Using a pervious pavement
6. Designing a suitable landscape for the local environment
7. Green stormwater management
8. Bioswale
9. Xeriscaping
10. Rainwater harvesting
11. Community food production (Urban farm, Edible landscape)

12. Diversity of garden design (Raised bed, Container Garden, Rooftop)

Regenerative Design Approaches for Buildings

1. Choosing a Green Building System
2. Designing building void ventilation and solar orientation
3. Using cool roof material
4. Designing a green roof
5. Using tree shading for the building
6. Dividing a building zone
7. Considering system sizing
8. Choosing Energy Star product
9. Choosing a digital programmable thermostat
10. Using green material for construction

Before a design engagement process is undertaken, the selection of participants to create a shared understanding of the regenerative design principle is essential. Furthermore, the chosen participants should not be solely from design fields and occupants. It should also cover other experts in the ecological field. Their expertise can help the design team discover crucial factors in the built environment design and focus more on revitalising an ecosystem. Therefore, the participants can exchange their diverse knowledge amongst themselves to achieve the most influential built environment design (Cole et al., 2012; Kilroy, 2014; Plaut et al., 2012; Svec et al., 2012).

Thai's Rating of Energy and Environmental Sustainability (TREES)

Thai's Rating of Energy and Environmental Sustainability or TREES was established by the Thai Green Building Institute (TGBI), and TREES rating systems are designed to suit varied building types, both new and existing buildings, and primarily focus on new construction building or large renovations (Thai Green Building Institute, 2016a). Generally, TREES is divided into four categories which are: -

1. TREES-NC (New Construction and Major Renovation)
2. TREES- PRE NC (Preparation of New Building Construction and Major Renovation)
3. TREES-NC/CS (New Construction and Major Renovation and Core and Shell Building)

4. TREES-EB (Existing Building: Operation and Maintenance)

Moreover, TREES Assessment criteria are divided into eight sections, prioritising the importance of protecting the ecosystem. All assessment sections are shown below: -

1. Building Management (BM)
2. Site and Landscape (SL)
3. Water Conservation (WC)
4. Energy and Atmosphere (EA)
5. Material and Resources (MR)
6. Indoor Environment Quality (IE)
7. Environmental Protection (EP)
8. Green Innovation in Design (GI)

Generally, the proportion of a score under each criterion differs since it depends on each type of building assessment. A score is evaluated from each section when there is a building performance evaluation. The TREES expert will use that score to identify the award levels (Platinum, Gold, Silver, and Certified). For instance, *Figure 7.3* is an example of the score proportions for TREES-NC. *Figure 7.4* is an example of the score proportions of the DAIKIN Research and Development Centre, which received a Platinum Green Building Award from TREES.

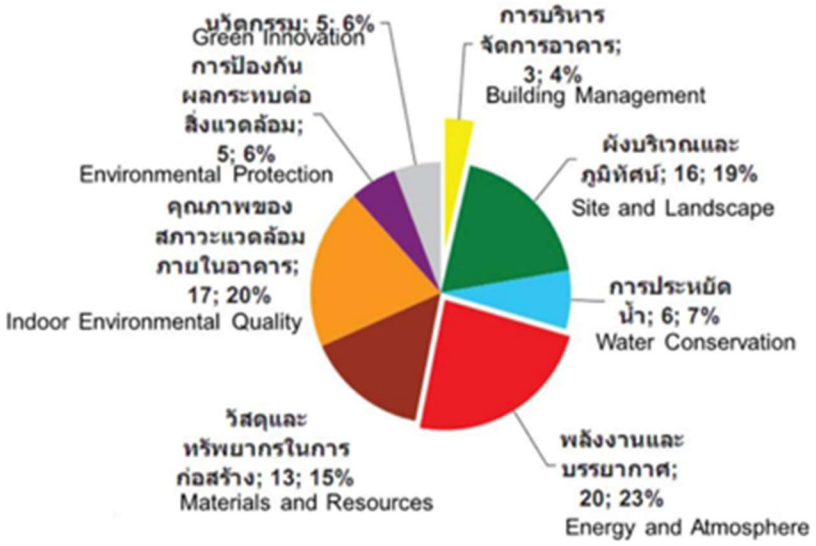


Figure 7.3 Example of the score proportion for TREES-NC

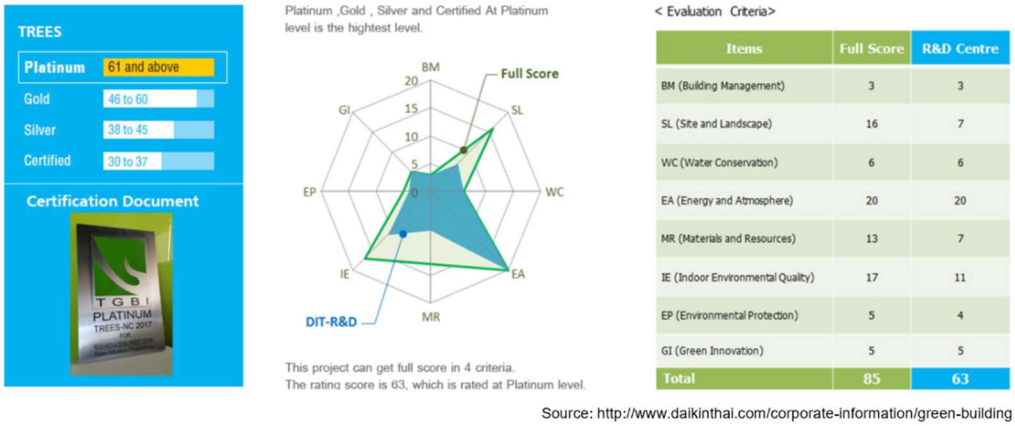


Figure 7.4 Example of the score proportions of 'DAIKIN Research and Development Centre with Platinum Green Building Award'

In addition, see what construction category suits a developing project; additional details can be found at https://tgbi.or.th/trees/all/. For design implementation, a project team should study the prerequisites under each criterion for more information, especially under Criterion 2: Site and Landscape (SL) and Criterion 7: Environmental Protection (EP), which have similar design requirements as the regenerative design approaches and both TREES and regenerative design approaches, will be used in a design process led by the RDF-T procedure.

Backcasting technique

The Backcasting Technique is the technique of forming desirable results and is mainly used to plan policy in the sustainability field (Miola, 2008; Quist, 2007; Wangel, 2011). Basically, the workshop process is an essential component of this technique for seeking consensus towards policy guidelines or is a way to achieve a desirable goal determined by stakeholders (Wangel, 2011).

The Backcasting technique procedure will encourage the stakeholders to address their desired results as a future target and then examine it backwards to the present to identify an agreed-upon guideline as a direction to achieve the goal. At the same time, one must be aware of how to avoid the potential risks of undesired results that might happen along the way. To give an example of the workshop procedure when using the Backcasting technique: -

1. Provide the topic and relevant fields of discussion.
2. Exchange perspectives among stakeholders and experts regarding the topic and relevant fields.

3. Observe, collect, and summarise data taken by the observer or researcher.
4. Make a conclusion of desirable policies and guidelines for long-term practice.

7.2.4 Thai Socio-Ecological Characteristics

Thai Socio-Ecological Characteristics are a crucial element that helps strengthen the distinctiveness of RDF-T, which includes the characteristics of Thai culture, religion, tradition and ceremony, beliefs, way of life, diversity of people in a community, socio-economics, governance structure, and local ecology, et cetera. These characteristics are an indicator of Thai uniqueness. This refers to a regenerative design principle that emphasises the story of a place as an essential factor in built environment design.

As established earlier, in RDF-T, utilising the regenerative design principle and the Backcasting technique requires the engagement of stakeholders as an essential procedure in the whole process for the accuracy of the results. Therefore, while TREES is Thai's Rating of Energy and Environmental Sustainability, each criterion has similar design requirements to the regenerative design approaches in terms of revitalising an ecosystem. In addition, the participants can use these design requirements as a built environment design tool. Therefore, both of these elements have an essential role to play in built environment design. At the same time, Thai Socio-Ecological Characteristics can support the distinctiveness of a built environment that is designed to suit a local context. Subsequently, using the Backcasting technique to create a strategy to achieve a built environment design goal is ideal.

Hence, all participants should understand these four elements of RDF-T at the beginning of the design engagement. The RDF-T has been developed to suit the Thai context in terms of maintaining a sustainable ecosystem and a local way of life. If the participants have a shared understanding of RDF-T, it will help them smoothly proceed with all of the activities in the engagement process. *Figure 7.5* shows the consideration factors in each RDF-T element when applied in the engagement activity. It urges the participants to examine these factors while brainstorming during the built environment design and ecology regeneration guideline-making process.

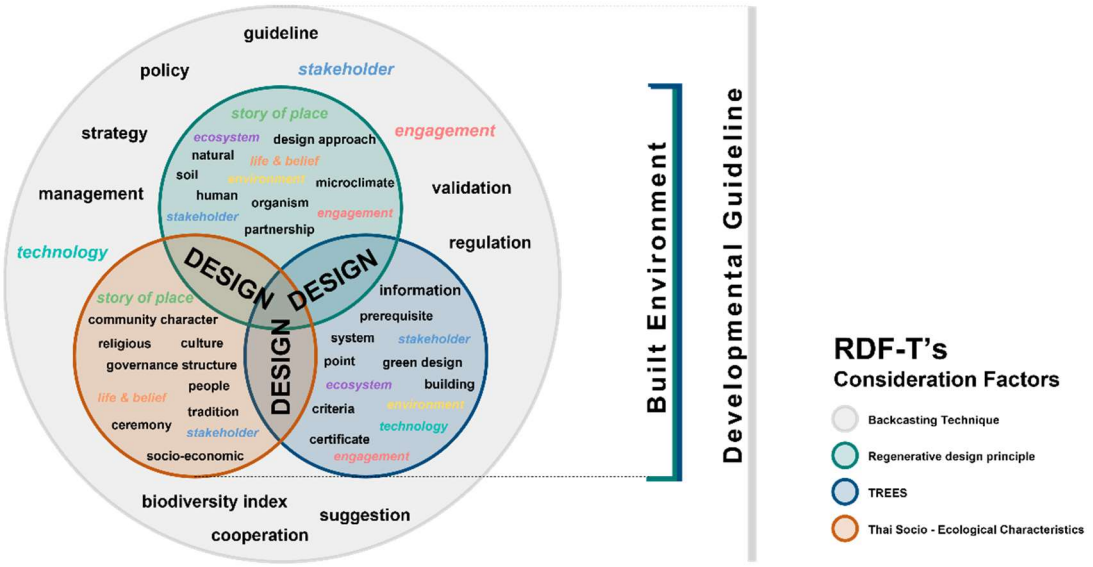


Figure 7.5 A diagram of the significant factors in each element of RDF-T that must be considered in the engagement process for a provision of the built environment and developmental guidelines

7.2.5 Engagement process

Initial information and site study

Usually, a project team must establish a shared understanding among team members about a principle of regenerative design for the Thai context, the working process of RDF-T, and they should study the initial information of a project's site that needs to regenerate an ecosystem and design a built environment. The project site's story is at the core of the engagement process as it can identify the whole picture of the project and can lead the project team to identify the essential participants who are relevant to the project before gathering them into the engagement process.

Stakeholder and relevant participant selection

Regenerative design studies confirm that the diversity of stakeholders and participants is required in the engagement process. Their different backgrounds of knowledge and expertise can provide different perspectives on a project's site (Kilroy, 2014; Miller, 2012). They can exchange ideas and deliberate on a consensus during the engagement process. Moreover, these different ideas can help them recheck and enhance the precision of the final result. Examples of potential participants and green design specialists include architects and landscape architects, ecologists, botanists, green

technology specialists, TREES specialists, property owners, local people in the community, local authorities, historians, et cetera. However, the number of participants in the engagement process depends on how it relates to the scope and scale of the project's site, the appropriateness of which the project team needs to examine carefully.

Built environment design workshop

Generally, the length of the workshop day is three days; it depends on the scope and scale of the development project in which RDF-T has been applied and the workshop's pattern from the previous regenerative design frameworks as such LENSE and Perkins+Will (Cole et al., 2012; Hes et al., 2018; Plaut et al., 2012). The first day is dedicated to site visiting. The following day should be for the design development process, which should take 1 to 2 days, depending on its complexity. The other days should be for regenerative development guidance or relevant policy-making processes. The details below will explain all of the procedures in the workshop.

Engagement Goal

After the project team members have an identical understanding of RDF-T and acknowledge the site's information, the project team should determine the goal of engagement from this step. The goal of engagement potentially scopes the work and helps lead the team to focus on crucial factors, creating an efficient workshop. Furthermore, awareness of the engagement goal can reinforce a pattern of activity that should be allocated for the workshop days.

For instance, the engagement goal is an initial built environment design schematic and regeneration guidance to maintain the ecosystem's quality on the project site. By means of this, the activities that should be allocated in the workshop days should be a built environment design charrette based on regenerative design approaches, TREES, and Thai Socio-Ecological Characteristics while using the Backcasting technique in a brainstorming process among the participants to reach an agreement on ecological regeneration guidelines as a regulation to follow when it comes to an actual construction stage. In addition, the project team can use the questions to stimulate the participants' thoughts in each activity. Furthermore, at the end of the workshop, the project team should prepare a survey for the participants, the feedback from which can later develop further workshops.

The details below show the workshop procedures when applying RDF-T towards regenerating an ecosystem on a particular site and will reveal the steps to follow for a precise understanding before implementing it into an actual developing project.

7.2.6 Workshop Activity

Step 1. RDF-T Explanation: Typically, it is necessary to explain the principle of regenerative design for the Thai context and the idea of RDF-T, including the explanation of an original regenerative design principle, Thai's Rating of Energy and Environmental Sustainability (TREES), the Backcasting technique, and the importance of Thai Socio-ecological characteristics at the beginning of the workshop. Due to each element of RDF-T being a determinant of all of the workshop's activities allocated to each day. Therefore, an explanation of the whole activity in the workshop is recommended to establish an understanding among the project team and workshop participants, which potentially encourages a smooth process during every activity. An example of the schedule of a 3-day workshop from Environmental Regenerative Design: Case study Nong Bua, Chiang Mai, and this workshop was held by the Chiang Mai World Heritage Initiative Project (CMWHI) on the 28th -30th September 2020 at the Social Research Institute, Chiang Mai University, is shown in *Table 7.1*

Table 7.1 An example of contents and activities in a 3-day workshop on Environmental Regenerative Design: Case study Nong Bua, Chiang Mai

Day	Contents and Activities
1	**Morning session (2-3 hrs.)** • The explanation of the regenerative design principle and regenerative design for the Thai context framework • "The work with nature (built environment & ecology)" by Jai Bann Studio – a community architecture firm • "TREES principle (Thai's rating of energy and environmental sustainability)" by a TREES specialist **Afternoon session (2-3 hrs.)** • Site visiting (the case study area is called Nong Bua in Chiang Mai, Thailand. Currently, this area belongs to The Central Group) to create an identical understanding. • Lecture "History of Place" by the Chiang Mai Historical expert • Group discussion "Story of place" (Old/New place's condition, Natural capital flows, Place's potential)
2	**Morning session (2-3 hrs.)** • Continue to discuss the place's potential (owner's aim, the local community's aim) / pros and cons of the place. • Discuss and find the possibility of the built environment in the place based on the regenerative design principle and TREES requirement. **Afternoon session (2-3 hrs.)** • Group discussion "schematic design of built environment" (Building and landscape) based on regenerative design principle and TREES requirement.
3	**Morning session (2-3 hrs.)** • Summarise an understanding of design (Desired Goal) • Use "The Backcasting technique" to set the policy/guidance to achieve the desired goal **Afternoon session (2-3 hrs.)** • Summarise the results of the workshop. • Feedback for the regenerative design for the Thai context framework

Step 2. **Site Visiting:** Site visiting is an activity that should be considered essential since the story of a place is the main factor that all participants must understand as much as possible regarding physical and spiritual aspects. *Table 7.2* is an example of questions that can help encourage the participants' thoughts during the site visiting process. However, the project team can use this worksheet or adjust some details for appropriateness before giving it to the participants in the workshop.

This step is important since, in a design charrette, understanding the story of the place will help the participants recall the pros and cons of the site and possibly use them as a design tool to indicate potential and insufficient factors for a built environment design. This process can urge interaction between humans and nature based on the regenerative design principle, which requires a design partnership based on the co-evolution of humans and nature for the benefit of the whole living system.

Table 7.2 An example of questions for a site visiting

What do you know/think about this place?	
Story of place	*Example* Physical Condition *(including - topography, ecology, climate, natural resources, community's linkage, etc.)*: History of the place *(including - local culture, way of life, and community's beliefs)*: Etc.:
Pros. and Cons. of place	
Potential of place	*Example* Ecological Development: A benefit to the Community:
Etc.	

Step 3. Design Charette: A built environment design charette should be held after the site visit. Before starting the design charette, asking the participants to exchange ideas about the site is crucial. Due to differences in background knowledge and their experiences with the site, this process can indicate different points of view, which can build interdisciplinary notions for a holistic built environment design at the end of the design charette. To achieve the goal of engagement based on the RDF-T procedure in this process, the project team should help the participants recall the regenerative design approaches and TREES requirements with a consideration of Thai Socio-Ecological Characteristics to use them as essential materials in the architecture and landscape design. However, during the design process, it might be difficult for the participants who do not have a design background – an example of the questions that can help them identify their ideas for the built environment design is shown in *Table 7.3*. However, depending on their expertise, the project team can use this worksheet or adjust some details of it for appropriateness before giving it to the participants in the workshop.

During the design charette, the architects and landscape architects will have an essential role in leading the other participants to create a schematic design of a built environment due to their expertise in design. Therefore, if the project team has divided the participants into several groups, then the number of schematic designs would depend on the number of groups in the workshop. On the other hand, even if there is only one group of participants, they can independently create more than one schematic design if needed before the design charette session ends.

To help the participants through this process and the project team to analyse the results eventually, an example of the critical components that the participants should examine while creating a built environment schematic design is shown in *Table 7.4*. However, the number of critical components will depend on the particular place and how the critical components relate to that place. Therefore, the project team needs to discuss this worksheet with the participants before providing it to them. Likewise, if the participants discuss these critical components during the design process, they can adjust them to what they think is appropriate for the place.

Table 7.3 An example of the questions to help the participants identify their ideas before a built environment design discussion

What kind of place or building do you want to develop in the place?	
What else would you like to have in this place?	
Pros. and Cons. of Ecosystem?	
Pros. and Cons. to the community?	
Etc.	

Table 7.4 An example of the critical components in the schematic design process (* means it depends on the individual place and how it relates to that place)

Building Type	Theme	Main User	Function Program					
			Building	Ecological Support	Historical Support *	Community's Benefit	Owner's Benefit *	Etc.*
			Landscape	Ecological Support	Historical Support *	Community's Benefit	Owner's Benefit *	Etc.*

Table 7.5 is an example of the design components which were considered for the schematic design during the design process. Each function program of the schematic design can benefit the Local ecology, Support historical value, Support the community's benefit, and the Owner's benefit. Therefore, *Figure 7.6* is an example of the results of the schematic design in the 3-day workshop on Environmental Regenerative Design: Case study Nong Bua, Chiang Mai, Thailand.

Table 7.5 An example of the design components which had been considered for the schematic design during a design process

Building Type	Theme	Main User	Function Program				
			Building	Ecological Support	Historical Support	Community's Benefit	Owner's Benefit
			1. Commercial Building				
			• Natural learning zone (Indoor playground)				
			• Restaurant				
			• Museum and Exhibition zone				
			2. Café				
			3. Lanna style residential (for tourist)				
Ecotourism Centre	Park "Lotus Swamp"	Family (All ages)	4. Bird watching tower				
			Landscape	Ecological Support	Historical Support	Community's Benefit	Owner's Benefit
			5. Rice field				
			6. Lotus swamp				
			7. Vertical forest / Buffer forest				
			8. Natural trial				
			9. Urban farm (Vegetable and Chicken coop)				
			10. Natural learning zone (Outdoor playground)				
			11. Bird Island				

Figure 7.6 The result of the schematic design in a 3-day workshop on Environmental Regenerative Design: Case study Nong Bua, Chiang Mai

Step 4. Policy and Guideline-making Process: The final activity of the workshop is to produce a guideline or policy that responds to the regeneration of the project's site to maintain the ecosystem quality, as this is one of the engagement's goals. Generally, when finishing the built environment design charrette, it will be followed by a policy-making process in which the Backcasting technique will be used as a tool to stimulate the thoughts of participants during discussions. With the different knowledge backgrounds of the participants, the Backcasting technique will lead them to think in diverse ways and reach a consensus with each development category for comprehensive guidance related to the project's site development. These are examples of development categories:

1. Community Cooperation and Interaction
2. Construction Cost, Budget & Construction Period
3. Green technology in Buildings and Surrounding Areas
4. Environmental design for the Ecosystem
5. Pollution Management & Ecosystem Quality Assessment
6. Engagement of Human and Nature
7. Natural Resource Regenerating
8. Regulation and Authority's approval
9. Transportation

The project team must ask the participants to grasp the obtained schematic design as a target that the project team and participants need to plan the guidelines to achieve. While imagining it as a desired goal of this development that will be constructed in the future, the participants need to plan backwards step by step from the starting point of the development to the end as the pathway to reach the desired goal.

Subsequently, the feedback and survey questions at the end of the workshop about the contents and activities are beneficial and potentially help the project team gain accurate results and prepare for development. Besides, the suggestions from participants can also be used to adjust and strengthen the RDF-T for other engagement events.

7.2.7 Workshop Observation

To help the project team address the successes or failures of the workshop, observation during every activity is necessary. Generally, there are several ways to record the activities in the workshop by requesting permission to do voice recordings, video recordings, photography, and observation. Especially for observation, it is essential to have a few project team members observe the activities happening during the workshop, as each element of RDF-T has different details which require close observation for effective result assessment. Hence, to investigate how it works, observation and note-taking are required. There is an example of a checklist table for the assessment of the participants' understanding of RDF-T shown in *Table 7.6*. This checklist helps the observers while observing each activity in the workshop.

7.2.8 Workshop Result and Conclusion

Commonly, an initial conclusion should be summarised before the end of the workshop to establish shared understanding and consensus on what the participants have done in the workshop. This is especially the case for the overview of the built environment schematic design, as shown in *Figure 7.7,* as well as pointing out all of the categories of the built environment guidance.

The following process is the deliberation among the project team while using voice recordings, video recordings, photographs, and the assessment of the participants' understanding of RDF-T to examine the ultimate conclusion. A deliberation should start by simplifying the result of the schematic design; if there is more than one schematic design, the project team needs to compare them with the same criterion. Subsequently, the project team needs to discuss and modify the design based on the obtained results in the architecture presentation as follows:

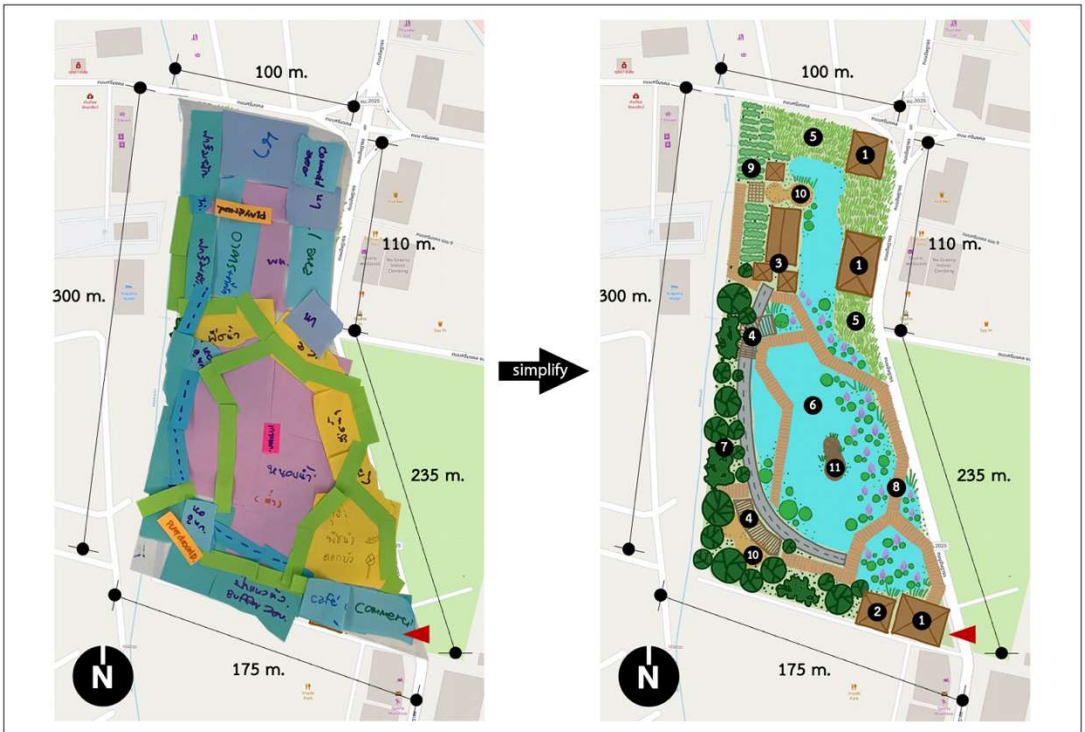
1. An architecture drawing
2. A landscape design plan
3. The cost of construction
4. Green technology and Systems in the project
5. TREES submission form
6. Building Material Chart
7. Vegetation in the project
8. Timeline table for a phasing construction

9. Additional materials, et cetera.

While the built environment guidance should be deliberated and prioritised, all of the policies and guidelines in each category should be planned for the subsequent implementation in terms of preparing for the actual construction, as these processes require time and depend on the circumstance. When finished, it is vital to provide a meeting to inform the participants about the plan and the ultimate built environment design based on their preliminary designs and brainstorming.

Table 7.6 The assessment of the participant's understanding of RDF-T

Activity	In-use element	Participants' understanding of RDF-T									Note.
		RDP			TREES			BT			
		N	Y	A	N	Y	A	N	Y	A	
Step 1. **RDF-T Explanation**	**-RDP** **-TREES** **-BT**										
Step 2. **Site Visiting**	**-RDP** **-TREES**										
Step 3. **Design Charette**	**-RDP** **-TREES**										
Step 4. **Policy and Guideline-making Process**	**-BT**										
Annotation: **RDP = Regenerative Design Principle** **TREES = Thai's Rating of Energy and Environmental Sustainability** **BT = Backcasting technique** **N = No** **Y = Yes** **A = Average**											



Building Type	Theme	Main User	Function Program				
			Building	Ecological Support	Historical Support	Community's Benefit	Owner's Benefit
			1. Commercial Building				
			• Natural learning zone (Indoor playground)				
			• Restaurant				
			• Museum and Exhibition zone				
			2. Café				
			3. Lanna style residential (for tourist)				
Ecotourism Centre	Park "Lotus Swamp"	Family (All ages)	4. Bird watching tower				
			Landscape	Ecological Support	Historical Support	Community's Benefit	Owner's Benefit
			5. Rice field				
			6. Lotus swamp				
			7. Vertical forest / Buffer forest				
			8. Natural trial				
			9. Urban farm (Vegetable and Chicken coop)				
			10. Natural learning zone (Outdoor playground)				
			11. Bird Island				

Figure 7.7 An example of the schematic design's summary from a 3-day workshop on Environmental Regenerative Design: Case study Nong Bua, Chiang Mai

7.2.9 Implementation

The implementation of construction depends on the timeline table and how the policy and guidance have been planned. Hence, the project team should consider it a checklist of the overall development. Significantly, following up after finishing each process helps to encourage the flow operation. Thus, whichever stage the development is at, the project team and stakeholders can easily follow and manage the error when the operation is distorted. Furthermore, due to the Backcasting technique, which is generally used in the sustainability field (Quist, 2007), this potentially ensures the desired goal and prevents any errors that could possibly happen during the operation. However, if there is more time required for an actual built environment development, then the implementation plan should be well prepared and covered in every dimension.

7.2.10 Biodiversity Index

The Biodiversity Index is the formula scientists use to depict species diversity in a particular area. Currently, there are various calculation formulas for biodiversity indices, and one of the most commonly used among ecologists is "The Shannon-Wiener Index (H')" (Claude, 1949; Marod, 2011; Yeom & Kim, 2011).

The formula is $H' = -\sum_{i=1}^{s}(P_i \ln P_i) = -\sum_{i=1}^{s}\left[\left(\frac{n_i}{N}\right)\ln\left(\frac{n_i}{N}\right)\right]$

Where: H'= The Biodiversity Index

P_i= The proportion of the number of species i (n_i) and the total number of all species (N) in the sample area

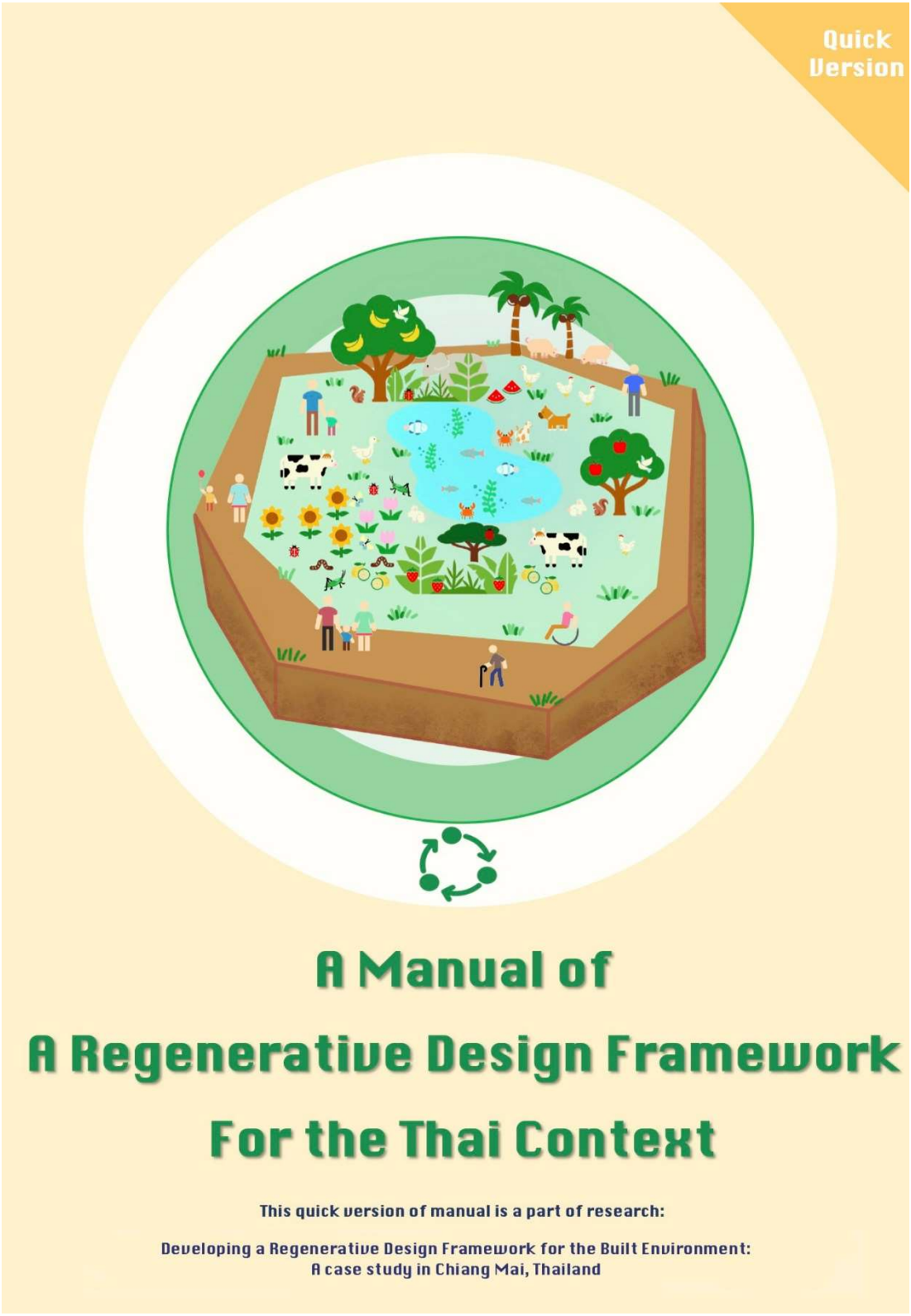
$\ln P_i$= The natural logarithm of P_i

s = The number of species found in the sample area (i = 1, 2, 3, … s)

Normally, the value range of the Shannon-Wiener Index is from 0 to 5, wherein the value close to 5 indicates that the number of individual species is equally spreading among the total number of all individual species; however, it needs to be considered with an evenness index (Marod, 2011; Yeom & Kim, 2011). The Biodiversity Index principle aims to quantitatively estimate the variety of biological species, which can use this index to compare biodiversity in the sample area within a different period of time (Ortiz-Burgos, 2016).

This manual intends to strengthen RDF-T's credibility and performance measurement, which suggests that the Biodiversity Index assessment should be calculated before/after the built environment development to indicate the difference. In addition, a recording of the Biodiversity Index in each assessment can explain a change or can be an indicator to be aware of when biological diversity in the project site decreases as it is one of the indicators to help maintain the quality of the ecosystem. However, while the Shannon-Wiener Index (H') is one of the Biodiversity Indices, the project team can decide to use another Biodiversity Index to assess the quality of the ecosystem as it might suit that particular site more. A Quick manual of RDF-T is depicted in the next section.

7.3 A Quick Manual of RDF-T



The quick version of manual is a part of research

Developing a Regenerative Design Framework for the Built Environment: A case study in Chiang Mai, Thailand

By Sasiprapa Srikraiphak
PhD Student in Architecture
University of Strathclyde, Glasgow, United Kingdom

"Regenerative design for the Thai context is an instruction to regenerate the abundance of Thailand's Ecosystem whilst applying common regenerative design principles and approaches along with Thai's beliefs and way of life for the built environment building and landscape design, including development guidance for proper use in the Thai environmental context"

Built Environment Design Tool

Regenerative Design Framework for Thai context (RDF-T) is a tool for a built environment design and planning that is adjusted to suit the Thai socio-environment. In terms of responding to regenerate an abundance of ecology and sustainably maintain a way of life of a local community by encouraging local people to consider a natural function as a crucial factor, and design with nature for a holistic benefit of human and other organisms in the ecosystem.

Whilst, RDF-T is designed to apply in the stakeholder engagement process, which all of them should be relevant to a target place. The engagement aims to produce a built environment design and green development guideline to prepare for the actual implementation based on the regenerate design for Thai context principle and a consensus agreement among the stakeholders.

Gathering the relevant stakeholders from difference background of knowledge into a built environment design engagement

RDF-T's Elements

There are 4 essential elements combined in RDF-T'

1. Regenerative design principle
2. Thai's Rating of Energy and Environmental Sustainability (TREES)
3. Backcasting technique
4. Thai Social - Ecological Characteristics

Each element has its role in an engagement process, which a combination of them can stimulate results and be presented in the form of a built environment design and green policy guidance for ecosystem development.

Regenerative design principle

The regenerative design principle emphasises a work between human and nature as a design partnership in terms of regenerating an ecosystem for the benefits of whole living systems in their specific place. By taking natural function into an account and allowing nature to be a significant partnership in the design process by prioritising building design to be suitable with place condition[1-8].

Thai's Rating of Energy and Environmental Sustainability (TREES)

Thai's Rating of Energy and Environmental Sustainability or TREES was established by Thai Green Building Institute (TGBI) which TREES' criteria are suitable for Thai context. The rating system is designed suitably to assess various building types both for pre-construction and post-construction buildings. Then, a building performance evaluation's score will be used to identify the award levels (Platinum, Gold, Silver, and Certified) for the qualified buildings.[9].

Backcasting technique

It is the technique of forming desirable results for the future. Especially use it in terms of the sustainability field. Backcasting entails looking back from a preferred future typically set by stakeholders and identifying the steps that need to be taken to achieve a goal, or alternatively, determine actions to avoid an undesired future[10-12].

Thai Socio – Ecological Characteristics

Thai Socio-Ecological Characteristics are crucial aspects that help strengthen the distinctiveness of RDF-T' which these characteristics are an indicator of Thai uniqueness. This refers to a regenerative design principle that emphasises a story of place as an essential factor in a built environment design.

3

RDF-T's Engagement Process

1. **Select a target area**

2. **Gathering stakeholders**

3. **Set up a workshop**
   - Create an understanding of a regenerative design in the Thai context
   - Site visiting (target area)
   - Discuss and design a built environment on a target area
   - Discuss guideline planning of future development

4. **Development & Implementation**

4

RDF-T's Application (1)

1 Target area

RDF-T can be applied to every area from a household unit scale to a community or region scale. RDF-T has the potential to apply in both vacant areas or any areas that require creating a built environment to strengthen an abundance of an ecosystem.

2 Stakeholders

RDF-T intends to have the relevant stakeholders who relate to a target area as members of the community. Therefore, they should have different backgrounds of knowledge and aptitude as such the green design specialists, including architects and landscape architects, ecologists, botanists, green technology specialists, TREES specialists, property owner, local people in the community, local authority, historian, etc. A variety of their thoughts can raise the ideas of the built environment in many dimensions based on their expertise which can help create a suitable design for all.

3 Set up a Workshop

The duration of a workshop should be at least 2-3 days. It depends on the scale of a target area and circumstance due to the activities that will happen in the workshop, as such Site visiting, A built environment design brainstorming and A future development plan & guidance which all these processes require time for quality of results.

Activities

- Gathering all stakeholders as the participants in a workshop to explain them and create an understanding of a regenerative design in the Thai context.

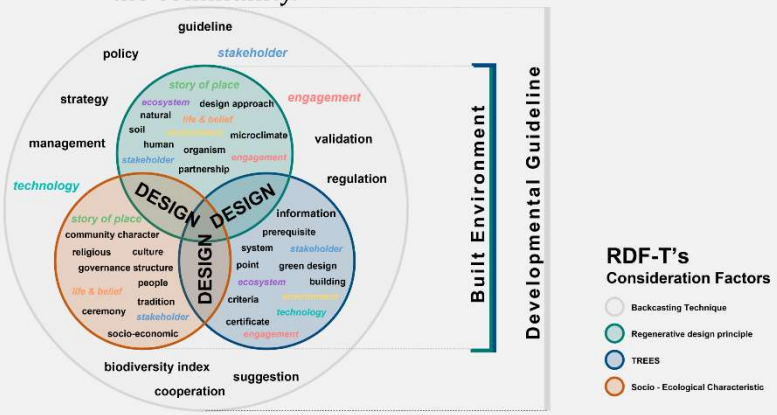
5

RDF-T's Application (II)

3 Set up a Workshop (continue)

Activities

- Prepare a site visiting activity for the participants. It is an important activity based on a regenerative design principle and this activity can raise awareness of the place and help the participants understand the conditions, and acknowledge a story of the place.
- Brainstorming to discuss and design a built environment on a target area using a regenerative design approach, TREES, and Thai Socio-Ecological Characteristics as key references. In this activity, the participants can share their thoughts and expertise and discuss among themselves. In the end, it is possible to have a comprehensive built environment design that suits their needs and community.
- Brainstorming to discuss guideline planning for future development. In this activity, the result from a built environment design activity can be used as a goal and apply Backcasting technique in the process when the participants share their thoughts and expertise and discuss among them how to design a pathway to reach that goal and to create an efficiently built environment for the community.



A diagram of an example of the significant factors in each element of RDF-T that must be considered in the workshop process for a provision of the built environment and developmental guideline.

RDF-T's Application (III)

4 Development & Implementation

The result from a workshop led by the RDF-T approach needs to be developed for completeness and must inform the stakeholders who have participated in the workshop for an update before actual construction. The example of materials that should complete after the workshop are

- A built environment site plan
- Architectural plan (if needed)
- Landscape plan included a vegetation list
- Developmental guidance for a built environment on site
- TREES submission form
- Budget list
- Green system planning
- Etc.

Moreover, there is a suggestion for supporting a performance measurement of a created built environment that can use biodiversity indices to evaluate the quality of the ecosystem on-site before, during, and after construction to indicate the performances. The results can be used as an indicator to improve and maintain the richness of the ecosystem.

" The engagement process is important "

For more details and helpful materials for the workshop are available on a full version of RDF-T explanation manual.

Scan me please!

7

Acknowledgement

- This quick version of manual is a part of research: A Development of a regenerative design framework for a contextual built environment, Case study : Chiang Mai, Thailand. By Sasiprapa Srikraiphak, a PhD Student in Architecture, University of Strathclyde, Glasgow, United Kingdom. This work is developed from the results that have received from A 3-day workshop of Environmental Regenerative Design: Case study Nong Bua, Chiang Mai, Thailand. The workshop was held by Chiang Mai World Heritage Initiative Project (CMWHI) on 28th -30th September 2020 at Social Research Institute, Chiang Mai University. This quick version of manual is yet to publish, and it is a draft that will only be used as a part of the conclusion of the research.

- The cartoon character artworks on page 2,3, and 7 are licensed under "designed by Freepik - Freepik.com".

Reference

1. Cole, R. J. (2012). Transitioning from green to regenerative design. Building Research & Information, 40(1), 39-53. doi:10.1080/09613218.2011.610608
2. Cole, R. J., Busby, P., Guenther, R., Briney, L., Blaviesciunaite, A., & Alencar, T. (2012). A regenerative design framework: setting new aspirations and initiating new discussions. Building Research & Information, 40(1), 95-111. doi:10.1080/09613218.2011.616098
3. du Plessis, C. (2012). Towards a regenerative paradigm for the built environment. Building Research & Information, 40(1), 7-22.
4. Kilroy, E. (2014). Regenerative Design: An Integrated Design Approach for the New Jersey Highlands. In: Regional Plan Association.
5. Lyle, J. T. (1994). Regenerative design for sustainable development: John Wiley.
6. Mang, P. (2001). Regenerative Design: Sustainable Design's Coming Revolution.
7. Plaut, J. M., Dunbar, B., Wackerman, A., & Hodgin, S. (2012). Regenerative design: the LENSES Framework for buildings and communities. Building Research & Information, 40(1), 112-122.
8. Svec, P., Berkebile, R., & Joel Ann, T. (2012). REGEN : toward a tool for regenerative thinking. *Building Research & Information, 40*, 81-94.
9. Thai Green Building Institute. Thai 's Rating of Energy and Environmental Sustainability (TREES). 2016;
10. Quist J. Backcasting for a sustainable future: the impact after 10 years. Eburon Academic Publishers; 2007.
11. Miola A. Backcasting Approach for Sustainable Mobility. Scientific and Technical Research Series. 2008.
12. Wangel J. Exploring social structures and agency in backcasting studies for sustainable development. Technological Forecasting and Social Change. 2011;78(5):872-882. doi:10.1016/j.techfore.2011.03.007

This quick version of manual is a part of research:

Developing a Regenerative Design Framework for the Built Environment:
A case study in Chiang Mai, Thailand

By Sasiprapa Srikraiphak , PhD Student in Architecture

University of Strathclyde, Glasgow, United Kingdom

Chapter 8

Research Conclusion

8.1 A Review of the Study Process

The focal proposal of this study aims to develop the RDF-T as a tool for contextual built environment design. This study has developed RDF-T from the regenerative design principle, which is a universal practice as an alternative built environment design approach in the sustainable design field. The basis of the regenerative design principle focuses on the co-evolution of humans and nature as organisms living on the same planet (Cole, 2012b; du Plessis, 2012; Mang & Reed, 2012; Reed & Regenesis, 2011). Therefore, the regenerative design development asserts that in regenerating an abundant ecosystem, a design process should consider natural functions as essential partners with humans due to regenerative design revealing that the organisms on planet earth are living in the same network which has interdependence to each living species in complicated and sophisticated ways (Cole, 2012b; du Plessis, 2012; Lyle, 1994; Mang, 2001; Reed, 2007; Van der Ryn & Cowan, 1996). Therefore, only humankind cannot develop the ecosystem's evolution; it is necessary to derive this from cooperation with nature since interdependence has evolved this planet generation by generation. This respect implies that the co-evolution of humans and nature is a significant factor that leads to genuine sustainability for all.

Generally, sustainability practice considers a natural capital consumption process from the transformation of the resource to the end at an efficient usage stage. This

predominantly linear system implies a starting point from an origin to consumption and the finishing point. A consumption process consumes natural resources effectively, and several sustainability approaches suggest ways to recycle and reuse those materials to reduce the excessive use of natural resources (Birkeland, 2012; McDonough & Braungart, 2002; Reed, 2007). On the other hand, this predominantly linear system has not established new natural resources and re-built them back into nature. As a consequence, natural capital has a high possibility of being decreased, as has been evident in the past decades in the form of environmental degradation. The sustainable design process can be defined as the effective use of natural resources, and it can possibly decelerate the degradation of the ecosystem. However, the consumption demand for natural resources dramatically increases. At the same time, there is no regeneration process to help generate new natural resources to respond to widespread needs, and the natural resources may vanish entirely (Lyle, 1994).

With this concern, John Tillman Lyle has suggested regenerative design to be an alternative sustainable design approach for solving these environmental issues. He developed the regenerative design notion from a concept of permaculture that strongly advises that the interdependence and connection between humans and nature can create a productive, ecologically harmonious community. As the word “regenerate” means “to create again”. Instead of a current linear flow system, there should be a cyclical flow as a replacement system. The cyclical flow system is the idea that reveals a flow at the source, and there is a utilising along with the flow, which will lead back to the source again. The process of cyclical flow means that during a regenerative system, resources can be provided with continued replacement and will be established back into nature (the origin source) through its operation (Lyle, 1994; Zanni et al., 2013). Significantly, in the regenerative design process, the natural function is vital in regenerating itself with the support of humans when designed with nature by choosing proper natural functions, including living organisms in the ecosystem, to create a holistic benefit for all.

Referring to a network connection that links all organisms together, Du Plessis (2012) has illustrated that the mainstream worldview towards ecology is seeing phenomena that happened as a mechanistic worldview. The patterns from the phenomena that have occurred can be used to predict upcoming ones. Some phenomena are indeed predictable by studying the patterns of past phenomena. However, for many phenomena, it remains a mystery as to how they have happened. The network that

creates lives in this biosphere is complicated, sophisticated, and overlayed across many layers in many dimensions. Thus, the suggestion is to shift this mechanistic worldview to an ecological worldview. An ecological worldview believes that all phenomena are difficult to understand and that it is difficult to discover how things happen (du Plessis, 2012; Haggard, 2002; Orr, 1992). This is a complexity of the living systems within the ecosystem, and humans should consider this aspect when it concerns the development of a healthier ecosystem for all who share the same planet. The ecological worldview can disclose the role of nature that could help humans understand the natural condition in different dimensions without grasping the patterns of life. Ultimately, the results might lead to new discoveries in the ecosystem (Mang & Reed, 2012; Orr, 1992).

In the past decades, there have been studies and the development of regenerative design, and the principle of it has been applied in some regenerative design frameworks. This study refers to the Regenesis Approach, REGEN Framework, LENSES Framework, and Perkins+Will Framework, as these frameworks have grasped regenerative design principles as a basis to combine with individual techniques to use them as a tool to regenerate and design a built environment that is led by the reliance of regenerative design approach (Miller, 2012). This study aims to develop a regenerative design framework that suits the Thai context; this study has analysed the origin, evolution and development of regenerative design, although these existing regenerative design frameworks' patterns are currently used in many places. This study has discovered some gaps in these regenerative design frameworks. The gaps affect the potential assessment of these frameworks, the credibility of results obtained after applying these frameworks, and their performance measurement. The capability of these regenerative design frameworks has been questioned: "Can these approaches genuinely regenerate an ecosystem?" and "What is the proof of this?". Scholars argue that regenerative design and development are not accessible, and the ability of regenerative design depends on the co-evolution of humans and nature, which requires time to prove its performance. Therefore, to re-establish a loss of natural resources and the abundance of ecology, it cannot indicate the results from available metrics (Cole et al., 2012).

This study intends to develop a new regenerative design framework from the gaps discovered during the literature study stage and situate it in the Thai context. Crucial elements that potentially elevate the capability of the new framework have been combined for the RDF-T. Referring to an assumption of the study, the RDF-T can be a tool

for creating a contextual built environment design in Thailand. This study aims to investigate the capability of RDF-T by applying it to the case study of the Nong Bua area in Chiang Mai City, Thailand. The investigation process has focused on researching the answers to the study's questions, which are: -

1. How does RDF-T impact Nong Bua's built environment design process?

2. What are the distinctiveness and definition of Regenerative Design for the Thai context compared to other built environment design tools?

3. After experimenting with the RDF-T with the case study area, does the finding show the repeatability of this framework for applying it in other areas in Thailand?

4. What is the most effective element of RDF-T in terms of underpinning the valid outcome?

5. What are the RDF-T's limitations and contribution plan of this research for supporting future study?

Subsequently, this study used a 3-day workshop of Environmental Regenerative Design to gather the relevant stakeholders who related to the case study area to participate in the workshop to exchange their thoughts and design a built environment paradigm for the case study area. At the end of the workshop, the participants brainstormed to create built environment guidelines for the case study area for further development. The participants in the workshop were the CMWHI team, property owner, community architects, landscape architects, TREES specialists, local people, a Chiang Mai historical expert, an ecologist, and a botanist; the total number of participants was 17 persons.

As mentioned before, the RDF-T combined three elements – the regenerative design principle, TREES, and the Backcasting technique. The regenerative design principle and TREES have a crucial role in the built environment design part that resulted in two schematic designs, and the participants in the 3-day workshop had agreed to design the "Ecotourism Centre" to be the main built environment architecture of the Nong Bua area. In addition, regenerative design approaches were mostly applied in the landscape design of the Nong Bua, mainly focused on using native plants to be the primary vegetation of the projects. Therefore, there was a concern about creating and

using natural functions in regard to using its operating systems to remedy itself and strengthen the site's ecosystem, including the local environment condition. At the same time, the TREES requirements had a crucial role in both the architecture and landscape design as the participants focused on Green building preparation, Reducing the negative impact on greenfield areas, Sustainable site planning, Infiltration of stormwater and flooding prevention, Reducing the pollution from construction, and Using natural light in the building.

Furthermore, the Backcasting technique was used in the built environment guideline-making process as this technique is acceptable mainly in the sustainability field in terms of planning the guidelines for green development. This study investigated the capability of the Backcasting technique in a 3-day workshop, and the results show that after the built environment guideline-making process, the participants agreed to plan the development of the Nong Bua area by the focal subjects that have been divided into five sections:

1. Community to City Cooperation
2. Regulation adjustment
3. Transportation
4. Additional research about Nong Bua
5. Environmental design for the ecosystem

The Backcasting technique led the participants to brainstorm about the built environment development of Nong Bua by grasping the built environment design paradigms that they created together as a desired goal. As the results show, the guidelines under each section mentioned in the previous chapter are from the consideration based on the built environment design paradigms. During the workshop, the participants drew the pathway from the goal achievement point backwards to the present time to examine all of the factors and obstacles that would affect the desired goal in the future. This technique urged the participants to plan the guidelines carefully, neatly, and broadly in every dimension. As an assumption, the obtained guidelines from the built environment guideline-making process have the possibility to ensure the success of this project due to the Backcasting technique being well-known as a beneficial

way of establishing sustainable development that could provide credibility to the participants who were involved in the process (Wangel, 2011).

In order to distinguish a comprehensive summary of the examination of the RDF-T, the satisfaction survey results for this framework and its elements reveal that most of the participants were very satisfied with RDF-T and each element of it. This result responds to the question, "How does the application of the Regenerative Design Framework for the Thai context impact the contextual built environment design process?". Since RDF-T was successfully applied in a 3-day workshop, this process led by this framework was able to provide the built environment design paradigms for the case study area based on a regenerative design principle, TREES requirement, and use the Backcasting technique to form the development guidelines as a strategy to follow for actual further development.

Regarding the limitations of this study that experimented with RDF-T solely applied to the Nong Bua area, the collection of results from the workshop might be inadequate. Therefore, this study requested an additional interview with the previous group of participants to search for supporting evidence that could help strengthen this framework's development. The additional interview asked the participants about the repeatability of RDF-T, and the results of the interview with the participants reinforced that RDF-T was helpful and successfully applied in the previous workshop. Therefore, there is a possibility to apply this framework and repeat the whole procedure in other developing areas in order to create green spaces and regenerate the quality of local ecosystems. Noticeably, the result illustrates that the Backcasting technique was crucial for the engagement process to lead practical discussions during the built environment guideline-making process in terms of rechecking the validity of all aspects related to the development of the area.

However, an analysis of the results based on the workshop and the suggestions from participants, including the interview, shows that there are additional factors which were neglected in the previous workshop that need extra consideration, such as (1) Cooperation, (2) Governmental Structure, (3) Regulation Adjustment, (4) Cost and Budget, (5) Management Plan, (6) Technology, (7) Soil and Water, (8) Way of life and Beliefs, (9) Human Behaviour towards Green Space, and (10) Biodiversity Index. Later, this study considered these factors as a critical development of the RDF-T by considering these additional factors and summarising them into five aspects:

1 Consideration of the stakeholders

2 Clarify the TREES prerequisite

3 Clarify the Regenerative design principle

4 Additional information

5 Ecosystem quality indicator

Subsequently, these aspects have led to the development of the completeness of the RDF-T, which intends to use them as consideration factors to guide RDF-T's users in future built environment design processes for more comprehensive workshops.

Therefore, to evaluate the capability and repeatability of the RDF-T after adding the neglected aspects, this study has defined a definition of Regenerative Design for the Thai context and created a manual of RDF-T to develop this framework to become more well-known. Therefore, the contents of RDF-T's manual have been generated from this study's results. Five aspects of additional factors were added to the contents section to underpin the comprehensiveness of information that potentially stimulates an effective built environment design workshop led by RDF-T. This study aims to establish a better understanding of the RDF-T and suggests that this framework should be known as a new contextual built environment tool. Furthermore, to testify the capability of the developed framework that is illustrated in the form of a manual, this study invited the participants from the previous workshop to participate in an online focus group to share their feedback and suggestions towards the manual.

An online focus group was held via Zoom due to the circumstances of the pandemic at the time. This study urged the discussion by leading the participants with questions that helped remind them of what happened in the previous workshop and potentially stimulate their thoughts towards the whole procedure led by the previous version of RDF-T. Moreover, the participants were able to compare the previous RDF-T with the developed version and review it based on their earlier suggestions. The discussion during the online focus group was an open conversation that regarded this framework and the completeness of the manual, including how to use the manual as an explanation of the RDF-T for future applications.

The results in the online focus group revealed three main points, which are (1) The practicality and efficiency of the workshop procedure led by RDF-T, (2) The manual is

slightly hard to read; it should have another version for user-friendly guidance, (3) The RDF-T has a possibility to be repeated and applied in other developing areas in Thailand. In addition, there was a suggestion to change the terminology of this framework for the reason of explaining the explicit purpose of the framework as a contextual built environment design tool.

8.2 A Conclusion of the RDF-T

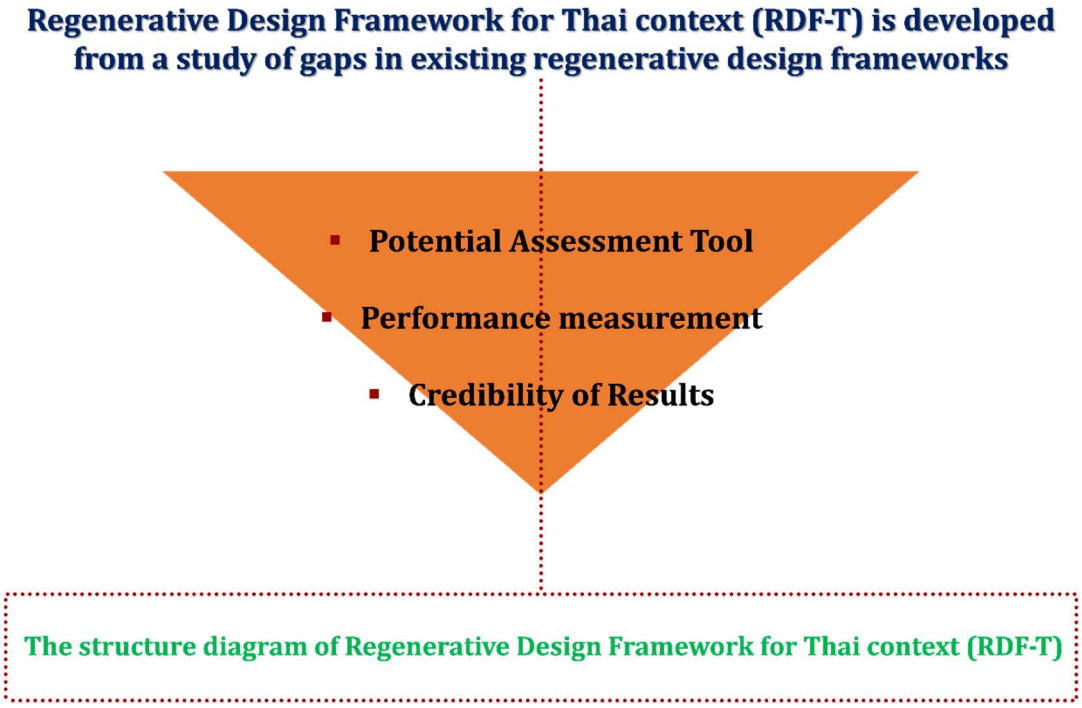


Figure 8.1 The origin of RDF-T

The RDF-T has been developed from fundamental regenerative design principles and existing regenerative design frameworks and adapted this notion to be a suitable RDF-T. Intentionally, as shown in *Figure 8.1*, this framework is developed from a study of gaps in existing regenerative design frameworks by examining (1) Potential Assessment Tool, (2) Performance measurement, and (3) The credibility of results for stakeholders, as crucial factors that require specific elements to reinforce the reliability of the Regenerative design and development approach. At the same time, using the Thai context as a case study in terms of examining this framework as a contextual built environment design tool led to the development of the RDF-T.

Figure 8.2 is the origin of the structural diagram of the RDF-T that was combined with three main elements – the Regenerative design principle, TREES, and the

Backcasting. Typically, the Regenerative design principle and Backcasting technique are well-known as universal practices that have been used in the sustainable design field. In contrast, TREES (Thai's Rating of Energy and Environmental Sustainability) is commonly used in Thailand as an environmental certification system, and this study uses it as a contextual practice to support the use of framework. In detail, these three elements had their role in supporting a contextual built environment design process in regard to filling the gaps that have been found in those existing regenerative design frameworks. Additionally, this study intends to use the Regenerative design principle as a basis of the design tool in a built environment design process and use the Backcasting technique to provide credible results for stakeholders by applying it in a built environment guideline-making process. Furthermore, TREES has been used to fill up gaps in terms of contributing to a potential assessment tool and performance measurement by considering TREES with the Regenerative design principle in a built environment design process.

The structural diagram of RDF-T in *Figure 8.2* was applied in the 3-day workshop in the Nong Bua area, Chiang Mai, Thailand, as a case study for investigating the capability of this framework as a contextual built environment design tool. The findings mentioned earlier imply that, except for TREES, contextual support is inadequate, possibly distinguishing the inclusiveness of the specifically built environment design for a specific context. With this concern, there is an adjustment of the structure diagram of RDF-T that has inserted Thai Socio-Ecological Characteristics as one of the essential elements of this framework. As shown in *Figure 8.3*, Thai Socio-Ecological Characteristics are the element that potentially prompts the user of this framework to examine other important facets of a particular place's story, including local natural organisms that have shared the same ecosystem to take part in the contextual built environment design, which can benefit all living systems.

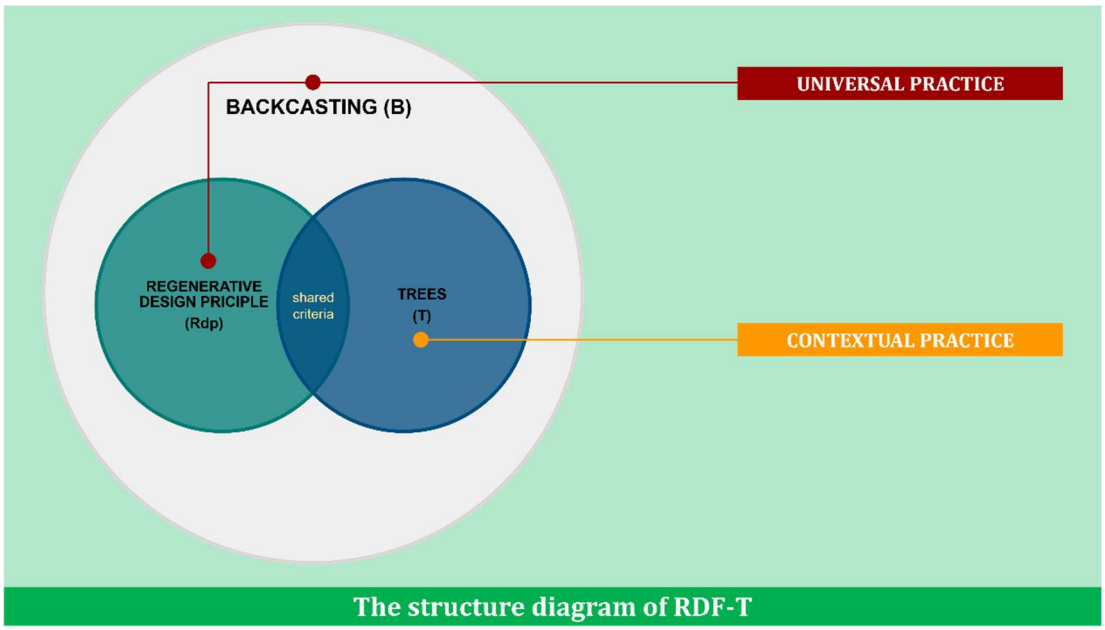


Figure 8.2 The origin of the structure diagram of the RDF-T

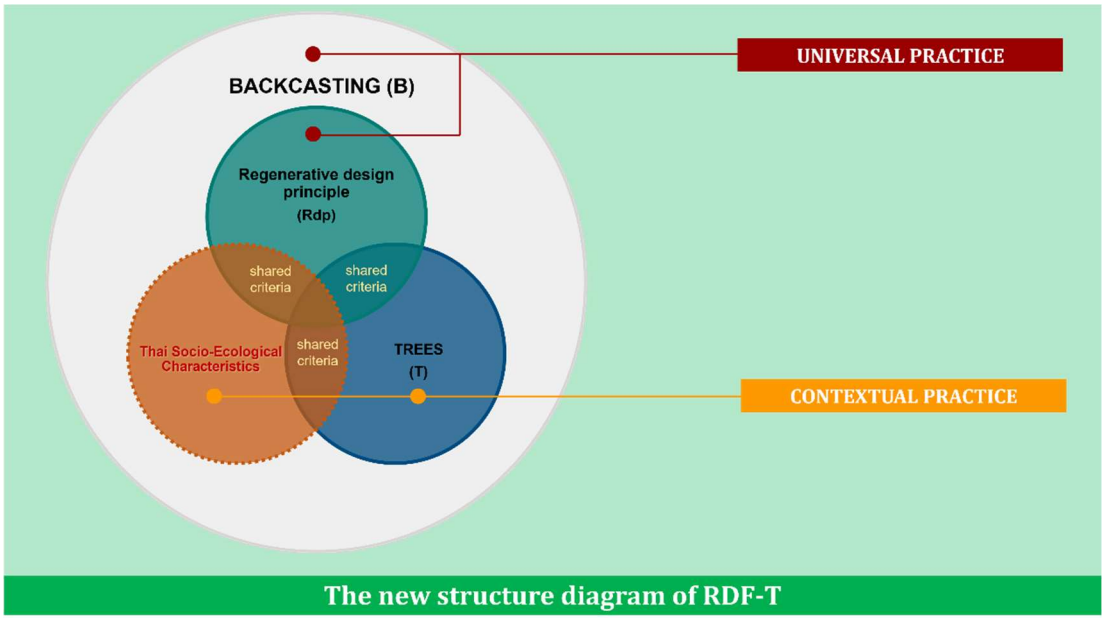


Figure 8.3 A New structure diagram of the RDF-T after an analysis result process

The fundamentals of regenerative development and design emphasise the co-evolution of humans and nature in terms of an interdependency that generates and sustains ecology for a whole system (Du Plessis & Brandon, 2015; Landry, 2006; Mang, 2009; Mang & Reed, 2012). Additionally, regenerative design practices suggest changing perspectives in environment development from a “mechanistic worldview” to an “ecological worldview” as a biosphere is sophisticated and detailed; there can be no explanation of all the phenomena that happen by studying the mechanical system solely (du Plessis, 2012). In another facet, the relationships of a whole living system are a nest

beginning from an individual scale to a global scale, and there is no certain pattern that is easy to predict (Haggard, 2002; Orr, 1992). When concerning a healthier planet that benefits all organisms, using an ecological worldview encourages disclosing the role of nature as a partner with humans for a better environmental design. The sophistication and fascination of the biosphere lead a designer to acknowledge deeper dimensions of diverse networks for considering decently built environment designs for each particular place (Mang & Reed, 2012; Orr, 1992).

To emphasise an equal role between humans and nature, the change in the RDF-T structure diagram in *Figure 8.3*, the Thai Socio-Ecological Characteristics have been reconsidered as a supporting element for the contextual practice. Thai Socio-Ecological Characteristics include a whole living system, i.e., Cultural, Religious, Belief, Economic, Political, Historical, Geographic, Climatic, and Organisms in an ecological network. This element helps to strengthen the distinctiveness of the place's character in terms of encouraging harmoniousness between intangible aspects and a built environment design that suits the local community, which refers to a regenerative design principle that emphasises a story of place as an essential factor in creating a built environment design effectively. Furthermore, it helps expand and include whole living organisms in the aspect of supporting a built environment for the Thai context based on the individuality of Thai ecosystems that allows the entire living system to be counted in a built environment design process to be the most suitable place for all.

At the same time, *Figure 8.4* suggests that Regenerative Design Framework (RDF) for individual contexts in other regions be a built environment design tool. Likewise, the basis of RDF has two crucial practices: universal practice and contextual practice. The universal practice combines the Regenerative design principle and the Backcasting technique. However, the difference in contextual conditions depends on a particular place – in this case, the contextual practice of RDF is slightly different.

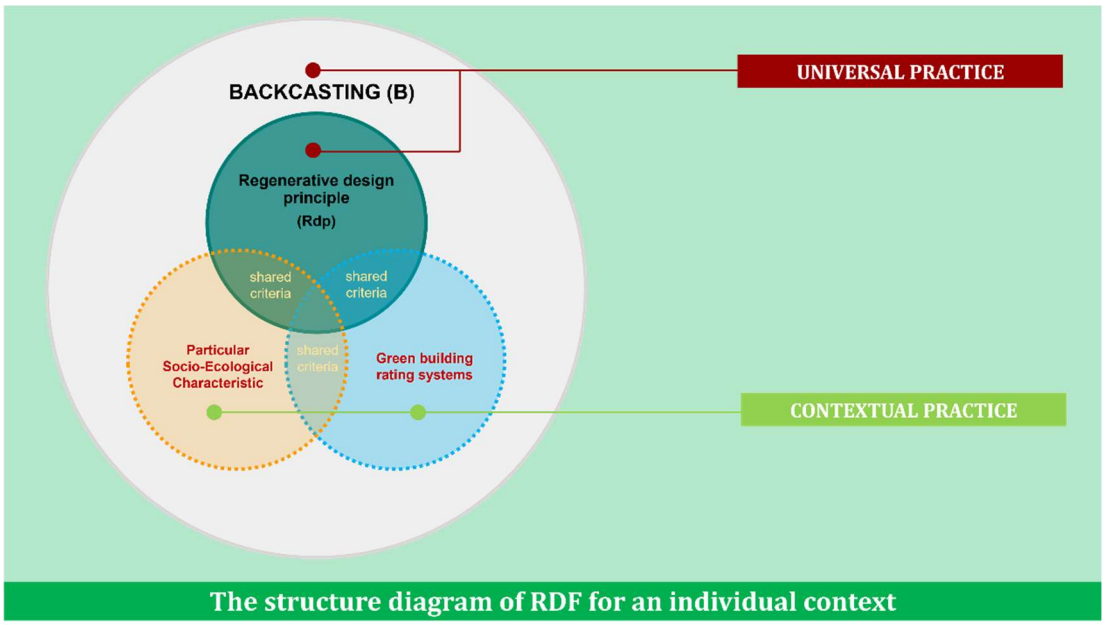


Figure 8.4 A suggestion for Regenerative Design Framework (RDF) for an individual context as a built environment design tool

To complete this RDF, one of the elements regarding the contextual practice should be a "contributor" to provide a potential assessment tool and a performance measurement such as Green building rating systems (LEED, BREEAM, Green Globes, GDNB, Green Star, BCA Green Mark Scheme, et cetera.) that are used across the world which suit each region and country. Furthermore, another element should consider a "Particular Socio-Ecological Characteristic" to maintain each place's specific character when combined with the Regenerative design principle and Backcasting technique. These four elements are crucial for a contextual built environment design process to encourage the most suitable environment for the local community.

8.2.1 A Definition of Regenerative Design for the Thai context

Based on the findings throughout the study of the Regenerative design development and design that has been developed into the RDF-T, this study aims to introduce a definition of Regenerative Design for the Thai context, which is:

"Regenerative design for the Thai context is an instruction to regenerate the abundance of Thailand's Ecosystem whilst applying common regenerative design principles and approaches along with Thai's beliefs and way of life for the built environment building and landscape design, including development guidance for proper use in the Thai environmental context".

To suggest that the RDF-T be acknowledged on a greater level, it is necessary to clarify the purpose of this notion, which might encourage future RDF-T users to better understand the whole idea before applying this framework in their own built environment design projects.

8.2.2 A Repeatability of the RDF-T

The conclusion of this study illustrates that the RDF-T has the possibility to be applied in other developing areas in Thailand. The procedure of the engagement for a built environment design and the guideline-making process is useful in terms of gathering all of the relevant stakeholders who are related to the developing area to participate in the workshop and exchange their thoughts based on their expertise and backgrounds of knowledge to create a built environment design that is more likely to benefit all living systems in the local community. Therefore, a consensus on the built environment guideline can lead to sustainable development when the guideline potentially becomes a pathway to achieve the desired built environment design goal.

The ultimate summary of this study implies that the Backcasting technique is the most influential factor that can support the RDF-T. This technique can produce an acknowledgement of the whole picture of the built environment design that helps the user to plan a strategy on account of establishing the occurrence of the desired built environment that applies the Regenerative design principle, TREES, and Thai Socio-Ecological Characteristics into the design, which potentially suits the Thai context. Moreover, a successful contextual built environment design requires the awareness of a place's story in diverse dimensions to become an essential tool to regenerate an abundant ecosystem for both humans and nature. Hence, the Thai Socio-Ecological Characteristics are an effective support that helps to distinguish the specific character of a specific place for inclusive contextual regenerative design.

Nevertheless, this study was limited as the RDF-T experimented solely in Nong Bua, Chiang Mai, Thailand, due to the circumstances and global pandemic at the time, which affected the breadth of the study. Consequently, the RDF-T is a primary proposal as a contextual built environment design tool for the Thai context. However, for further study, more time is required to research and experiment in order to continually develop this framework for further certainty, which would potentially discover the most suitable way to regenerate the fruitfulness of Thailand's ecosystem.

8.2.3 A Manual of RDF-T

From the outcomes of this study, a manual of RDF-T is one of the most significant results. It has been developed based on the results that this study analysed and synthesised with the feedback from the workshop participants to encourage the possibility of repeating the application of the RDF-T in other developing areas in Thailand. In detail, this manual has been created with two versions: - A full description of a manual of RDF-T and A quick version of a manual of RDF-T. The two versions of the manual are initial resources that can possibly lead to further studies. Notably, both of these versions are drafts that have been developed from the results of this study, which have the possibility to be developed further in future studies.

8.3 A Conclusion of the study for future development

The study's findings highlight the significant dependence on collaboration with the CMWHI team for successfully implementing the RDF-T in a case study area as a built environment design project, signifying its potential as a foundational tool for future built environment projects. This substantiates the primary goal of this study, which aimed to develop and evaluate the RDF-T tailored for the context of Thailand's built environment. This underscores the potential in terms of promoting the RDF-T for broader adoption, encouraging project teams committed to embracing its effectiveness to lead initiatives and engage relevant stakeholders. Recognising the unique contextual demands of each project, involving a diverse range of stakeholders enriched the overall outcome of built environment design. Moreover, the result shows that the active participation of local architects, landscape architects, and TREES specialists during the built environment design charrette emerged as a crucial factor, utilising their expertise to promote a more comprehensive design approach.

Furthermore, the primary findings led to the further development of the RDF-T, as shown in the creation of the RDF-T manual in regards to contributing this notion to be well-known among design practitioners to consider this framework as an alternative built environment design tool. Additionally, the study uncovered the effectiveness of online meetings during the global pandemic. Leveraging technology became a prudent strategy, reducing transportation costs and time commitments associated with engagement processes. While virtual meetings facilitated focused discussions, physical engagement during site visits and design charrettes fostered a unified understanding among participants. This alignment was essential in synchronising perceptions

concerning on-site observations and concurrent design activities. These outcomes directly address the overarching research aims, questions, and objectives set forth at the study's commencement:

Impact of RDF-T in Contextual Built Environment Design: The practicality of RDF-T elements in shaping built environment design and green guideline formulation aligns with the initial intent of developing an effective framework.

Repeatability and Applicability of RDF-T in Thailand: The demonstrated capability of RDF-T to be replicated in various developing built environment projects across Thailand resonates with the research objective of testing and refining the framework's adaptability.

Role of Thai Socio-Ecological Characteristics in Supporting RDF-T: Highlighting the pivotal role of socio-ecological characteristics in bolstering contextual design offers insights aligned with the objective of examining characteristics that exhibit significant efficacy.

Dissemination of RDF-T: The provision of two versions of the RDF-T manual serves as foundational materials for future users, aligning with the objective of proposing an applicable framework for built environment design practitioners.

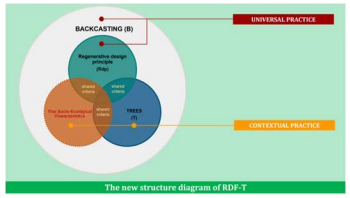
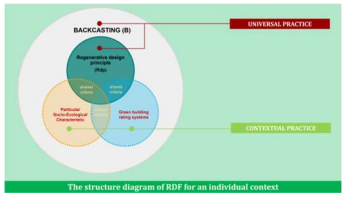
Evolution and Limitations of RDF-T: Recognising RDF-T and its manual as preliminary studies underscores the need for further exploration and refinement, a response in line with the research objective of identifying limitations and suggesting avenues for future research.

Moreover, this study posits the applicability of the RDF-T framework across a spectrum of built environment projects, ranging from community to regional scales. Crucially, it highlights the imperative of engaging relevant stakeholders within the targeted area seeking to regenerate the local environment. For those interested in utilising the RDF-T for their projects, the study advocates for the formation of a collective project team equipped with the potential to gather pertinent stakeholders. Within this team, a pivotal role in the built environment design process should be occupied by an individual possessing expertise in architecture and landscape architecture. This expert facilitates guidance for participants from diverse backgrounds, steering them towards a unified design objective. Given the RDF-T's primary objective of regenerating the local environment in alignment with community needs, collaboration and cooperation with

the community emerge as fundamental prerequisites for its successful application. Critical application of the RDF-T transpires on-site, necessitating stakeholder visits to appraise the site's actual conditions and participate in the built environment design and policy-making processes. However, circumstances permitting, online meetings serve as a viable alternative for discussions, reducing costs and time commitments for both interviewers and participants.

Ultimately, this study aims to shed light on ongoing efforts that could contribute to future developments, as outlined in *Table 8.1*. Recognising the study's limitations, further experimentation is warranted to evaluate the RDF-T and RDF frameworks through actual project applications within Thailand for the RDF-T and across diverse regions for the RDF. Refined iterations of these frameworks hold promise in fostering a more comprehensive approach to regenerative design and revitalising ecosystems within Thailand and globally to promote genuine sustainability. To enhance the frameworks' capabilities, advocating their potential in academic conferences, seminars, or live built environment design events could extend their application across varied case studies—an undertaking necessitating further study and implementation. Continued research and implementation could enhance the recognition of regenerative design principles, substantiating the credibility of RDF-T and RDF frameworks among design practitioners and fostering their adoption in diverse projects. This study's foundational insights aim to catalyse future research, nurturing the evolution of regenerative design frameworks as alternative tools for advancing global sustainability initiatives.

Table 8.1 The contribution of current work to future development

The current work as a contribution to future work		Further Development
Study Findings	**Improvement and Suggestion**	
• Definition of Regenerative Design for Thai context • The RDF-T Manuals	• The RDF-T manuals provide a more precise explanation of the regenerative design principle that involved the Thai context as a critical factor in a built design process, including all design procedures of the RDF-T. Therefore, the manuals can help design practitioners be aware of this alternative design tool for their decision to apply this framework in their projects.	• Using this study for being a material to develop the RDF-T to suit the Thai context better. At the same time, further development can urge regenerative design and development to be known at a wider scale as another alternative built environment design tool. Hopefully, if there is a chance to apply the RDF in other developing areas of different regions, this opportunity possibly stimulates more studies and developments to research the most suitable regenerative design framework that can be used as the global basis standard of the built environment design tool.
• A new structure of the RDF-T  	• A suggestion structure of the RDF for a global usage  	
• A capability of the RDF-T for repeating in other developing areas in Thailand • A limitation of the RDF-T as it has been applied solely in 1 area regarding experiments with the RDF-T	• A suggestion for applying the RDF-T in other developing areas in Thailand. For the further experiment with the RDF-T in terms of improving its capability for future usage	

References

Akbari, H. (2005). Energy Saving Potentials and Air Quality Benefits of Urban Heat Island Mitigation. *Lawrence Berkeley National Laboratory*, 19.

Åkerman, J., & Höjer, M. (2006). How much transport can the climate stand?—Sweden on a sustainable path in 2050. *Energy Policy*, *34*(14), 1944-1957. https://doi.org/https://doi.org/10.1016/j.enpol.2005.02.009

Al-Kodmany, K. (2018). The Sustainability of Tall Building Developments: A Conceptual Framework. *Buildings*, *8*(1), 7. https://doi.org/10.3390/buildings8010007

Alexander, C. (1977). *A pattern language: towns, buildings, construction*. Oxford university press.

Alexander, C. (1979). *The timeless way of building* (Vol. 1). New york: Oxford university press.

Anderson, K. L., Mander, S. L., Bows, A., Shackley, S., Agnolucci, P., & Ekins, P. (2008). The Tyndall decarbonisation scenarios—Part II: Scenarios for a 60% CO2 reduction in the UK. *Energy Policy*, *36*(10), 3764-3773. https://doi.org/https://doi.org/10.1016/j.enpol.2008.06.002

Azizi, M. M. (2006). Sustainable Residential Neighborhood: The Case Study Of Narmak Neighborhood, Tehran. *HONAR-HA-YE-ZIBA*, -(27), -. https://www.sid.ir/en/Journal/ViewPaper.aspx?ID=61581

Benne, B., & Mang, P. (2015). Working regeneratively across scales—insights from nature applied to the built environment. *Journal of Cleaner Production*, *109*, 42-52. https://doi.org/10.1016/j.jclepro.2015.02.037

Birkeland, J. (2008). *Positive development : from vicious circles to virtuous cycles through built environment design*.

Birkeland, J. (2012). Design Blindness in Sustainable Development: From Closed to Open Systems Design Thinking. *Journal of Urban Design*, *17*(2), 163-187. https://doi.org/10.1080/13574809.2012.666209

Charney, M. W. (2011). The Chiang Mai Chronicle. Translated by David Wyatt and Aroonrut Wichienkeeo. Chiang Mai, Thailand: Silkworm Books, 1995. Pp. xxxvi, 225. Maps, Tables, Index, Revised Index, Insert. *Journal of Southeast Asian Studies*, *31*(2), 450-451. https://doi.org/10.1017/s0022463400017926

Charoenmuang, D. A. (2007). *Sustainable cities in Chiang Mai : a case of a city in a valley / Duongchan Apavatjrut Charoenmuang ; [edited by Carole Beauclerk and Tanet Charoenmuang]*. Urban Studies Section, Social Research Institue, Chiang Mai University.

Chiang Mai World Heritage, I. (2020). *Chiangmai World Heritage Initiative - Chiang Mai World Heritage Initiative*. https://chiangmaiworldheritage.org/

Claude, E. S. a. W. W. (1949). The Mathematical Theory of Communication.

Cole, R. J. (2012a). Regenerative design and development: current theory and practice. *Building Research & Information*, *40*(1), 1-6. https://doi.org/10.1080/09613218.2012.617516

Cole, R. J. (2012b). Transitioning from green to regenerative design [Article]. *Building Research & Information*, *40*(1), 39-53. https://doi.org/10.1080/09613218.2011.610608

Cole, R. J., Busby, P., Guenther, R., Briney, L., Blaviesciunaite, A., & Alencar, T. (2012). A regenerative design framework: setting new aspirations and initiating new discussions. *Building Research & Information*, *40*(1), 95-111. https://doi.org/10.1080/09613218.2011.616098

Daily, G. C., & Matson, P. A. (2008). Ecosystem services: From theory to implementation. *Proceedings of the National Academy of Sciences*, *105*(28), 9455-9456. https://doi.org/doi:10.1073/pnas.0804960105

De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological economics*, *41*(3), 393-408.

du Plessis, C. (2012). Towards a regenerative paradigm for the built environment. *Building Research & Information*, *40*(1), 7-22. https://doi.org/10.1080/09613218.2012.628548

Du Plessis, C., & Brandon, P. (2015). An ecological worldview as basis for a regenerative sustainability paradigm for the built environment. *Journal of Cleaner Production*, *109*, 53-61. https://doi.org/https://doi.org/10.1016/j.jclepro.2014.09.098

Fox, J., Vogler, J. B., Sen, O. L., Giambelluca, T. W., & Ziegler, A. D. (2012). Simulating land-cover change in montane mainland southeast Asia. *Environmental management*, *49*(5), 968-979.

Friend, R., Choosuk, C., Hutanuwatr, K., Inmuong, Y., Kittitornkool, J., & Lambregts, B. (2016). Urbanising Thailand : Implications for Climate Vulnerability Assessments. Asian Cities Climate Resilience Working Paper Series. *30*.

Gale, E. L., & Saunders, M. A. (2013). The 2011 Thailand flood: climate causes and return periods. *Weather*, *68*(9), 233-237.

Geurs, K., & Van Wee, B. (2000). Backcasting as a Tool to Develop a Sustainable Transport Scenario Assuming Emission Reductions of 80-90%. *Innovation: The European Journal of Social Science Research*, *13*(1), 47-62. https://doi.org/10.1080/135116100111658

Green, K., & Vergragt, P. (2002). Towards sustainable households: a methodology for developing sustainable technological and social innovations. *Futures*, *34*(5), 381-400. https://doi.org/https://doi.org/10.1016/S0016-3287(01)00066-0

Haggard, B. (2002). Green to the power of three. In *Environmental Design + Construction* (Vol. March/April, pp. 24-31).
Hes, D., & Coenen, L. (2018). *Regenerative development and transitions thinking*. Springer Singapore. https://doi.org/10.1007/978-981-10-7320-5_2
Hes, D., Stephan, A., & Moosavi, S. (2018). Evaluating the Practice and Outcomes of Applying Regenerative Development to a Large-Scale Project in Victoria, Australia. *Sustainability*, *10*(2). https://doi.org/10.3390/su10020460
Höjer, M., & Mattsson, L.-G. (2000). Determinism and backcasting in future studies. *Futures*, *32*(7), 613-634. https://doi.org/https://doi.org/10.1016/S0016-3287(00)00012-4
Hoxie, C., Berkebile, R., & Todd, J. A. (2012). Stimulating regenerative development through community dialogue. *Building Research & Information*, *40*(1), 65-80. https://doi.org/10.1080/09613218.2011.628546
Huss, W. R. (1988). A move toward scenario analysis. *International Journal of Forecasting*, *4*(3), 377-388. https://doi.org/https://doi.org/10.1016/0169-2070(88)90105-7
Jai Bann, S. (2019). Green book : 2021 Public Policy for Greening Chiangmai Vision.
Jarernwong, K., Gheewala, S. H., & Sampattagul, S. (2021). Health Risk Map related to Particulate Matter Exposure in Chiang Mai, Thailand. *Chemical Engineering Transactions*, *89*, 229-234.
Jarungrattanapong, R., & Manasboonphempool, A. (2016). *Adapting to Flood in Chiang Mai: Confronting the Gaps*.
Jompakdee, W. (2004). Rivers in jeopardy and the role of civil society in river restoration: Thai experiences. *CMU Journal*, *3*(1), 59-71.
Julia Parzen and John Cleveland and Scott Bernstein and Robert Friedman and Carolyn, H. (1996). Staying in the Game: Exploring Options for Urban Sustainability.
Kilroy, E. (2014). Regenerative Design: An Integrated Design Approach for the New Jersey Highlands. In: Regional Plan Association.
Kishita, Y., McLellan, B. C., Giurco, D., Aoki, K., Yoshizawa, G., & Handoh, I. C. (2017). Designing backcasting scenarios for resilient energy futures. *Technological Forecasting and Social Change*, *124*, 114-125. https://doi.org/10.1016/j.techfore.2017.02.001
Köves, A., Király, G., & Pataki, G. (2013). Transition to Sustainable Employment: Using Backcasting Technique for Designing Policies. *Managing Global Transitions*, *11*(2), 119-139.
Krone, C. (1992). Notes from Singular Integrated Developmental Business series. *Session 2. Unpublished notes, Institute for Developmental Processes, Carmel, CA.*
Kumar, S., Kusakabe, K., Shrestha, P., Linh, N. K., & Suwanprik, T. (2016). Sustainable urban tourism through low-carbon initiatives.
Kusakabe, K., Shrestha, P., Kumar, S., & Suwanprik, T. (2014). The case of Chiang Mai, Thailand. *Energy (electricity and fuel used)*, *77*, 1.8.

Landry, C. (2006). The art of city making. *Australian Planner*, *43*(4), 47-47. https://doi.org/10.1080/07293682.2006.9982528

Lebel, L., Garden, P., Subsin, N., & Nan, S. N. (2009). Averted crises, contested transitions: water management in the Upper Ping River basin, northern Thailand. *Water policy entrepreneurs. A research companion to water transitions around the globe. Edward Elgar, Cheltenham, UK*, 137-157.

Lebel, L., Thaitakoo, D., Sangawongse, S., & Huaisai, D. (2007). Views of Chiang Mai: The contributions of remote-sensing to urban governance and sustainability. In *Applied remote sensing for urban planning, governance and sustainability* (pp. 221-247). Springer.

Lim, H. S., Boochabun, K., & Ziegler, A. D. (2012). Modifiers and amplifiers of high and low flows on the Ping River in Northern Thailand (1921–2009): the roles of climatic events and anthropogenic activity. *Water resources management*, *26*(14), 4203-4224.

Littman, J. A. (2009). Regenerative Architecture : A Pathway Beyond Sustainability. *Master Thesis*. http://scholarworks.umass.edu/theses/303

Lyle, J. T. (1994). *Regenerative design for sustainable development*. John Wiley.

Mahir, A. (2014). Exploring the Potential for Regenerative Design : A DISSERTATION SUBMITTED TO CARDIFF UNIVERSITY IN PARTIAL. 0-76.

Mander, S. L., Bows, A., Anderson, K. L., Shackley, S., Agnolucci, P., & Ekins, P. (2008). The Tyndall decarbonisation scenarios—Part I: Development of a backcasting methodology with stakeholder participation. *Energy Policy*, *36*(10), 3754-3763. https://doi.org/10.1016/j.enpol.2008.06.003

Mang, N. S. (2009). *Toward a regenerative psychology of urban planning* Saybrook University].

Mang, P. (2001). Regenerative Design: Sustainable Design's Coming Revolution. https://www.di.net/articles/regenerative-design-sustainable-designs-coming-revolution/

Mang, P., & Reed, B. (2012). Designing from place: a regenerative framework and methodology. *Building Research & Information*, *40*(1), 23-38. https://doi.org/10.1080/09613218.2012.621341

Maria-Angeliki Zanni and Robby Soetanto and Kirti, R. (2013). Exploring the potential of BIM-integrated sustainability assessment in AEC. *Sustainable Building Conference*.

Marod, D. (2011). Sampling technique and plant Community analysis. https://bioff.forest.ku.ac.th/PDF_FILE/MAY_2011/DOKRAK_2011.pdf

Masud, M. B., Soni, P., Shrestha, S., & Tripathi, N. K. (2016). Changes in Climate Extremes over North Thailand, 1960–2099. *Journal of Climatology*, *2016*, 4289454. https://doi.org/10.1155/2016/4289454

Mathews, F. (2011). Towards a Deeper Philosophy of Biomimicry. *Organization & Environment*, *24*(4), 364-387. https://doi.org/10.1177/1086026611425689

McDonough, W., & Braungart, M. (1998). The NEXT Industrial Revolution. *The Atlantic Monthly*, *282*, 82-92. https://www.lwvnm.org/Sustainability/NEXTRevolution.pdf

McDonough, W., & Braungart, M. (2002). *Cradle to Cradle: Remaking the Way We Make Things*. Farrar Straus and Giroux|North Point Press.

McHarg, I. L. A. M. o. N. H. (1969). *Design with nature*. Published for the American Museum of Natural History [by] the Natural History Press.
Miller, D. (2012). Regenerative Design an Exploration of Process, Practice, and the Role of Planners.
Millikin, M. (2016). *Toyota launches Biodiversity & Sustainability Learning Center to complement Biotope project in Thailand*. https://www.greencarcongress.com/2016/06/20160623-toyota.html
Mills, J. N., Gage, K. L., & Khan, A. S. (2010). Potential influence of climate change on vector-borne and zoonotic diseases: a review and proposed research plan. *Environmental Health Perspectives*, *118*(11), 1507-1514. https://doi.org/10.1289/ehp.0901389
Miola, A. (2008). *Backcasting Approach for Sustainable Mobility*. https://doi.org/10.2788/77831
Mithun. (2004). Sustainable Urban Design + Catalyst Development by Mithun - Issuu. https://issuu.com/mithun/docs/lloyd_crossing?mode=embed&layout=http%3A%2F%2Fskin.issuu.com%2Fv%2Flighticons%2Flayout.xml&autoFlip=true&autoFlipTime=6000 [Accessed
Moffatt, S., & Kohler, N. (2008). Conceptualizing the built environment as a social–ecological system. *Building Research & Information*, *36*(3), 248-268. https://doi.org/10.1080/09613210801928131
Mollison, B., & Holmgren, D. (1978). *Permaculture one : a perennial agricultural system for human settlements*. International Tree Crops Institute.
Mostafanezhad, M., & Evrard, O. (2021). Chronopolitics of crisis: A historical political ecology of seasonal air pollution in northern Thailand. *Geoforum*, *124*, 400-408.
National Strategy 2018-2037. (2018). National Strategy Secretariat Office. Office of the National Economic and Social Development Board. https://dl.parliament.go.th/handle/20.500.13072/573515
Navanugraha, C. (1997). Preliminary findings from validation of a methodology for landuse and landcover change study in Thailand. Proceedings of the Synthesis Workshop on Greenhouse Gas Emission. Aerosols, Landuse and Landcover Changes in Southeast Asia,
Ng, S., Wood, S. H., & Ziegler, A. D. (2015). Ancient floods, modern hazards: the Ping River, paleofloods and the'lost city'of Wiang Kum Kam. *Natural Hazards*, *75*(3), 2247-2263.
Nuanla-Or, S. (2016). *Creating Sustainable Future of a Degraded Urban Canal: Mae Kha, in Chiang Mai, Thailand*. Louisiana State University and Agricultural & Mechanical College.
Orr, D. W. (1992). *Ecological literacy: Education and the transition to a postmodern world*. Suny Press.
Ortiz-Burgos, S. (2016). Shannon-Weaver Diversity Index. In M. J. Kennish (Ed.), *Encyclopedia of Estuaries* (pp. 572-573). Springer Netherlands. https://doi.org/10.1007/978-94-017-8801-4_233
Our Common Future : the World Commission on Environment and Development. (1987). The United Nations, Oxford University Press.

Paital, B. (2020). Nurture to nature via COVID-19, a self-regenerating environmental strategy of environment in global context. *Science of the Total Environment*, *729*, 139088. https://doi.org/10.1016/j.scitotenv.2020.139088

Palacios-Agundez, I., Casado-Arzuaga, I., Madariaga, I., & Onaindia, M. (2013). The Relevance of Local Participatory Scenario Planning for Ecosystem Management Policies in the Basque Country, Northern Spain. *Ecology and Society*, *18*(3). https://doi.org/10.5751/es-05619-180307

Peterson, G. D., Cumming, G. S., & Carpenter, S. R. (2003). Scenario planning: a tool for conservation in an uncertain world. *Conservation biology*, *17*(2), 358-366.

Phanthuwongpakdee, N. (2016). *Living with floods: Moving towards resilient local-level adaptation in Central Thailand* King's College London].

Plaut, J. M., Dunbar, B., Wackerman, A., & Hodgin, S. (2012). Regenerative design: the LENSES Framework for buildings and communities. *Building Research & Information*, *40*(1), 112-122. https://doi.org/10.1080/09613218.2012.619685

Pourdehqan, B., Rashidi, M., Saeed Firouzbakht, M., & Najafi, N. (2015). Environment and Sustainable Architecture. *European Online Journal of Natural and Social Sciences: Proceedings*, *3*, 5-10.

Quist, J. (2007). *Backcasting for a sustainable future: the impact after 10 years*. Eburon Academic Publishers.

Quist, J., & Vergragt, P. (2006). Past and future of backcasting: The shift to stakeholder participation and a proposal for a methodological framework. *Futures*, *38*(9), 1027-1045. https://doi.org/10.1016/j.futures.2006.02.010

Rebecca, B. (2019). The role of heritage conservation in disaster mitigation: a conceptual framework for connecting heritage and flood management in Chiang Mai, Thailand. *Urban Geography*, *40*(2), 257-265. https://doi.org/10.1080/02723638.2018.1534568

Reed, B. (2007). Shifting from 'sustainability' to regeneration. *Building Research & Information*, *35*(6), 674-680. https://doi.org/10.1080/09613210701475753

Reed, B., & Regenesis. (2011). *Regenerative Development and Design – Working with the Whole*.

Rigg, J., & Ritchie, M. (2002). Production, consumption and imagination in rural Thailand. *Journal of Rural Studies*, *18*(4), 359-371.

Robinson, J., Burch, S., Talwar, S., O'Shea, M., & Walsh, M. (2011). Envisioning sustainability: Recent progress in the use of participatory backcasting approaches for sustainability research. *Technological Forecasting and Social Change*, *78*(5), 756-768.

Robinson, J. B. (1990). Futures under glass: A recipe for people who hate to predict. *Futures*, *22*(8), 820-842. https://doi.org/https://doi.org/10.1016/0016-3287(90)90018-D

Rodale Institute. (2014). Regenerative Organic Agriculture and Climate Change A Down-to-Earth Solution to Global Warming. 15. https://rodaleinstitute.org/wp-content/uploads/rodale-white-paper.pdf

Sangawongse, S. (2006). Land-use/land-cover dynamics in Chiang Mai: appraisal from remote sensing, GIS and modeling approaches. *CMU Journal*, *5*(2), 243-254.

Sangawongse, S., & Peterson, J. A. (1997). Integration of Remote sensing and GIS to Land-use/Land-cover Change Detection in the Chiang Mai Area Northern Thailand: a case study from the Doi Saket District. International Congress on Modelling and Simulation 1997,

Sangawongse, S., Prabudhanitisarn, S., & Karjagthimaporn, E. (2011). Agricultural land use change and urbanization in Thailand. UM conference,

Sangawongse, S., Sun, C. H., & Tsai, B.-W. (2005). Urban growth and land cover change in Chiang Mai and Taipei: results from the SLEUTH model. Proceedings of MODSIM,

Satsue, S. (2018). Spatial Configuration and Community's Composition in Chiang Mai Citadel Area.

Sattayanurak, S. (2005). The construction of mainstream thought on "Thainess" and the "truth" constructed by "Thainess". *Unpublished Doctoral Dissertation. Chiang Mai University.[cite 25 July 2018] Available from http://www. fringer. org/wpcontent/writings/thainesseng. pdf*.

Scheer, B., & Scheer, D. (2002). Towards a sustainable urban form in Chiang Mai. In *Managing intermediate size cities* (pp. 253-272). Springer.

Singh, B. B., Sharma, R., Gill, J. P. S., Aulakh, R. S., & Banga, H. S. (2011). Climate change, zoonoses and India. *Rev. sci. tech. Off. int. Epiz*, *30*, 779-788.

Squizzato, S., Masiol, M., Rich, D. Q., & Hopke, P. K. (2018). A long-term source apportionment of PM2.5 in New York State during 2005–2016. *Atmospheric Environment*, *192*, 35-47. https://doi.org/https://doi.org/10.1016/j.atmosenv.2018.08.044

Sustainable Development Goals | United Nations in Thailand. (2023). https://thailand.un.org/en/sdgs

Svec, P., Berkebile, R., & Joel Ann, T. (2012). REGEN : toward a tool for regenerative thinking. *Building Research & Information*, *40*, 81-94.

Thai Green Building Institute. (2016a). Thai 's Rating of Energy and Environmental Sustainability (TREES). https://www.tgbi.or.th/tag/show/1

Thai Green Building Institute. (2016b). *Thai 's Rating of Energy and Environmental Sustainability (TREES) for New Construction and Major Renovation* https://tgbi.or.th/uploads/trees/2017_03_TREES-NC-Eng.pdf

The Third Revision of the Chiang Mai Comprehensive Plan. (2010). (Vol. 130, Part 43). Urban Planning Act. 2010, The Royal Thai Government Gazette.

US EPA. (24 September, 2012). *Showing buried streams the daylight, Science Matters Newsletter*. https://archive.epa.gov/epa/sciencematters/epa-science-matters-newsletter-volume-3-number-3.html

Van der Ryn, S., & Cowan, S. (1996). *Ecological design*. Island Press.

Van der Ryn, S., & Cowan, S. (2007). *Ecological design*. Island Press.

Vanderbilt, T. (2008). Mitchell Joachim: Redesign Cities From Scratch. *Wired*. https://www.wired.com/2008/09/sl-joachim/

Vaz Monteiro, M., Handle, P., Morison, J., I. L. , & Doick, K. J. (2019). The role of urban trees and greenspaces in reducing urban air temperatures. 1-12.

Vergragt, P. J., & Quist, J. (2011). Backcasting for sustainability: Introduction to the special issue. In (Vol. 78, pp. 747-755): Elsevier.

Waldron, D., Cayuela, A., & Miller, D. (2013). Regenerative Neighbourhoods – scaling up from net positive buildings. *Stream 5– Pushing the Boundaries: Net Positive Buildings (SB13). CaGBC National Conference & Expo*, 69-82.

Wangel, J. (2011). Exploring social structures and agency in backcasting studies for sustainable development. *Technological Forecasting and Social Change*, *78*(5), 872-882. https://doi.org/10.1016/j.techfore.2011.03.007

Wara-Aswapati, P. (1991). Image processing technique for urban and rural land use monitoring in northern Thailand.

Whitfield, S., Geist, H. J., & Ioris, A. A. R. (2011). Deliberative assessment in complex socioecological systems: recommendations for environmental assessment in drylands. *Environmental Monitoring and Assessment*, *183*(1), 465-483.

Wibulpolprasert, W. (2016, Wednesday, July 13). More must be done to fight climate change. *Bangkok Post*. https://tdri.or.th/en/2016/07/climate-change/

Wilcox, B. A., & Gubler, D. J. (2005). Disease ecology and the global emergence of zoonotic pathogens. *Environment Health and Preventive Medicine*, *10*(5), 263-272. https://doi.org/10.1007/BF02897701

Williams, K. (2012). Regenerative design as a force for change: thoughtful, optimistic and evolving ideas. *Building Research & Information*, *40*(3), 361-364. https://doi.org/10.1080/09613218.2012.662389

Wollenberg, E., Edmunds, D., & Buck, L. (2000). Using scenarios to make decisions about the future: anticipatory learning for the adaptive co-management of community forests. *Landscape and Urban Planning*, *47*(1), 65-77. https://doi.org/https://doi.org/10.1016/S0169-2046(99)00071-7

Wongwatcharapaiboon, J. (2020). Review Article: Toward Future Particulate Matter Situations in Thailand from Supporting Policy, Network and Economy. *Future Cities and Environment*, *6*(1). https://doi.org/10.5334/fce.79

Wood, S. H., & Ziegler, A. (2008). Floodplain sediment from a 100-year-recurrence flood in 2005 of the Ping River in northern Thailand. *Hydrology and Earth System Sciences*, *12*(4), 959-973.

Yeom, D.-J., & Kim, J. H. (2011). Comparative evaluation of species diversity indices in the natural deciduous forest of Mt. Jeombong. *Forest Science and Technology*, *7*(2), 68-74. https://doi.org/10.1080/21580103.2011.573940

Zanni, M.-A., Soetanto, R., & Ruikar, K. (2013). Exploring the potential of BIM-integrated sustainability assessment in AEC. *Sustainable Building Conference*.

Zari, M. P. (2012). Ecosystem services analysis for the design of regenerative built environments. *Building Research & Information*, *40*(1), 54-64. https://doi.org/10.1080/09613218.2011.628547

Zari, M. P. (2017). *Utilizing relationships between ecosystem services, built environments, and building materials*. Elsevier Inc. https://doi.org/10.1016/B978-0-08-100707-5.00001-0

Zurek, M. B., & Henrichs, T. (2007). Linking scenarios across geographical scales in international environmental assessments. *Technological Forecasting and Social Change*, *74*(8), 1282-1295. https://doi.org/https://doi.org/10.1016/j.techfore.2006.11.005