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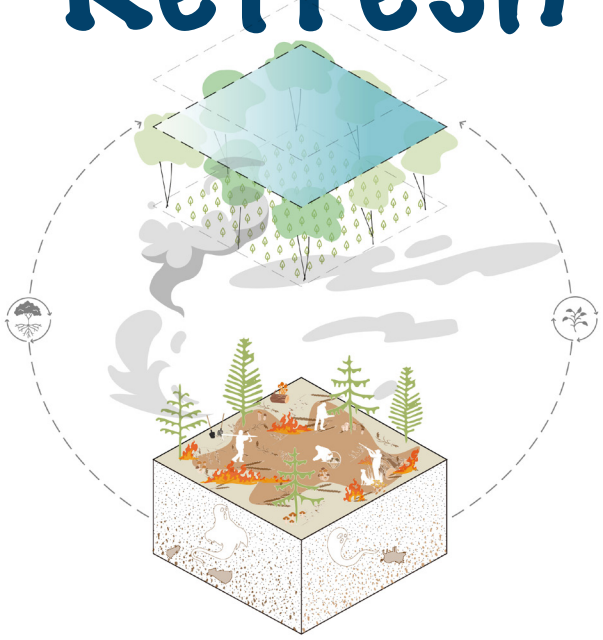

Cultivating a new paradigm of integrated farming as mitigation of air pollution in Chiang Mai, Thailand

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MSc Thesis in Landscape Architecture
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Delft University of Technology

Colophon

Refresh
Cultivating a new paradigm of integrated farming as mitigation of air pollution in Chiang Mai, Thailand

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I would like to thank Rapa Surajaras, a thai alumnus who graduated from the landscape architecture track in 2019, for proposing the topic that sparked my interest. Engaging in a project focused on global environmental crisis has been a attractive opportunity, considering the growing importance of environmental issues and the imperative to incorporate them into our work. This project has allowed me to explore air pollution, a concern we encounter in our daily lives, from the position of a landscape architect. As I am less familiar with the Southeast Asian context, Rapa's guidance has been valuable in validating my design proposal.

Last but not least, I want to express my deepest appreciation to my parents for their unconditional support. I am grateful to my labmates from Urban Ecology for their companionship and the inspiration from their remarkable works. To my friends, thank you for the valuable exchange of ideas and for helping me get through challenging times, and dispelling negative emotions.

Your support and contributions have played a vital role in my personal and professional growth, and I am truly fortunate to have you all in my life.

Abstract

Air pollution poses a significant threat to human health globally, with Southeast Asia being one of the most affected regions. Chiang Mai, as the largest cultivated area in northern Thailand, faces severe haze pollution due to traditional farming practices, especially during the burning season. As urban areas encroach upon agricultural land and farmers increasingly turn to forests for land and resources, the pollution situation is intensifying in the negative way.

The thesis proposes a comprehensive strategic spatial framework which applied a multi-layered approach, including policy, social, and natural layers, to control pollution sources in agriculture and forest area and to eliminate air pollution that has already been generated in urban area. Envision a harmonious landscape where regenerative forests, integrated agriculture, and a haze-free environment synergistically contribute to refreshing the city. The thesis outlines pilot projects selected from rural and urban areas, which will be implemented and further elaborated with strategies and involve with site-specific intervention, aiming at achieving the goal of mitigating air pollution. These pilot projects will serve as models for surrounding areas facing similar challenges.

The ultimate aim is to transform agricultural areas into sustainable systems through the implementation of agroforestry practices, foster self-sufficiency within communities through urban farming initiatives, and promote a self-circulating urban environment through urban greening efforts. With synthesis of all systems, the existing fragmentation with be filled with green infrastructure throughout the entire area. By adopting this comprehensive strategic framework, Chiang Mai can address air pollution issues, promote sustainable land use practices, and create resilient landscapes that improve the well-being and quality of life for its residents.

Keywords

Air pollution, Sustainable agriculture, Agroforestry, Urban farming, Urban greening, Biodiversity, Chiang Mai

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1

INTRODUCTION

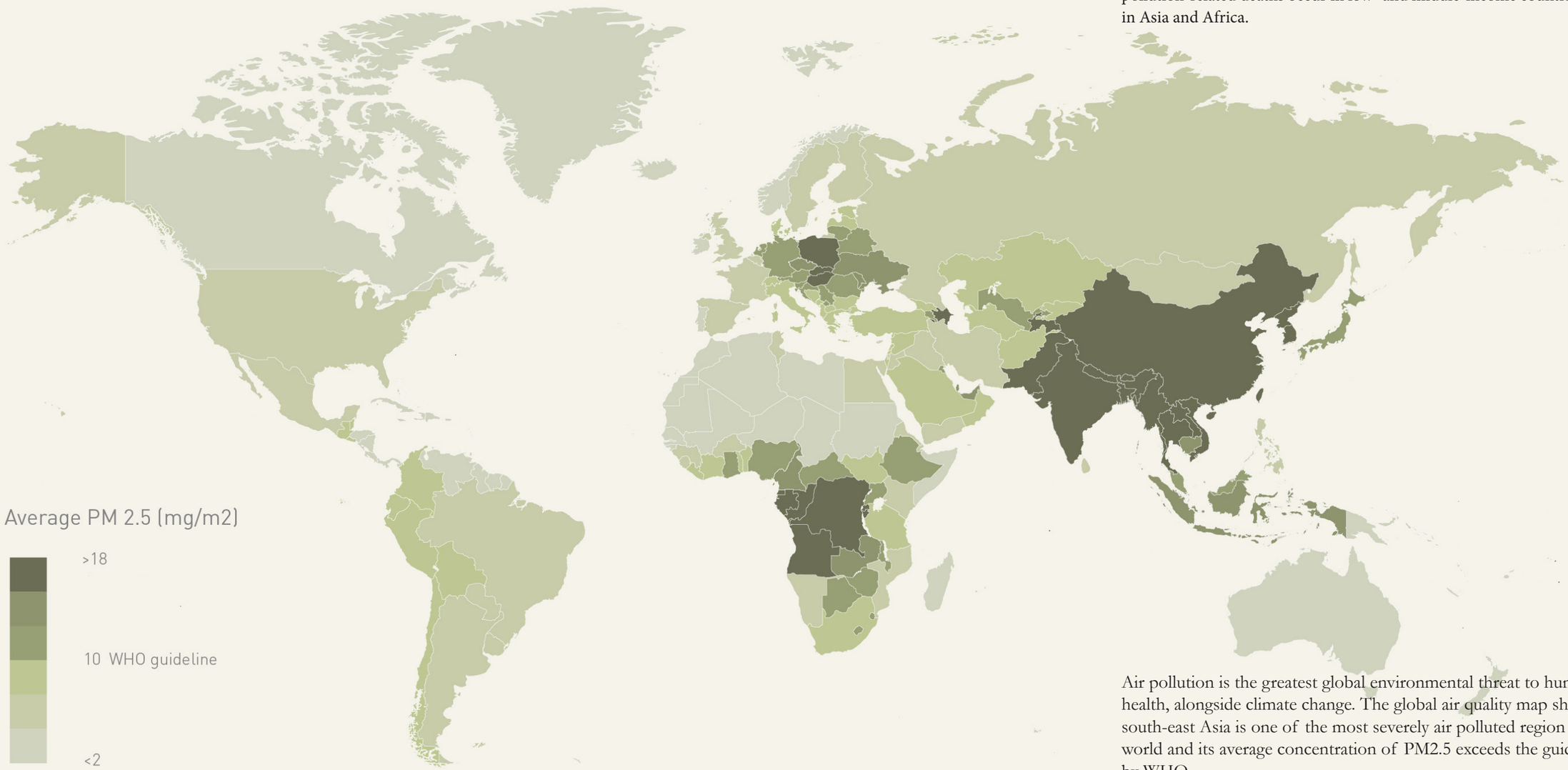
This chapter begins by highlighting air pollution as a global environmental issue, serving as the primary motivation for this graduation project. It starts by introducing the context of Chiang Mai, providing general information about the region and its agriculture system. The focus then shifts to the annual burning season, a recurring problem in Chiang Mai, which serves as the basis for the problem statement.

1.1 Motivation
1.2 Problem statement

MOTIVATION
Global Air Quality

According to World Health Organization (WHO), 90% of worldwide population is breathing unhealthy air. Every year air pollution causes approximately 7 million premature deaths and is responsible for the loss of millions more healthy years of life worldwide. More than 90% of air pollution-related deaths occur in low- and middle-income countries, mainly in Asia and Africa.

Fig. 1.1 Global Air Quality (concentration of PM2.5)
Drawn by author, Data source: ArcGIS Online, https://www.arcgis.com/home/webmap/viewer.html?webmap=eb0e3086f6d54554a84b7cd027de9c29



Air pollution is the greatest global environmental threat to human health, alongside climate change. The global air quality map shows that south-east Asia is one of the most severely air polluted region in the world and its average concentration of PM2.5 exceeds the guideline set by WHO.

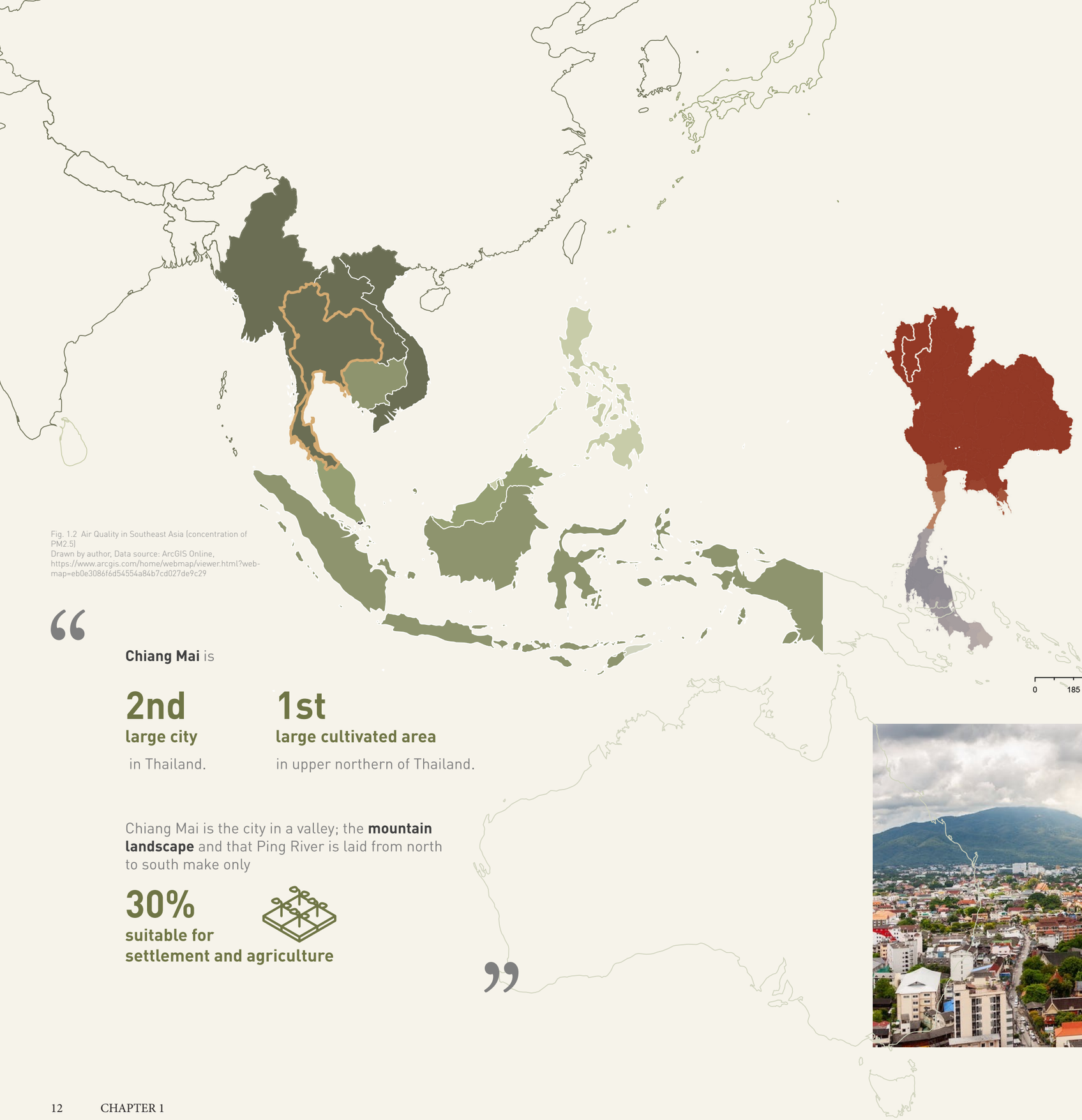


Fig. 1.2 Air Quality in Southeast Asia (concentration of PM2.5)
Drawn by author, Data source: ArcGIS Online, https://www.arcgis.com/home/webmap/viewer.html?webmap=eb0e3086f6d54554a84b7cd027de9c29

“

Chiang Mai is

2nd
large city
in Thailand.

1st
large cultivated area
in upper northern of Thailand.

Chiang Mai is the city in a valley; the **mountain landscape** and that Ping River is laid from north to south make only

30%
suitable for settlement and agriculture

”

MOTIVATION
Context of Chiang Mai

When zooming into south-east Asia, Thailand is one of those countries suffering from the severe effects of air pollution and it is particularly acute in north Thailand.

Chiang Mai is the largest city in northern Thailand, and the second largest city in Thailand. It is worth mentioning that Chiang Mai is the largest cultivated area in upper northern Thailand. However, the mountain landscape and that Ping River is laid from north to south make only 30 percent of area suitable for settlement and agriculture. It is therefore a conflict between limited land and development.

With its topography, climate and long cultural history, it has become a popular tourist destination for many decades. (Liwa Pardthaisong et al., 2018) In 2015, there were 7.4 million tourists visited Chiang Mai in which 35 per cent of them was foreign tourists. (National Statistical Office, 2017)

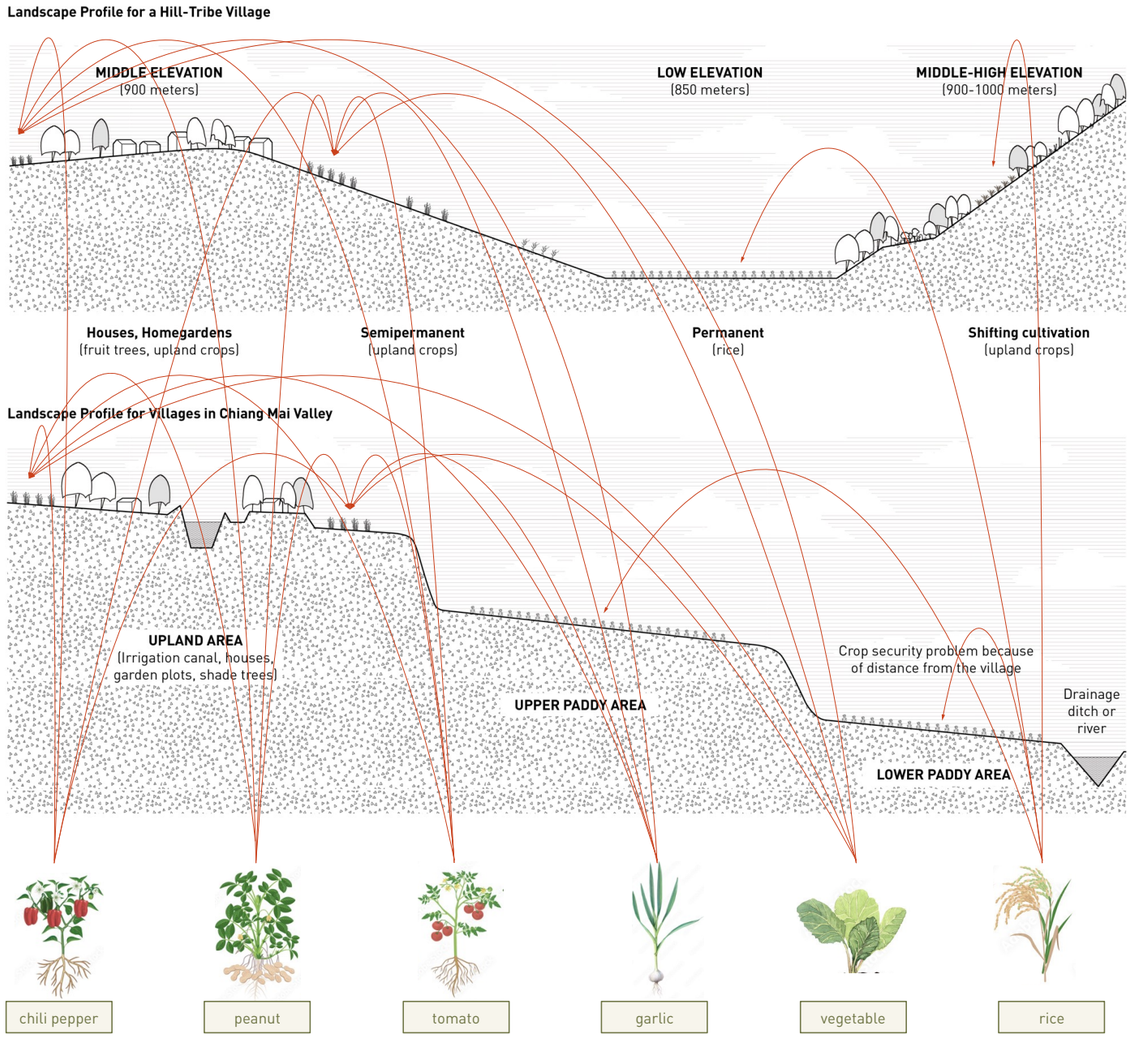
Fig. 1.3 Air Quality in Thailland (concentration of PM2.5)
Drawn by author, Data source: ArcGIS Online, https://www.arcgis.com/apps/mapviewer/index.html?webmap=5f-0f00a15d7f47d093c096b27a9c3b8c

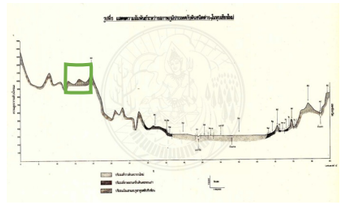
Fig. 1.4 Panarama of Chiang Mai City
Photo by Pim Kemasingki, Thu. 1 Nov 2018

MOTIVATION

Agriculture in Chiang Mai

Fig. 1-5 Agriculture in Chiang Mai
Photo by INGimage2, retrieved from: https://699pic.com/tupian-306849982.html





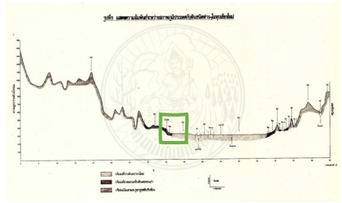


Fig. 1-6 Two Typical Landscape Profiles in Chiang Mai
Drawn by Author

Fig. 1-7 Cross Section of Chiang Mai Valley
Retrieved from Srimongkol, K., & Marten, G. G. (1986). Traditional agriculture in northern Thailand (pp. 85-102). Westview Press.

Fig. 1-8 Topography of Chiang Mai Valley
Retrieved from Srimongkol, K., & Marten, G. G. (1986). Traditional agriculture in northern Thailand (pp. 85-102). Westview Press.

MOTIVATION

Agriculture System in Chiang Mai

The Highland Area (Hill-tribe village)
The first one is landscape profile for a hill-tribe village, which is located built on top of a gently sloping hill. Farmer usually have them farmland around their houses. In this case, because of limited land for agriculture, farmers tend to do shifting cultivation in forest area.

Crops
Vegetables and fruit crops (e.g., bananas, papayas, and local peaches) are common in the peripheral area adjacent to the village. Upland crops such as corn, dry rice, sesame, opium poppies, peanuts, soybeans, kidney beans, and potatoes are cultured somewhat farther away from the village, and many of these crops may be interplanted.
Sesame and opium are the main cash crops, with additional income from livestock, off-farm labor, and the sale of forest products, including foods such as mushrooms, bamboo shoots, and wild vegetables that are gathered from the forest.

The Lowland Area (Chiang Mai valley)
The second one is landscape profile in Chiang Mai valley, which is located in between mountains and urban area. The village is surrounded by cropland located at discrete elevations. And residential areas composed of houses, home gardens, shade trees and roads.Upland crops are grown in monoculture, contrasting with tribe areas where a number of upland crops are often interplanted.

Crops
Rice is the main subsistence crop, usually has massive production in large cropland in the wet season. While chili pepper, peanut, tomato, garlic, vegetable would be planted after harvest of rice and they also exist in farmers home gardens.

Irrigation
Besides, the conditions in the Chiang Mai basin are ideal for irrigation.
The basin has a relatively high catchment-to-area ratio and so the flow of water is plentiful in the wet season.
Flooding is not excessive because the sloping terrain allows rapid drainage.
During the dry season the main rivers and streams do not dry up.

MOTIVATION

Paddy Field in Chiang Mai

Fig. 1.7 Terraced Paddy Fields in Chiang Mai
Photo by deposit photos, retrieved from
https://699pic.com/tupian-501378771.html

PROBLEM STATEMENT
BURNING SEASON

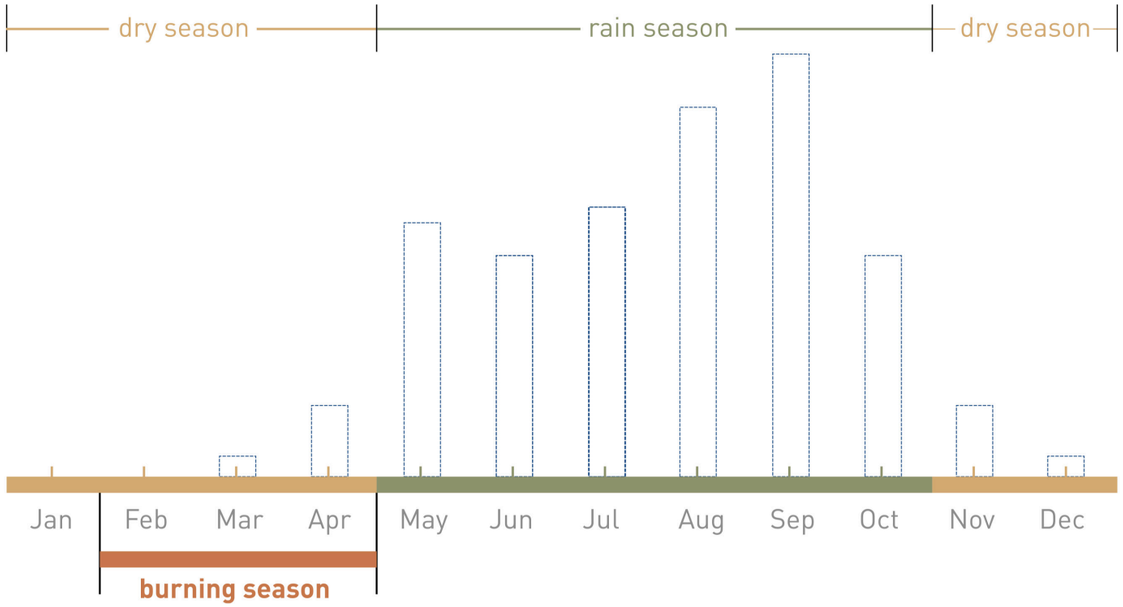


Fig. 1-11 Period of Burning Season in Chiang Mai
Drawn by Author

Generally, Chiang Mai experiences two distinct seasons: the wet season, which occurs from May to October, and the dry season, which spans from November to April. During a specific period within the dry season, from February to April, Chiang Mai and its surrounding areas are settled over by thick and stifling haze. This period is commonly referred to as the Burning Season.

This phenomenon has persisted for decades, impacting both the local population and tourists in a negative way. More significantly, the annual air pollution during this particular period poses a severe threat to the health of the population.

Fig. 1-10 Comparison Scene between Normal time and Burning Season in Chiang Mai City
Photo: by MFU PHOTOCLUB

PROBLEM
STATEMENT
Fire Hotspot in Chiang Mai Province 2011-2020

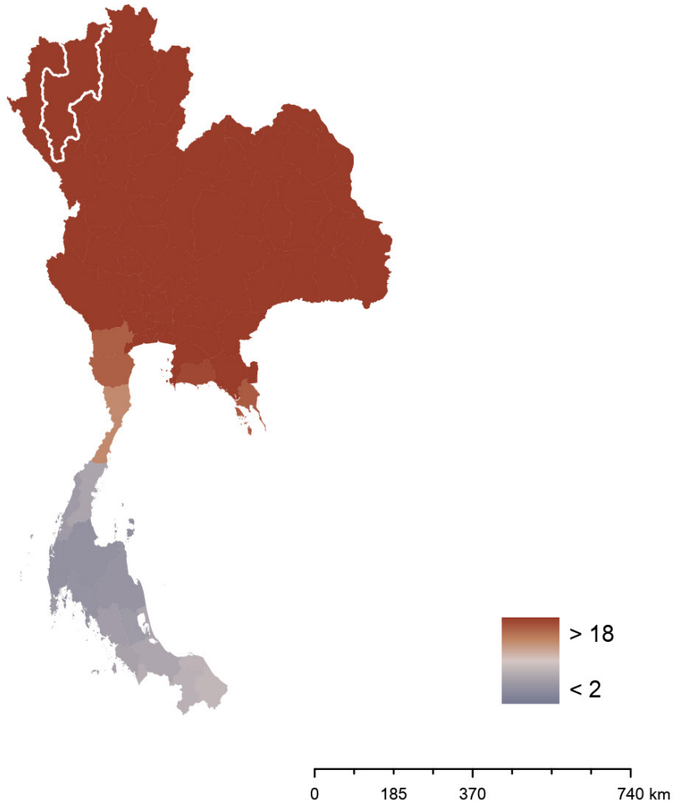


Fig.1-11 : Air quality in Thailand (PM 2.5 Concentations)
Drawn by author, Data source: ArcGIS Online, https://www.arcgis.com/apps/mapviewer/index.html?webmap=5f-0f00a15d7f47d093c096b27a9c3b8c

The map right side mainly shows the distribution of fire in Chiang Mai province in last decade.

The fire basically occurred in forest area, especially in fringe of forest, which is most accessible with frequent human activities.

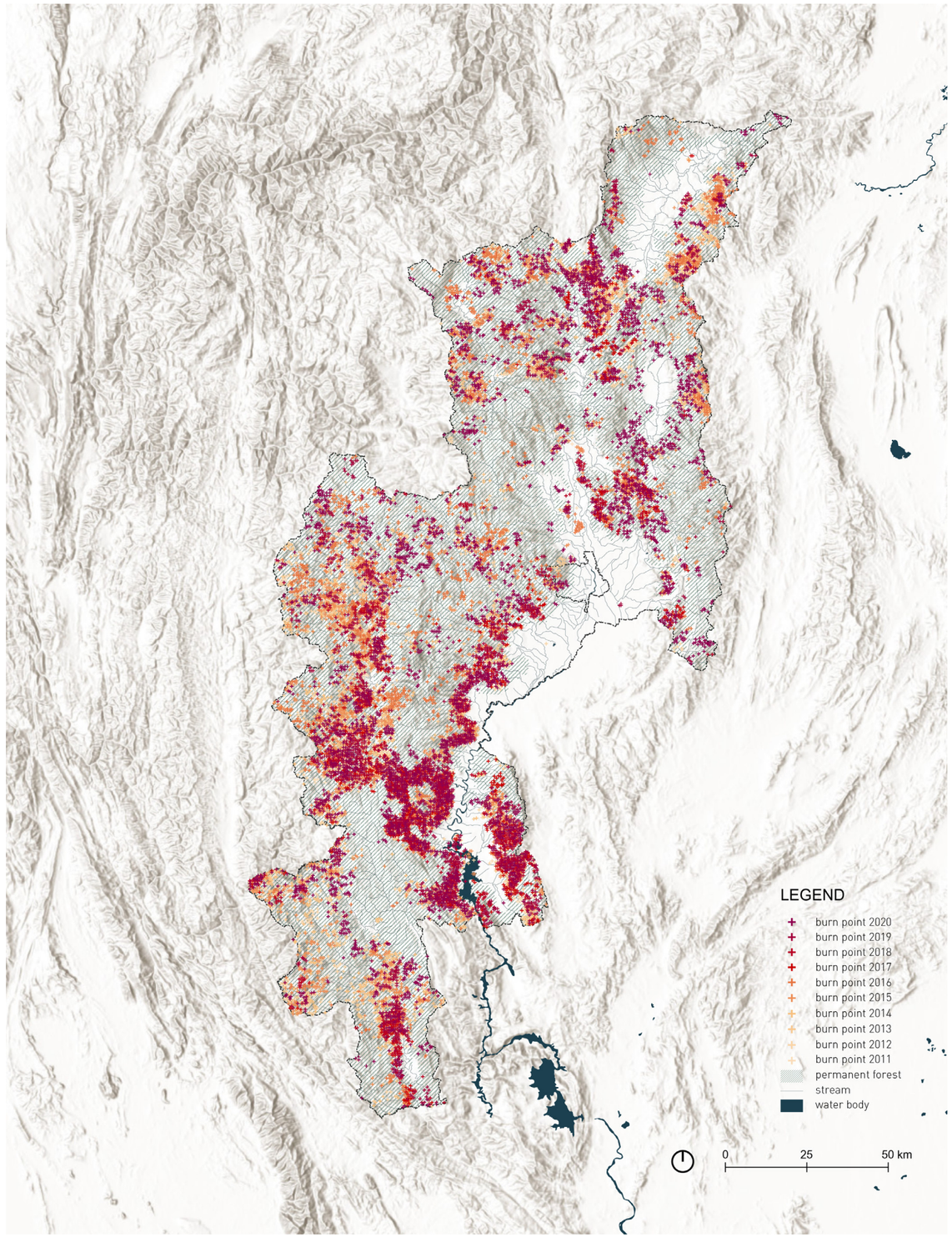


Fig.1-12 : Fire Hotspot in Chiang Mai Province 2011-2020
Drawn by author, Data source: http://www.thaiopendata.org/, https://data.humdata.org/dataset?q=thailand

PROBLEM
STATEMENT
A Cascade of Effects

Fig.1-13 : A cascade of effects caused by air pollution
Drawn by author

Human induced open burning and forest fires triggers a cascade effect with severe consequences on both the environment and human health.
The primary impact of open burning and forest fires is the release of large amounts of particulate matter, carbon monoxide, and other harmful pollutants into the atmosphere.

Open burning and forest fires that caused by human has direct ecological impacts, including the loss of habitat for wildlife and soil degradation. These impacts have knock-on effects on ecosystems and their services, such as reducing soil fertility and increasing the risk of erosion and landslides. It gradually contributes to global climate change, which has far-reaching effects such as sea level rise, changes in weather patterns, and the loss of biodiversity.

The smoke and pollutants released from burning and fires also contribute to regional and even global air pollution. It causes respiratory problems and aggravate existing health conditions, particularly in vulnerable populations such as children and the elderly, even for those living far from the source of the fire.

PROBLEM STATEMENT
Effects on Health

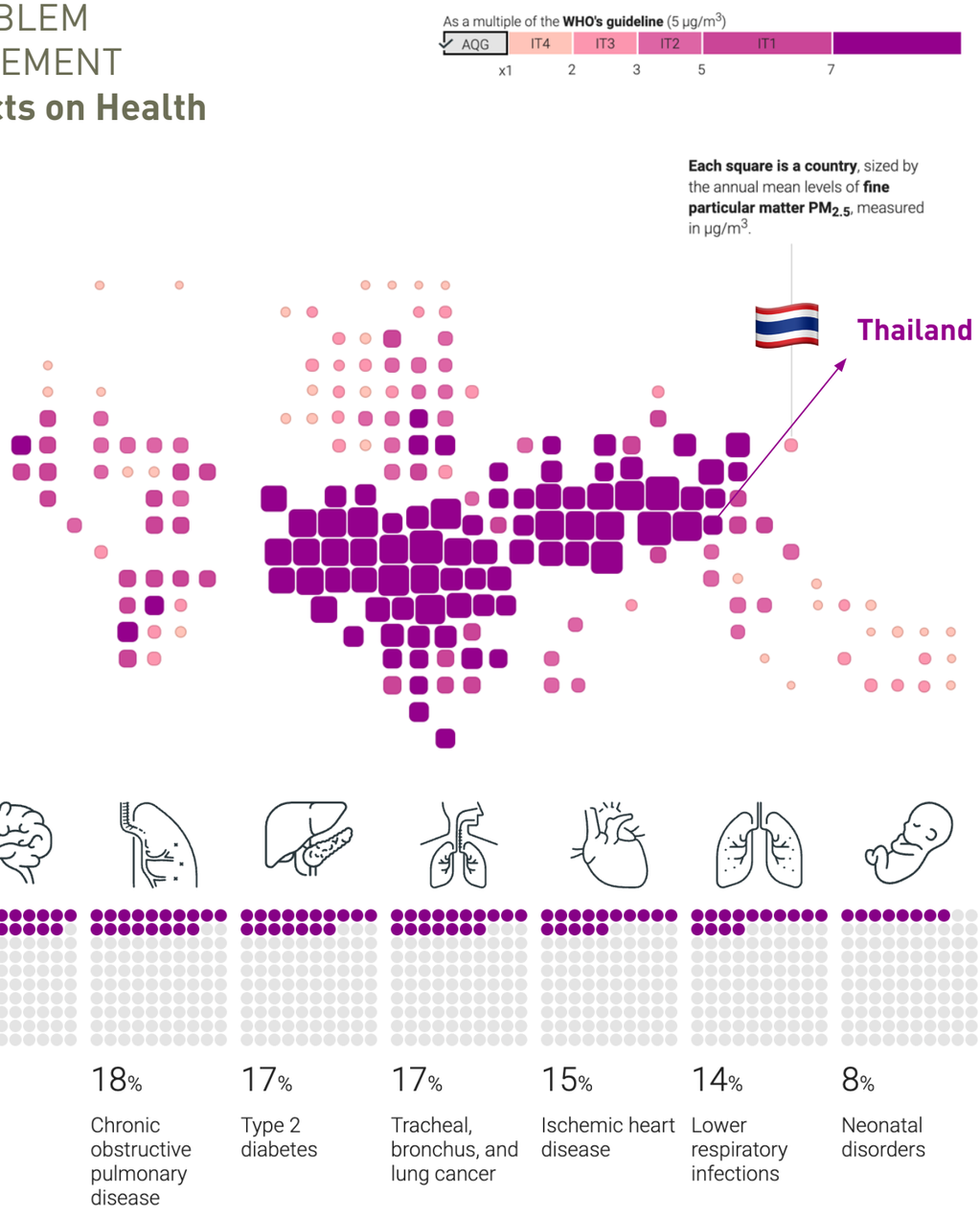


Fig.1-14 : Global PM2.5 concentration and diseases caused by air pollution
Retrieved from UNEP, Institute for Health Metrics and Evaluation (IHME), 2020

Air pollution is a major global health crisis and causes one in nine deaths worldwide. Exposure to PM2.5 reduces average global life expectancy by approximately one year in 2019.

Fine particle pollution is an important factor in deaths from stroke, chronic obstructive pulmonary disease, type 2 diabetes, tracheal, bronchus and lung cancer, ischemic heart disease, lower respiratory infections and neonatal disorders.

In Thailand, each person's annual mean exposure is 27µg/m³, 5.4 times WHO's guideline and 46 deaths per 100,000 people attributed to fine particle pollution in 2019. (UNEP, 2022)

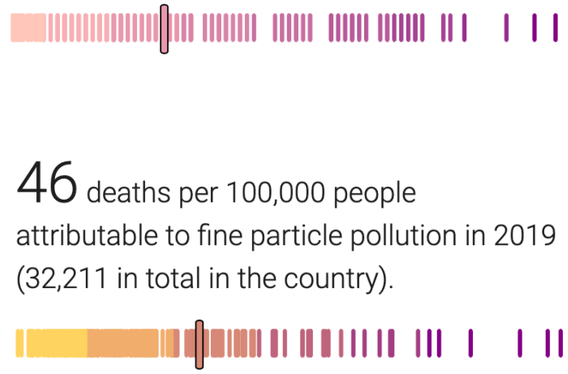


Fig.1-15 : Each person's PM2.5 concentration and death caused by air pollution in Thailand
Retrieved from UNEP, Institute for Health Metrics and Evaluation (IHME), 2020

2

PROJECT APPROACH

With a clear problem statement in place, the aim of this project is to identify and propose potential solutions to address the issue of severe air pollution during the burning season in Chiang Mai. In this chapter, Considering the complexity of the project, the methods and theoretical framework are presented to provide the research and design approaches, and solid theoretical foundation to guide the work.

2.1 Aim of study
2.2 Methods
2.3 Theoretical framework

The objective of the project is to propose a landscape-based solution to address the issue of severe air pollution during the burning season in Chiang Mai, Thailand. This solution is based on a comprehensive analysis from different layers, including social, natural, and policy layer within the region. By studying the forest, agriculture, and urban areas, as well as their interrelationships, and conducting policy research, both top-down and bottom-up strategies are developed with the aim of transforming into a sustainable social-ecological system and envisioning a refreshing living environment.

These goals are related to the Sustainable Development Goals (SDGs) from the UN.

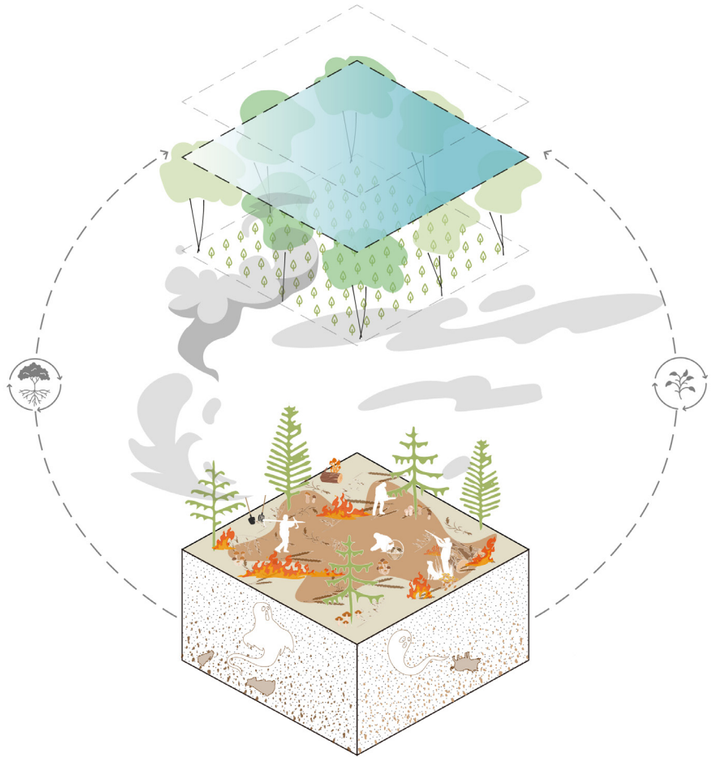


Fig.2-1: Diagram of objectives
Drawn by author

Aim of Study
OBJECTIVES

The Sustainable Development Goals

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs). (United Nations, Department of Economic and Social Affairs, 2015)

Given the severity of the issue, air pollution is specifically mentioned in two Sustainable Development Goal (SDG) targets, SDG 3 (good health and well-being) and SDG 11 (sustainable cities and communities). Attached to the former is a specific indicator tracking progress directly on "Mortality rate attributed to household and ambient air pollution".

The wider impacts of air pollution mean the issue also has implications for a number of other SDGs. These include: SDG 7 (affordable and clean energy) and SDG 13 (climate action), given the interplay between climate, energy and pollution; SDG 6 (clean water and sanitation) and SDG 14 (life below water), given the impact on water quality; and SDG 15 (life on land) and SDG 12 (responsible production and consumption), given wider environmental causes and impacts. (Kelly, 2018)

Reference: Kelly, B., &Beale, R. (2018). Air pollution: Sustainable development and investment opportunity.

Fig. 2-2: SDGs with sub-goals relating to air pollution
Retrieved from United Nations, https://sdgs.un.org/goals

Aim of Study
MAIN RESEARCH QUESTION

How to cultivate **a new paradigm of integrated farming practice** as mitigation of air pollution in Chiang Mai through tailoring **sustainable agriculture system** and **sustainable landscape framework** in the context of southeast Asia?

Aim of Study
SUB QUESTIONS

1. How does **a regional strategy framework** incorporate regional landscape system and local agricultural system to control air pollution?

2. How to cultivate **a new relationship** between farmland and urban expansion that provides a sustainable crop production network?

3. What kind of **sustainable production mode** can improve the living conditions of local residents without harming the ecological environment?

4. What kind of **sustainable cultivation pattern** of crops can be practiced in farmland in the context of Southeast Asia?

5. What is the most efficient local **vegetation species** and **planting pattern** to remove air pollution in urban area?

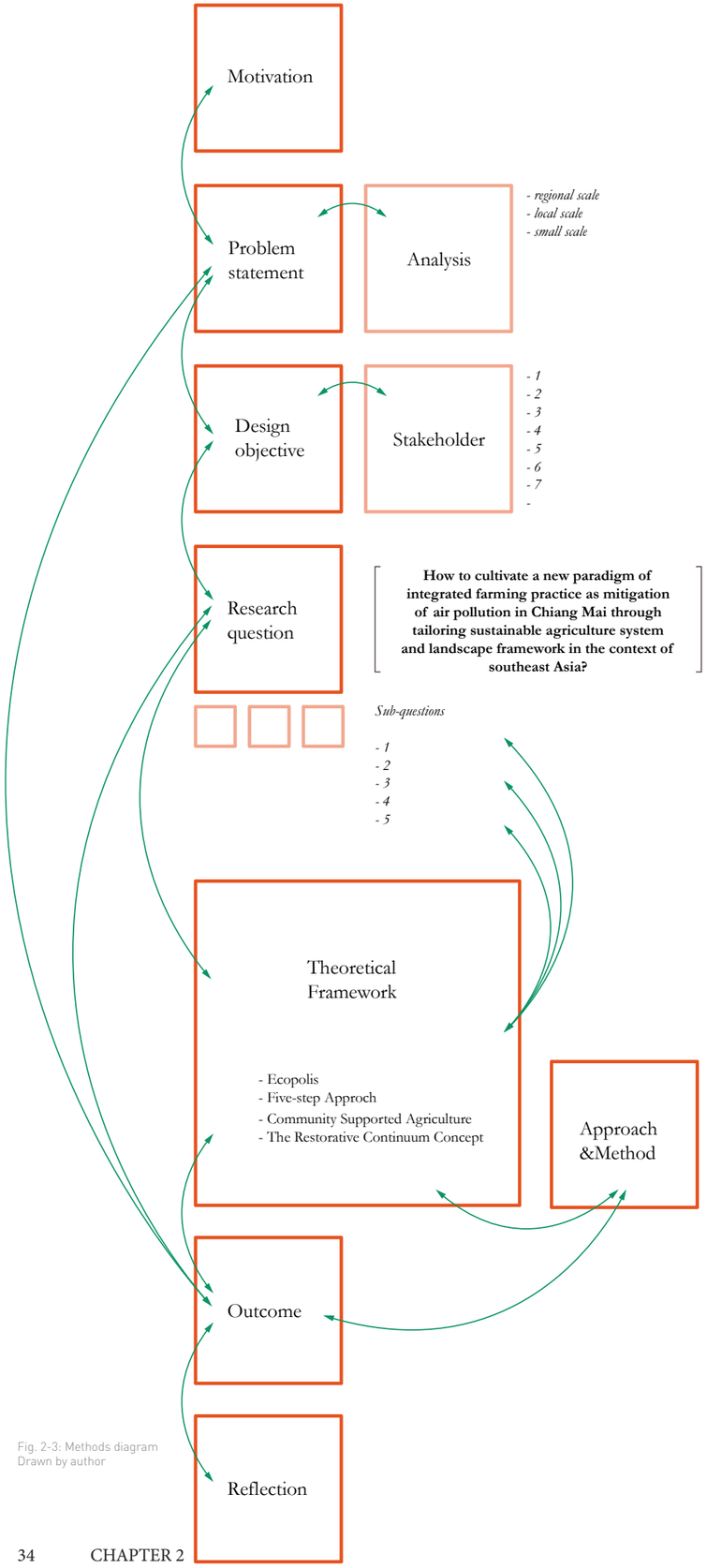


Fig. 2-3: Methods diagram
Drawn by author

1. How does a regional strategy framework incorporate regional landscape system and local agricultural system to control air pollution?
- Literature review
- Policy analysis
- Stakeholder analysis
- Developing design principles

2. How to cultivate a new relationship between farmland and urban expansion that provides a sustainable crop production network?
- Literature review
- Mapping
- Stakeholder analysis
- Case study

3. What kind of sustainable production mode can improve the living conditions of local residents without harming the ecological environment?
- Literature review
- Stakeholder analysis
- Case study

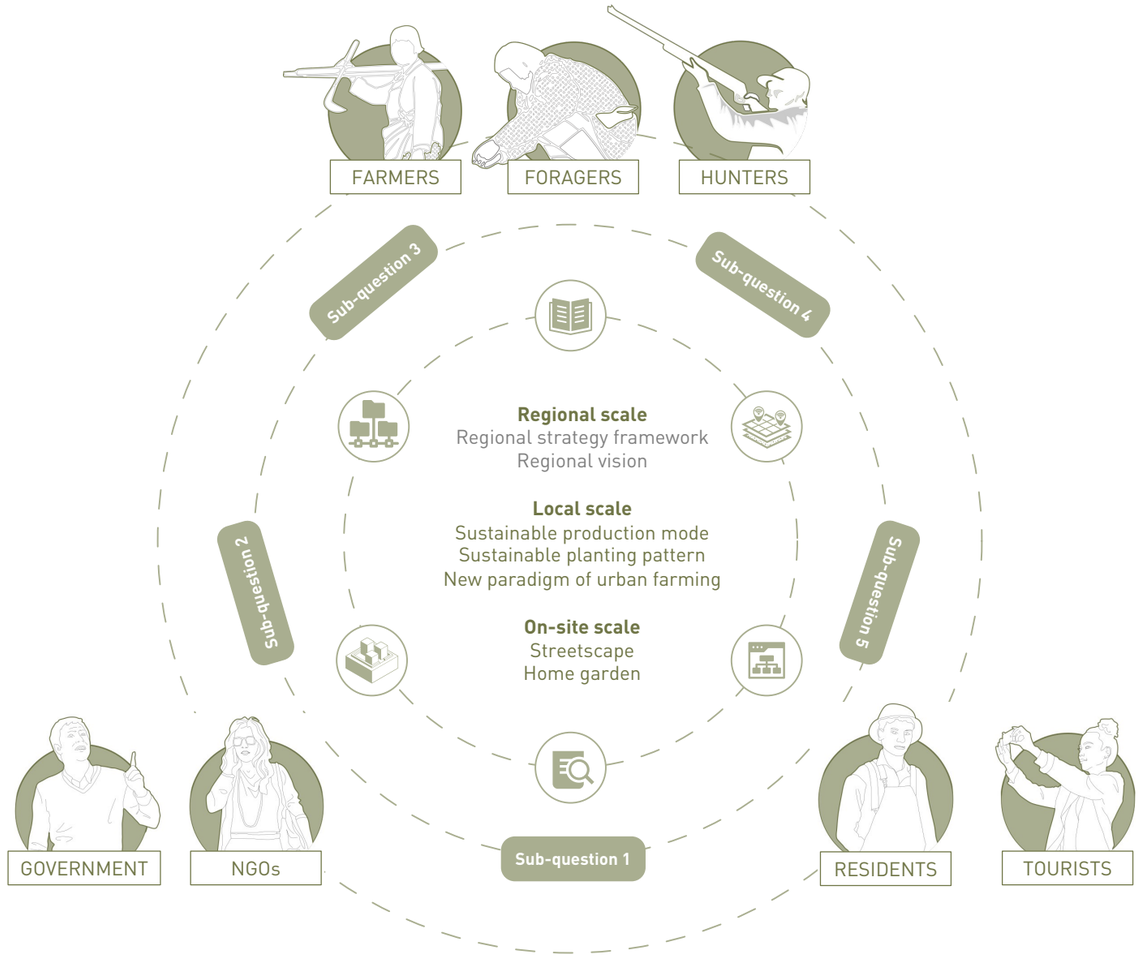
4. What kind of sustainable cultivation pattern of crops can be practiced in farmland in the context of Southeast Asia?
Case study
Design intervention
Scenario exploration

5. What is the most efficient local vegetation species and planting pattern to remove air pollution in urban area?
Case study
Design intervention
Scenario exploration

METHODS

By analysis the needs of all stakeholders, develop sub-questions to try to engage them and by using the listed methods, like literature review, case study, policy research, mapping, scenario exploration to get some outcomes through scale.

Fig. 2-4: Methods diagram
Drawn by author



THEORETICAL FRAMEWORK
I. ECOPOLIS
SUMMARY

Reference:
Tjallingii, Sybrand. (1995). Ecopolis: Strategies for Ecologically Sound Urban Development.

Ecopolis is a concept that can be realized when an environment provides ecosystem services and people consciously maintain the environment at the same time.

Tjallingii (1995) proposed a threefold strategies framework to develop suitable plans for ecopolis. These strategies involve flows, sites/areas, and participants, which correspond to the responsible city, the living city, and the participating city. Each perspective addresses different objectives and challenges. This framework also serves as an evaluation guideline for completed projects. The ultimate goal is to promote a harmonious relationship between human activities and natural processes, thus creating sustainable and balanced urban environments..

THE RESPONSIBLE CITY
From the perspective of flows, it pursues the responsible city. It is concerned with sustainable flow management with an integral chain of flows of energy, water, waste and transportation. The responsible city emphasizes ecological responsibility and stewardship towards the environment.

THE PARTICIPATING CITY
The participating city perspective emphasizes community engagement, participation, and collaboration. It involves actively involving residents, stakeholders, and various actors in decision-making processes and the implementation of sustainable initiatives. The participating city encourages partnerships, citizen involvement, and social cohesion to foster a sense of ownership and shared responsibility in shaping the city's future.

THE LIVING CITY
The living city perspective emphasizes the well-being and quality of life for its residents. It involves creating a healthy, inclusive, and vibrant urban environment. This perspective includes aspects such as access to green spaces, sustainable transportation systems, affordable housing, social amenities, and cultural activities. The living city aims to enhance the overall livability and happiness of its inhabitants. Tjallingi suggests to use of local natural and cultural potential should be priority. The city needs to build spatial structure for 'flow management' and create healthy habitat both for people and for flora and fauna. (Tjallingii, 1995)

I. ECOPOLIS
APPLY TO DESIGN

Implement sustainable strategies that align with the principles of Ecopolis. Incorporate renewable energy systems, utilize recycled agricultural residues, and integrate waste management solutions, including composting and waste-to-energy. Consider strategies for reducing the project's ecological footprint and promoting long-term sustainability.

Engage with stakeholders, including local residents, government agencies and NGOs throughout the design process. Foster a participatory approach that encourages collaboration, information sharing, and co-creation. Seek feedback, involve the community in decision-making, and integrate their knowledge and experience into the design solutions.

Seek opportunities to enhance ecosystem services, such as establishing ecological corridors with the existing water structure, promoting biodiversity. Ensure the design supports the well-being of residents, with considerations for public spaces, walkability, accessibility, and community interaction.

With environment providing ecosystem services and people contributing to maintenance of the environment at the same time, a sustainable and balanced urban environments can be realized in Chiang Mai.

Fig. 2-5: Integrating Ecopolis into the design principle and evaluation guideline
Drawn by author

THEORETICAL FRAMEWORK **II. FIVE-STEP APPROACH** SUMMARY

Reference:
Stremke, S., Kann, F. van, Koh, J. (2012). Integrated Visions (Part I): Methodological Framework for Longterm Regional Design, European Planning Studies · vol. 20 DOI: 10.1080/09654313.2012.650909.

The five steps in the Five-step Approach are as follows:

Step 1: analyzing present conditions: how does the present region function and how can it be evaluated in comparison with other regions?

Step 2: mapping near-future developments: how will the region change in the near-future?

Step 3: illustrating possible far futures: what kind of possible long-term developments (at which location) are expected in the study region?

Step 4: developing integrated visions: how can we turn a possible future into a desired future?

Step 5: identifying spatial interventions: which possible intervention should be implemented?

Although the framework consists of five consecutive steps, the envisioning process is iterative. It may be necessary to return to an earlier step in order to answer all questions fully. If necessary, certain steps can be elaborated more than others; thus, the framework can be adapted to the time and resources available.

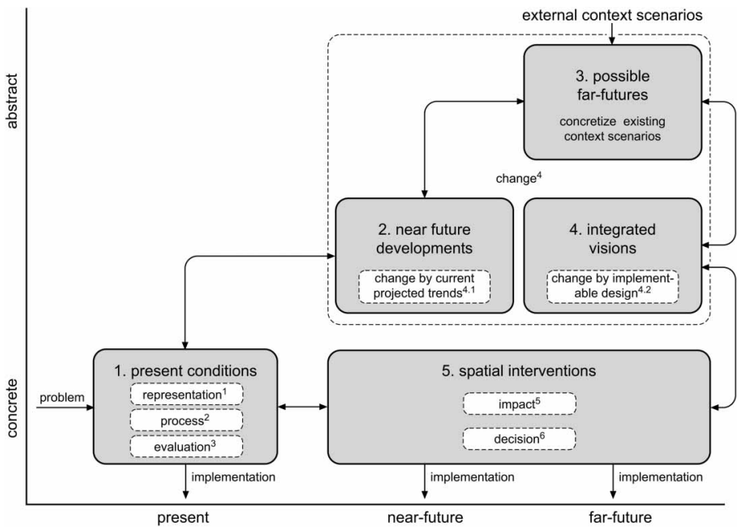


Fig. 2-6: Methodological framework of Five-step Approach (Stremke et al., 2012)

II. FIVE-STEP APPROACH APPLY TO DESIGN

Step 1: Analysing the cause of severe haze in urban area of Chiang Mai, from social, environmental, and policy layers.

Step 2: Mapping near-future developments. The suitability of rice field will be analysed to determine if the land should be retained for rice cultivation or replaced for better alternative uses in the near future.

Step 3: Illustrating possible far futures. Based on mapping near-future developments, a range of possible far futures scenarios can be illustrated. Within these possibilities, the most suitable one with great potentials will be chosen to develop intergrated regional visions.

Step 4: Developing integrated visions. Integrated visions provide ways to reach a proposed future. In this case, regional vision will be further specified to address the focal issue from FOREST, AGRICULTURE and URBAN layer.

Step 5: Regional vision identifies possible interventions under the chosen scenario. The spatial intervention can be linked with the elements in first step.

The previous steps can function as evaluation, if necessary, return to previous steps to elaborate and explore another possibility.

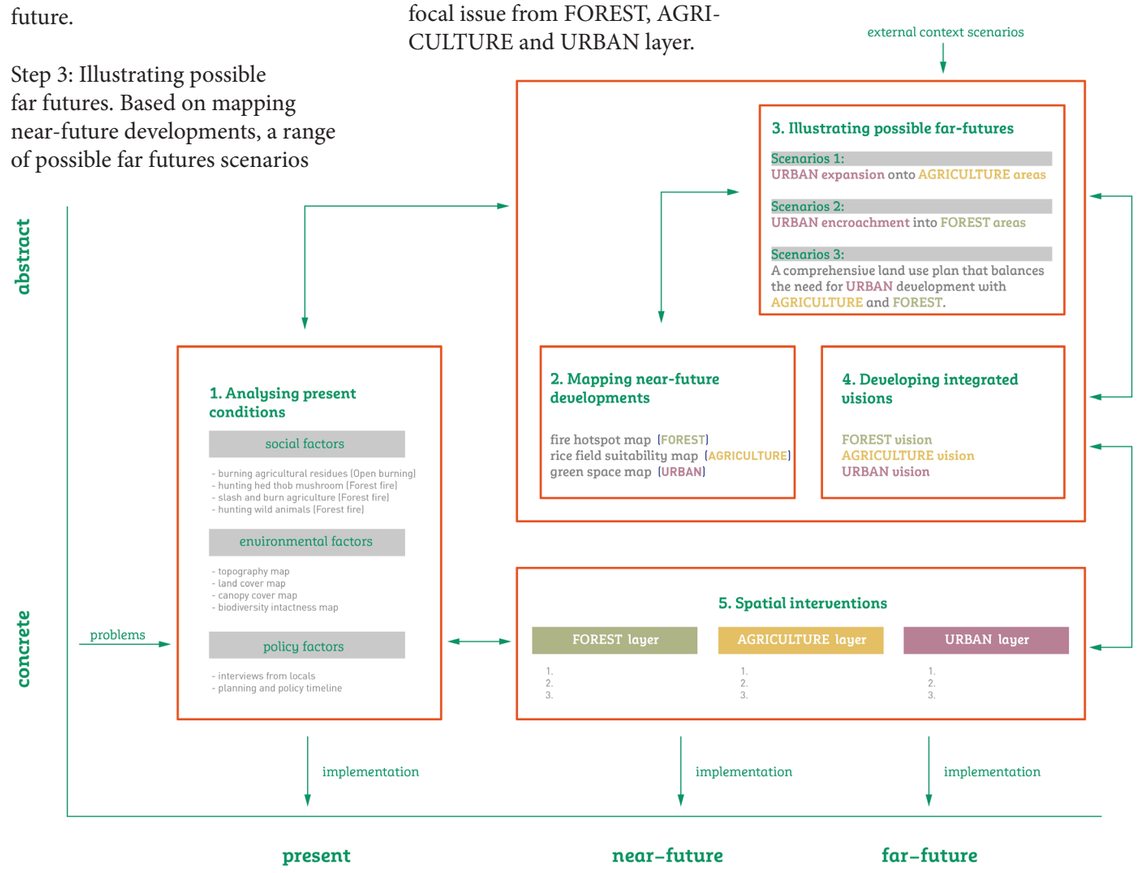


Fig. 2-7: Integrating Five-step Approach into the design process, Drawn by author

THEORETICAL FRAMEWORK
III. RESTORATIVE CONTINUUM CONCEPT
INTERVENTION FOR ECOLOGICAL RESTORATION

Reference:
Gann, G.D., McDonald, T., Walder, B., Aronson, J., Nelson, C.R., Jonson, J., Hallett, J.G., Eisenberg, C., Guariguata, M.R., Liu, J., Hua, F., Echeveria, C., Gonzales, E., Shaw, N., Decleer, K. & Dixon, K.W. (2019). International principles and standards for the practice of ecological restoration. Second edition. Ecological Restoration 27(S1): S1–S46. www.ser.org/page/ SERStandards

Restorative continuum concept can be used as **Approaches and Tools for effective restoration measures for species and habitats**.

It is a **Solutions-based Approach** that engages communities, scientists, policymakers, and land managers to repair ecological damage and rebuild a healthier relationship between people and the nature.

The Restorative Continuum includes **a range of Activities and Interventions** which can be implemented to achieve better ecological conditions and reverse ecosystem degradation and landscape fragmentation by:

- Reducing societal impacts.
- Improving ecological conditions (remediation).
- Repairing ecosystem functions (rehabilitation).
- Recovering native ecosystems (ecological restoration).

Eight Principles for Ecological Restoration

- Engages stakeholders
- Draws on many types of knowledge
- Informed by native reference ecosystems, while considering environmental change
- Supports ecosystem recovery processes
- Assessed against clear goals and objectives using measurable indicators
- Seeks the highest level of recovery possible
- Gains cumulative value when applied at large scales
- Part of a continuum of restoration activities

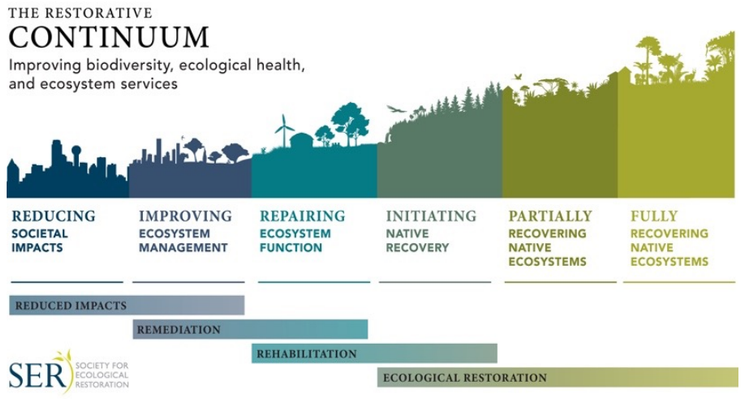


Fig. 2-8: Diagram of Community Supported Agriculture
Retrieved from International principles and standards for the practice of ecological restoration(Gann,2019)

THEORETICAL FRAMEWORK
IV. COMMUNITY SUPPORTED AGRICULTURE
STRATEGY FOR SELF-SUFFICIENT AGRICULTURE

Reference:
Suzanne DeMuth, Community Supported Agriculture (CSA): An Annotated Bibliography and Resource Guide, September 1993.
Robyn Van En, Basic Formula to Create Community Supported Agriculture. Great Barrington, MA, 1992. Summary

Farmers and Consumers Supporting Each Other

The concept of CSA originates from Switzerland and Japan, where consumers looking for safe food work together in economic partnerships with farmers who want to build a steady stream of customers. Literally, CSA means that everyone in the community makes a commitment to the farm operation so that the farm can legally and spiritually become the farm of the community, allowing farmers and consumers to support each other and share the risks and benefits of food production. (DeMuth,1993)

Utilizing the Highest Ecological Potential

Community Supported Agriculture (CSA) operates in various forms, but all share a common commitment to creating a local and equitable agricultural economy. CSAs enable farmers to prioritize land management while ensuring the productivity and profitability of small-scale farms. The main goal of these Community Supported Agriculture programs ..... is to help participating farms reach their highest ecological potential and to develop a network that encourages and allows other farms to participate. that encourages and allows other farms to participate (Van En,1992). CSA farmers typically apply organic or biodiverse farming methods, offering fresh and high-quality produce. Gradually, people prefer to CSA program because of its sustainability and benefit to health.

Agriculture in most areas of Chiang Mai is based on small-scale and is in charge by individuals or household. The establishment of CSA model can benefit both farmers and residents. Farmers can have a stable source of income while residents can be assured of food security. In addition, it can improve the sustainability of the agricultural system and enhance community engagement. Therefore, this self-sufficient system can be an alternative for traditional one.

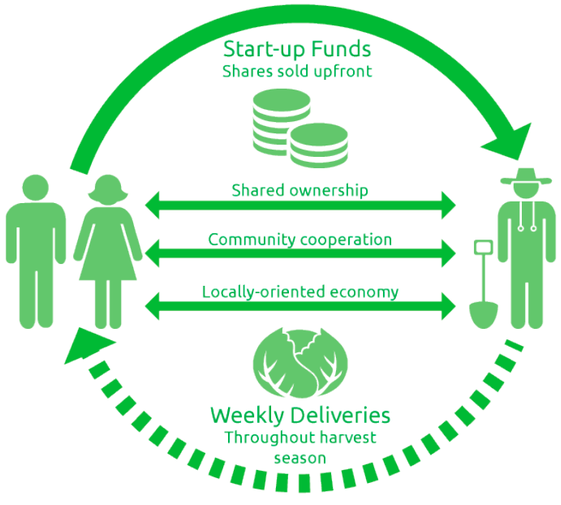


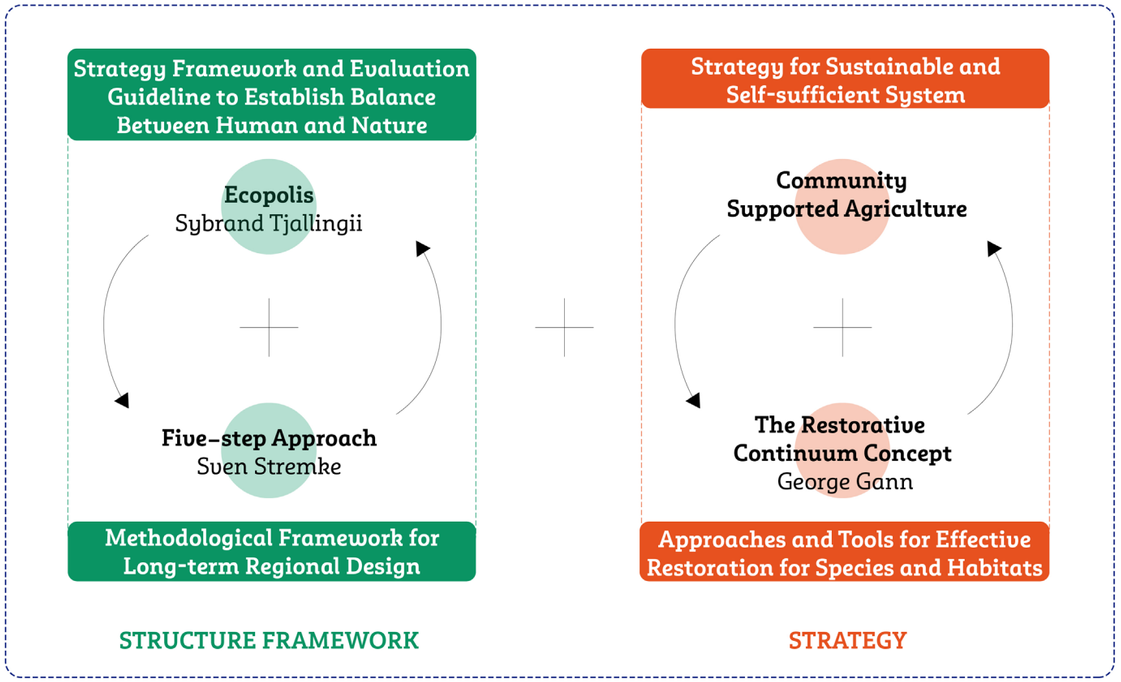
Fig. 2-9: Diagram of Community Supported Agriculture
Retrieved from: https://caff.org/csa/

THEORETICAL FRAMEWORK
HOW TO APPLY

The issue of air pollution in Chiang Mai is multifaceted, involving social, environmental, and policy-related factors. To address this complexity, this thesis will be grounded in four theories as a theoretical foundation.

I. ECOPOLIS presents strategy framework and evaluation guideline to create sustainable and balanced urban environments, involving flows, sites/areas, and participants.
II. FIVE-STEP APPROACH provides methodological framework for long-term integrated regional design.
III. RESTORATIVE CONTINUUM CONCEPT functions as approaches and tools for effective restoration measures for species and habitats, including a range of activities and interventions.
IV. COMMUNITY SUPPORTED AGRICULTURE (CSA) provides a new food production mode towards a sustainable and self-sufficient system.

Fig. 2-10: Theoretical framework diagram
Drawn by author



3

AIR POLLUTION IN CHIANG MAI

In this chapter, the causes of the air pollution problem in Chiang Mai are explored across social, environmental, and policy layers, with the following three questions answered correspondingly.
- What causes severe haze in urban area?
- Why does it have lasting impacts?
- How was it limited to mitigate identified issue?

1.1 What causes severe haze in urban area?
1.2 Why does it have lasting impacts?
1.3 How was it limited to mitigate identified issue?

1 OPEN BURNING
Burning Agricultural Residues

Fig. 3-1: Agriculture area in Chiang Mai province
Drawn by author

Fig. 3-2: Farmers burning agricultural residues after harvesting
Drawn by author

Fig. 3-3: open burning agricultural residues
Photo retrieved from: https://www.iqair.com/newsroom/thailand-2021-burning-season

Farmers engage in the practice of burning agricultural residues, such as rice straw, as a method to clear their fields in preparation for the next planting season, particularly during the dry season. However, this practice significantly contributes to the haze issue by releasing substantial amounts of smoke and particulate matter into the atmosphere. Open burning is a human-initiated activity that serves multiple purposes, including preparing the field for the next crop, removing residues, controlling weeds, and releasing nutrients for the upcoming crop cycle.

Farmers often resort to open burning due to its convenience and efficiency in preparing the land for cultivation. However, scientific evidence suggests that open burning just does not work as well as the farmers would like it to. In fact, burning agricultural residues can result in detrimental effects, including the loss of organic soil, reduced soil fertility, and ultimately lower crop production. (Pasukphun, 2018)

FOREST FIRE 2
Hunting Hed Thob Mushroom (เห็ดถอบ)

Fig. 3-4: Forest area in Chiang Mai province
Drawn by author

Fig. 3-5: Foragers setting fires diliberately to easily seek out hed thob mushrooms in forest
Drawn by author

Fig. 3-6: A series of photos show foragers looking for mushroom
Photo retrieved from the internet

Hed thob (เห็ดถอบ)or Thai truffles as they are called, the bulbous little black mushrooms, botanically known as Astraeus hygrometricus. These mushrooms can only be gathered once a year and cannot be cultivated commercially. Hed thob mushrooms thrive in recently burnt areas and the fact has resulted in foragers setting fires in forest deliberately to seek out these valuable hed thob mushrooms. Unfortunately, this practice contributes, to varying degrees, to the annual haze issues in the northern regions. (City News, 2015)

3 FOREST FIRE
Slash and Burn Agriculture

Fig. 3-7: Forest area in Chiang Mai province
Drawn by author

Fig. 3-8: Farmers cutting down trees and burning it to clear land for cultivation
Drawn by author

Fig. 3-9: A series of photo show farmers setting fire in forest to clear the land
Photo retrieved the internet

Slash and burn agriculture involves cutting down vegetation and burning it to clear land for cultivation. When these fires get out of control or are not properly managed, they can spread to nearby forests, leading to larger-scale forest fires. Huge sections of forestry being set on fire to clear the agricultural land of any remaining vegetation. Once burnt the resulting ash provides a nutrient-rich layer to help fertilize new crops. These forest fires release large amounts of smoke, pollutants and fine particles that contribute to the haze problem.

FOREST FIRE
Hunting Wild Anmials 4

Fig. 3-10: Forest area in Chiang Mai province
Drawn by author

Fig. 3-11: Hunters setting fires diliberately to easily gather wild animals and catch them in forest
Drawn by author

Fig. 3-12: A series of photos show wild animals dead due to the forest fire
Photo retrieved from the internet

In some cases, hunters may intentionally start fires to flush out or trap wild animals. The act of burning makes it easier for hunters to locate and hunt wildlife, as their natural habitats are destroyed. These fires, if uncontrolled, can quickly escalate into forest fires and contribute to the haze. Additionally, the combination of forest fires and hunting practices can disrupt ecosystems and biodiversity, leading to further environmental concerns.

I. TOPOGRAPHY

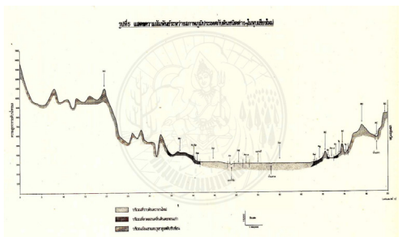


Fig. 3-13: Topography of Chiang Mai Valley
Retrieved from Srimongkol, K., & Marten, G. G. (1986). Traditional agriculture in northern Thailand (pp. 85-102). Westview Press.Fig. 3-7: Forest area in Chiang Mai province

Fig. 3-14: Cross Section of Chiang Mai Valley
Retrieved from Srimongkol, K., & Marten, G. G. (1986). Traditional agriculture in northern Thailand (pp. 85-102). Westview Press.

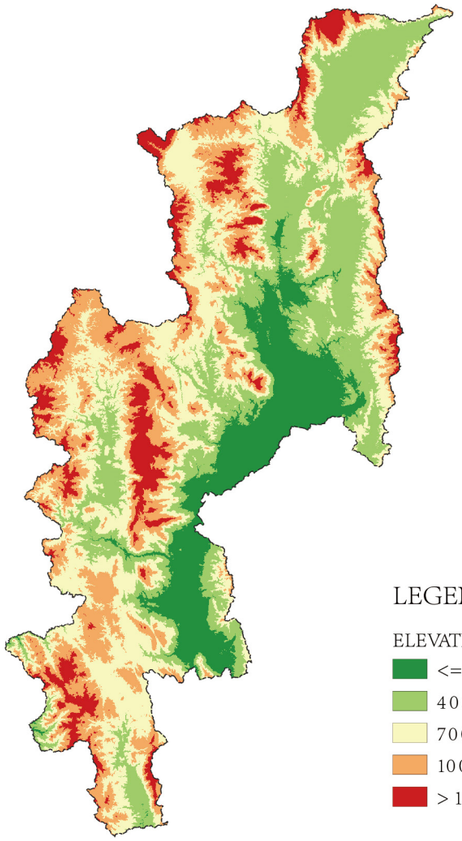
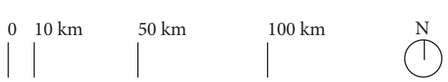


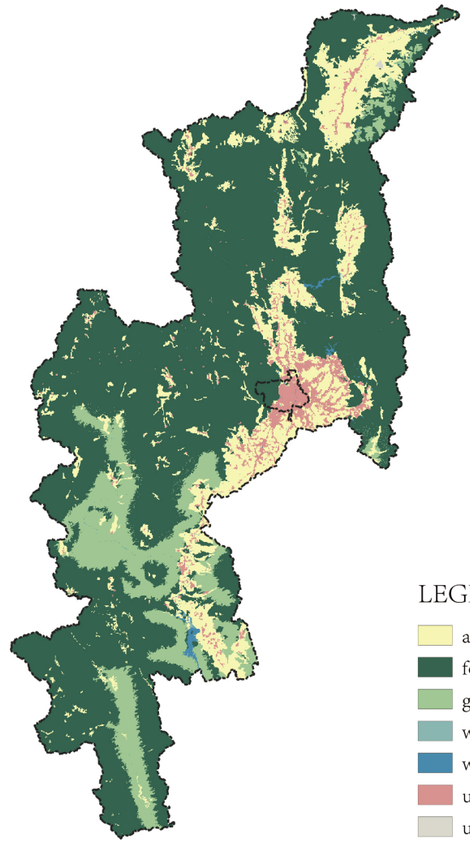
Fig. 3-15: Elevation mapping of Chiang Mai Province
Drawn by author, Data source: OpenTopography, https://opentopography.org/

The city area is located in a basin-shape flat plain but surrounded by mountain ranges on eastern and western sides.

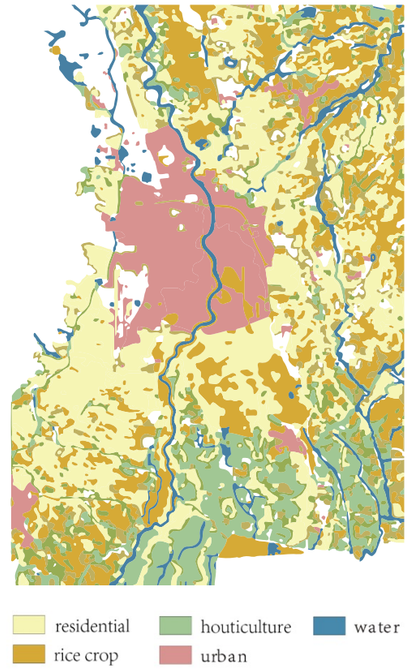
Therefore, the concentration of harmful substances in the air is high and the yearly air pollution has been a serious threat to the health of the local population.



II. LAND COVER



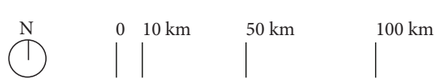
Urban expansion leads to fragmentation of forests and agricultural lands and urban sprawl of residential area are invading into cultivated area.



The impact of air pollution from open burning is more severe for people because agricultural land and residential areas are merging.

Fig. 3-16: Land cover mapping of Chiang Mai Province
Drawn by author, Data source: Open Government Data of Thailand, https://data.go.th/en/Thai Open Data, http://www.thaiopendata.org/

Fig. 3-17: Land cover mapping of Chiang Mai City
Drawn by author, Data source: Open Government Data of Thailand, https://data.go.th/en/Thai Open Data, http://www.thaiopendata.org/



Why does it have lasting impacts?

III. CANOPY COVER

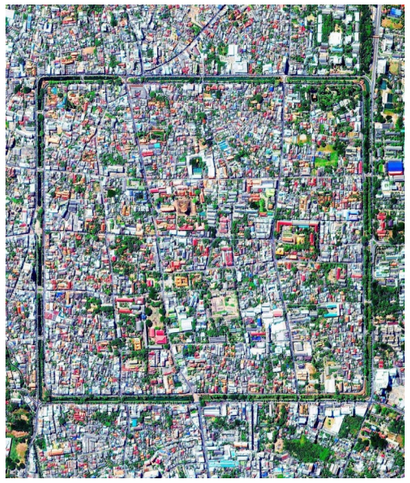


Fig. 3-18: Satellite map of Chiang Mai City
Photo retrieved from: https://www.over-view.com/overviews/chiang-mai?fbclid=IwAR3tMso0l1BY8r-RzM4GMsg95BZUpt1WSx3Dz9GqEUPW8y3oeN88gZY-SYam4

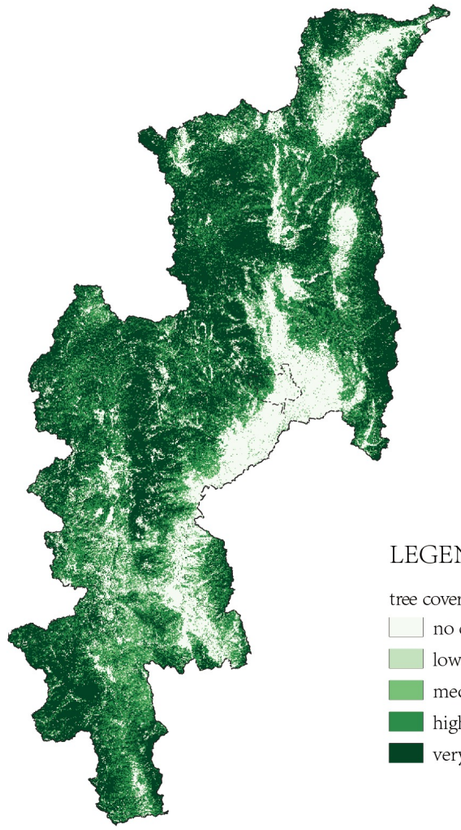
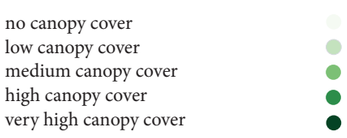


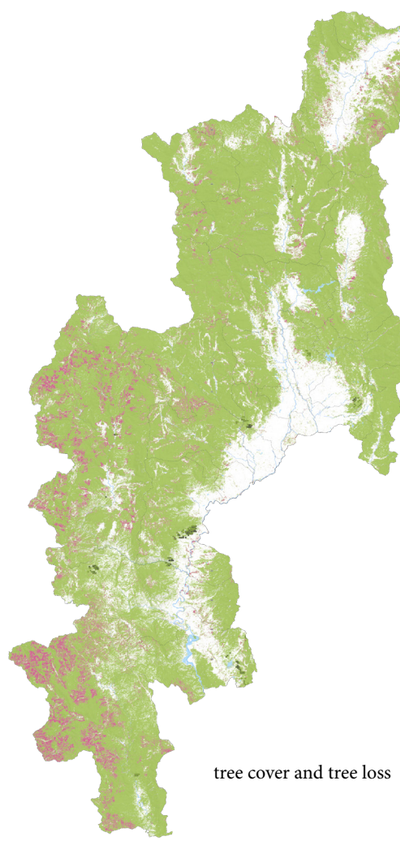
Fig. 3-19: Canopy cover mapping of Chiang Mai Province
Drawn by author, Data source: Open Government Data of Thailand, https://data.go.th/en/Thai Open Data, http://www.thaiopendata.org/

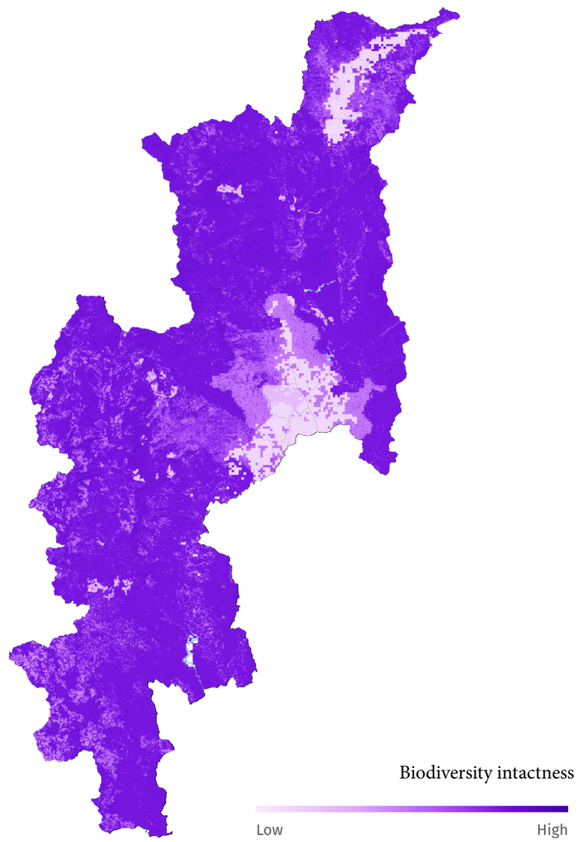
There is basically no large area of tree cover within the Chiang Mai city. Low tree cover in urban area is unfriendly to the absorption of haze in the city. Haze that cannot be dispersed poses a lasting health risk to people in city.



Why does it have lasting impacts?

IV. BIODIVERSITY





Based on two mappings above, the light purple area in Biodiversity Intactness map which is original forest area has lost some of biodiversity because of massive human activities especially setting fire in forest intentionally.

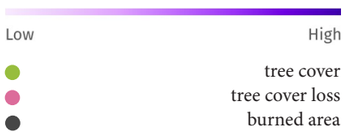


Fig. 3-20: Tree cover and tree loss mapping of Chiang Mai Province
Drawn by author, Data source: https://www.globalforest-watch.org/

Fig. 3-21: Biodiversity intactness mapping of Chiang Mai Province
Drawn by author, Data source: https://www.globalforest-watch.org/

How was it limited to mitigate identified issue?

Interview from Locals

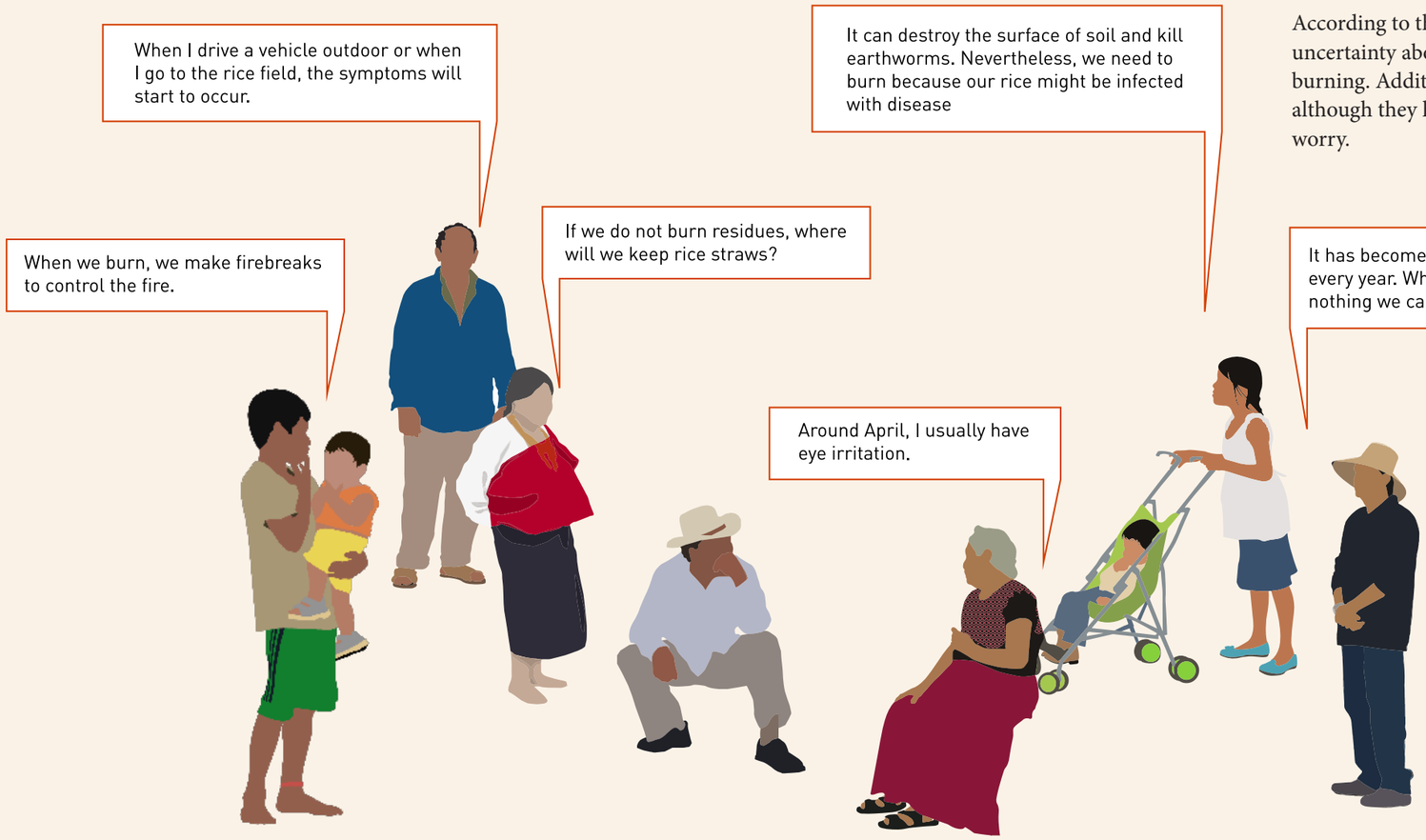


Fig. 3-22: Interview from local residents
Drawn by author, Interview content from: Contributing factors and impacts of open burning in Thailand: perspectives from farmers in Chiang Rai province, Thailand (Adeleke A, Apidechkul T, Kanthawee P, et al., 2017)

Interview from locals

Gathering information from external sources is valuable, but it is equally important to consider the perspectives of local people. It provides a comprehensive understanding and considers the socio-cultural aspects that influence their attitudes and practices towards open burning.

According to the interviews of locals from a paper, some farmers expressed uncertainty about alternative methods of managing crop residues aside from burning. Additionally, some residents view open burning as a way of life and although they have some symptoms but they think it's fine and no need to worry.

How was it limited to mitigate identified issue?

Planning and Policy Context

PAST
Subsistence Agriculture

1961
Shift in policy:
Agriculture products export

1980s
NGOs: Promoting sustainable agriculture

1991
NGOs: Promoting organic agriculture

1997
National Fire Haze Control Plan of Action

2004
National Master Plan for Open Burning
(2004-2009)

2005
Government agencies:
Focusde on organic agriculture

2007
Zero Burning Measure

2015
Northern Haze Prevention & Mitigation Plan

Planning and policy timeline

The government and NGOs had made considerable efforts to stop open burning and other unsustainable farming practices. However, based on the timeline, it can be clearly found that since transition from subsistence agriculture to export agriculture in Thailand, many problems came into existence. Since 1980s, NGOs started promoting sustainable and organic agriculture. But the farmers didn't respond or act on it. In 2007, the government introduced Zero Burning Measures policy to control open burning.

Fig. 3-22: Planning and policy timeline
Drawn by author, Policy research: Opportunities and constraints of organic agriculture in Chiang Mai Province, Thailand (Pattanapant, A., & Shivakoti, G. P., 2009)

How was it limited to mitigate identified issue?

A Ban That is Never a Ban

“

Offenders are charged and made to pay fines which could range from

฿ 2000-5000

= 0.5x-1.5x monthly income

The main actors are fearless young-adult males who mostly perpetrate the act at night,

regardless of the rules.

”

“

Open-air burning is illegal under a number of central and local legislations, including Article 220 of the Criminal Codes, which carries a maximum punishment of

7 YEARS in prison

but those laws are rarely enforced.

”

Fig. 3-33: Fines and penalties on open burning
Drawn by author, Data source: Opportunities and constraints of organic agriculture in Chiang Mai Province, Thailand (Pattanapant, A., & Shivakoti, G. P., 2009)

A ban that is never a ban

However, a ban that is never a ban. Imposed bans on open burning may not be effective in stopping the practice due to lack of enforcement. Unfortunately, there are those who disregard regulations and engage in illegal activities regardless of the existing rules.

Therefore, based on the interview and policy context, it is concluded that open burning has always been existing because farmers lack of expertise, technology and public awareness regarding health impacts of open burning and haze, and inadequate and inefficiently implemented policies.

Lack of expertise and technology dealing with organic waste

Lack of public awareness regarding health impacts of open burning and haze

Inadequate and inefficiently implemented policies

4

REGIONAL VISION & STRATEGY

In this chapter, a regional vision is proposed based on the regional site analysis. This vision is supported by an integrated strategy framework that outlines pathways to achieve the proposed future. The overall strategies identify a wide range of possible interventions from multiply layers, emphasizing the importance of collaboration among experts, decision-makers, and stakeholders. By synthesizing all these strategies, the ultimate goal of mitigating air pollution in Chiang Mai is pursued.

4.1 Towards a vision
4.2 Regional Vision
4.3 Strategy framework
4.4 Five strategies
4.5 Strategic positioning & phasing

Towards a vision
Distribution of Rice Field

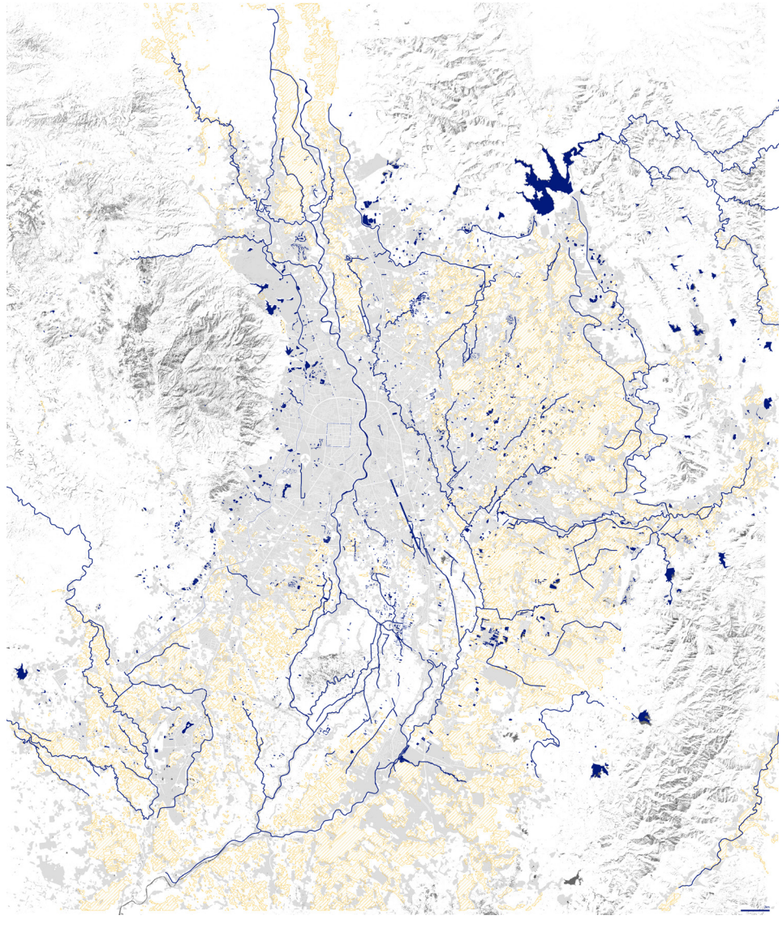


Fig. 4-1: Zoom-in area in Chiang Mai Province
Drawn by author

Fig. 4-2: Distribution of rice field in Chiang Mai
Drawn by author, Data source: https://agri-map-online.moac.go.th/

The map shows the distribution of rice field in Chiang Mai. The open burning will happen in these areas.

0 2 km 10 km 20 km N

rice field

Towards a vision
Suitability for Rice Field

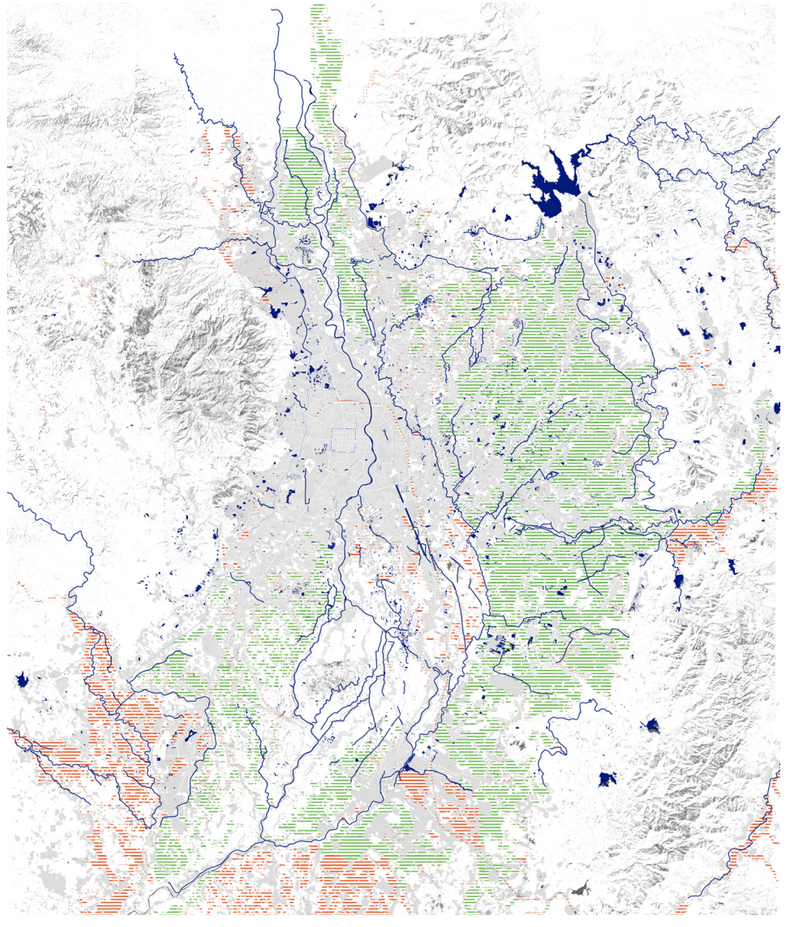


Fig. 4-3: Zoom-in area in Chiang Mai Province
Drawn by author

Fig. 4-4: Suitability for rice field in Chiang Mai
Drawn by author, Data source: https://agri-map-online.moac.go.th/

Different areas within Chiang Mai may have varying soil types, topography, microclimates, and water resources. This analysis of suitability for rice fields ensures that careful planning and selection of suitable areas to ensure optimal use of resources and maximize productivity.

high suitabilty

low suitabilty

N

Based on suitability for rice field, it could be determined if the land should be **retained** for rice cultivation or **replaced** for better alternative uses.

0 2 km 10 km 20 km

Towards a vision
Fire Hotspot in Forest

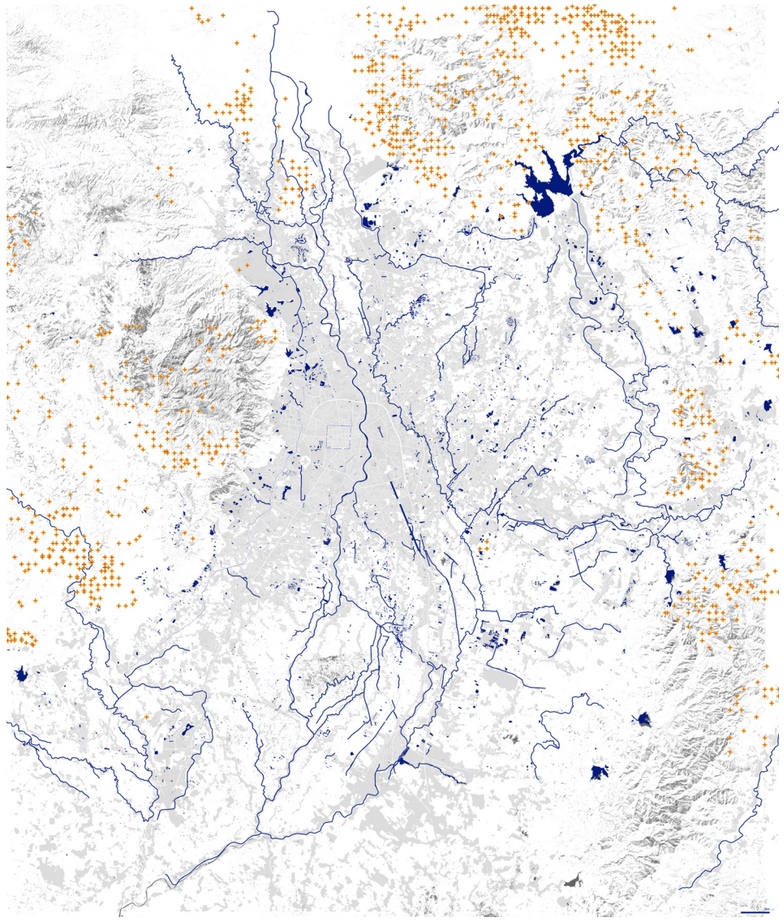
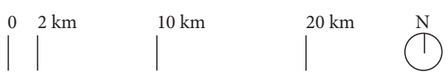


Fig. 4-5: Zoom-in area in Chiang Mai Province
Drawn by author

Fig. 4-6: Fire hotspot in forest in Chiang Mai
Drawn by author, Data source: http://www.thaiopendata.org/, https://data.humdata.org/dataset?q=thailand

The fires basically occur in the **fringe** of the forest, surrounding urban area.



Towards a vision
Green Space in Urban Area

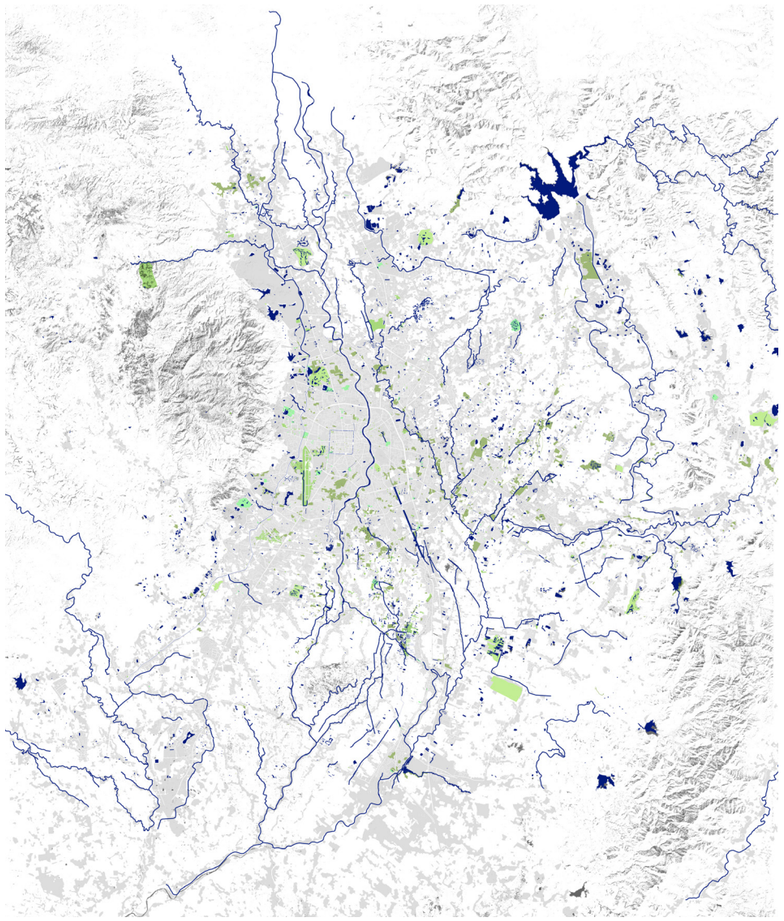
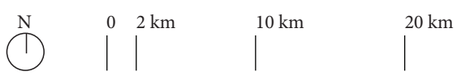


Fig. 4-7: Zoom-in area in Chiang Mai Province
Drawn by author

Fig. 4-8: Green space in urban area in Chiang Mai
Drawn by author, Data source: https://www.openstreet-map.org/

Low rate of greening in urban area obviously has **too little capacity** to capture air pollutants generated from open burning on agricultural lands and forest fires.



Towards a vision
CONCLUSION

Based on the regional analyses, specific strategies are proposed to be implemented in different areas of Chiang Mai to control sources of air pollution and remove the pollution that already generated:

Forest areas: Immediate actions should be taken to prevent man-made forest fires to minimize sources of air pollution and efforts should be made to restore lost biodiversity in the forests, as a diverse ecosystem can help clean the surrounding air.

Agricultural areas: In order to control the sources of pollution, adopt sustainable agricultural system, for instance, replace the existing rice field of low suitability with agro-forestry.

Urban areas: Enhancing overall green coverage in urban areas is essential to address pollution that has already been generated.

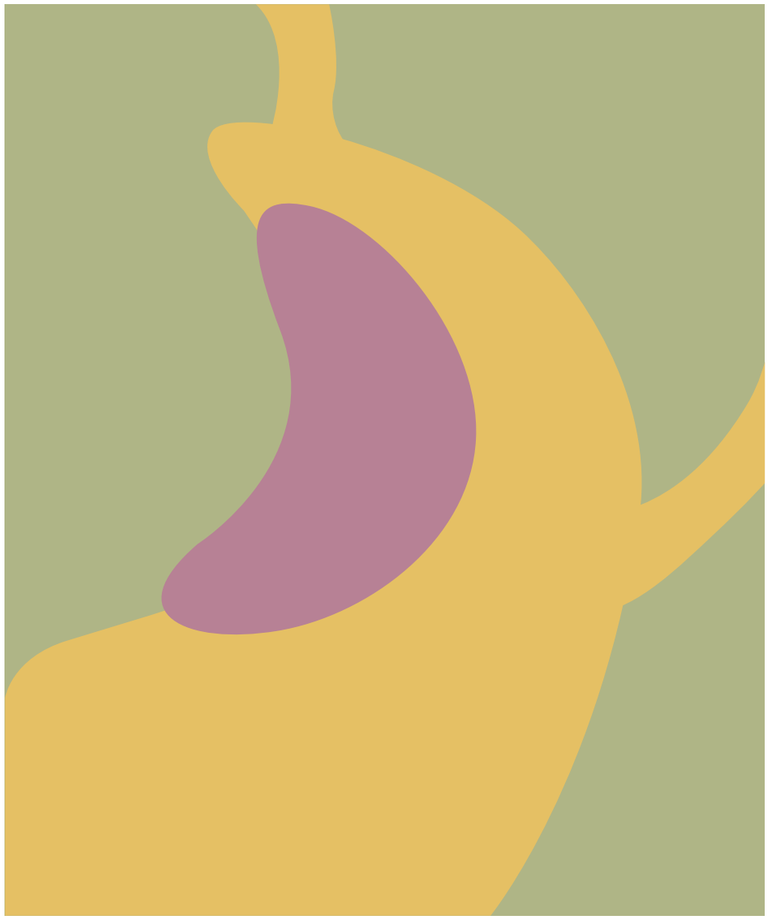
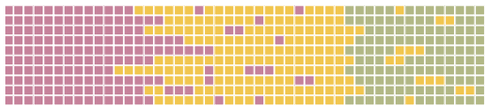


Fig. 4-9: Simplified structure of Chiang Mai City (zoom-in region)
Drawn by author



FOREST

damaged
undiversified

Restore Biodiversity

AGRICULTURE

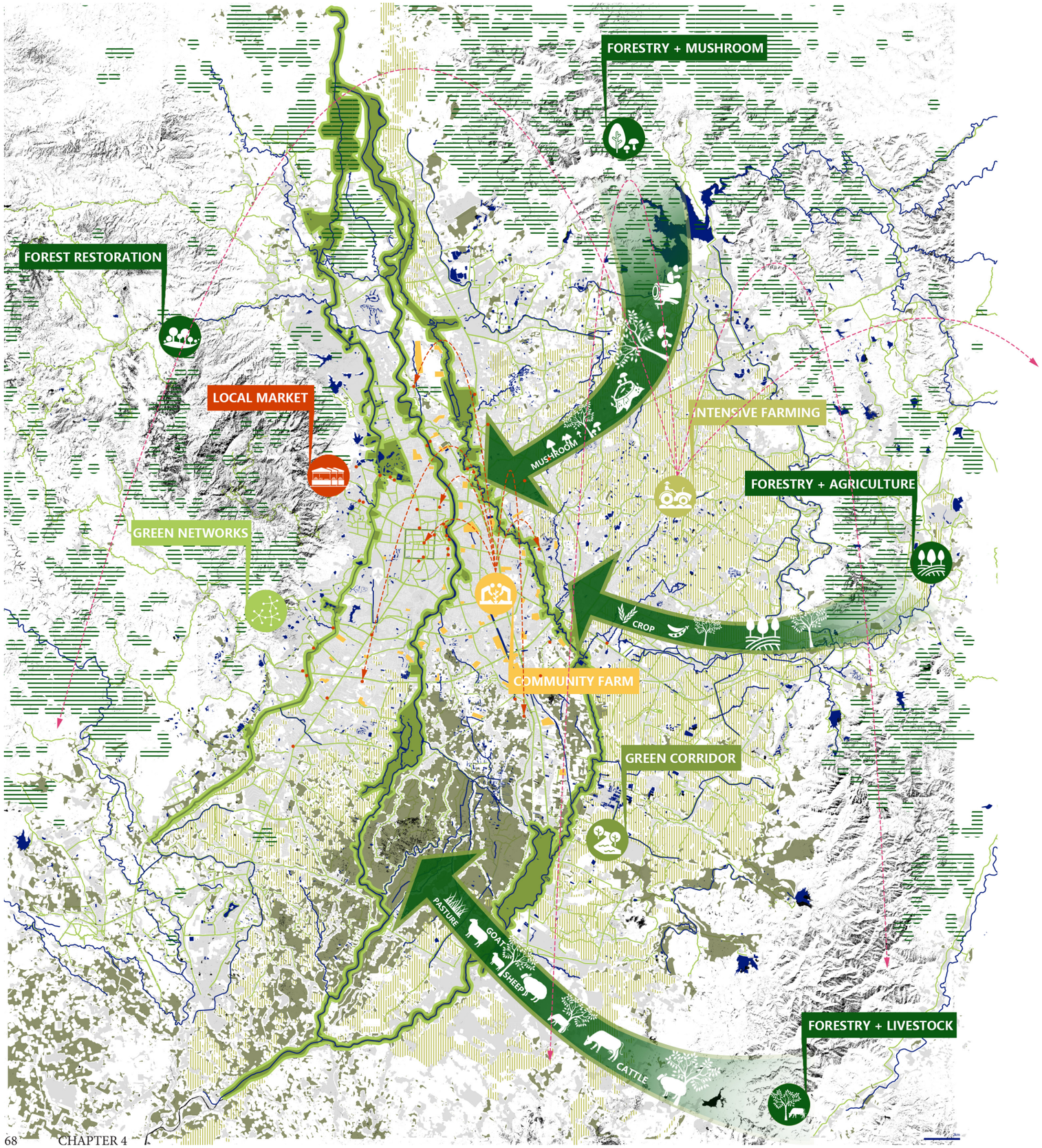
monocultural
unsustainable

Promote Sustainable Agriculture

URBAN

ungreen
air polluted

Improve Green Coverage



REGIONAL VISION

The regional vision presented here is the result of extensive research and analysis, focusing on two fundamental principles: controlling sources of air pollution and mitigating existing pollution. This vision outlines specific strategies for different areas:

Forest area: Achieve Regenerative Forest Scenario by active restoration method.

Agriculture area: Introduce agroforestry, community supported agriculture and intensive farming to achieve an Integrated Farming Scenario.

Urban area: Envision a Haze-free Urban Scenario by establishing green networks and with help of urban greening and urban farming.

REGENERATIVE
Forest Scenario

INTEGRATED
Farming Scenario

HAZE-FREE
Urban Scenario

agroforestry
intensive agriculture
active restoration
green corridor
community farm
orchard
local market
aim at local market
aim at global market

Fig. 4-10: Regional vision for zoom-in region
Drawn by author

N 0 1 km 5 km 10 km

STRATEGY FRAMEWORK **STRATEGIES**

STRATEGY 1

Create Partnerships among Farmers, Government and NGOs

STRATEGY 2

Reconfigure Relationship between Farmland and Urban Development

STRATEGY 3

Apply Active Restoration Methods for Biodiversity Recovery

STRATEGY 4

Rehabilitate with Agroforestry as an Alternative to Agriculture

STRATEGY 5

Improve Green Coverage and Build Green Network

Reference:

Xu, J., Mercado, A., He, J., & Dawson, I. (2013). An agro-forestry guide for field practitioners. World Agroforestry Centre.

Reducing intensification by shifting cultivation through sustainable climate-smart practices in tropical forests: A review in the context of UN Decade on Ecosystem Restoration (2021), Villa, P. M.

STRATEGY FRAMEWORK **STRATEGIC PHASING**

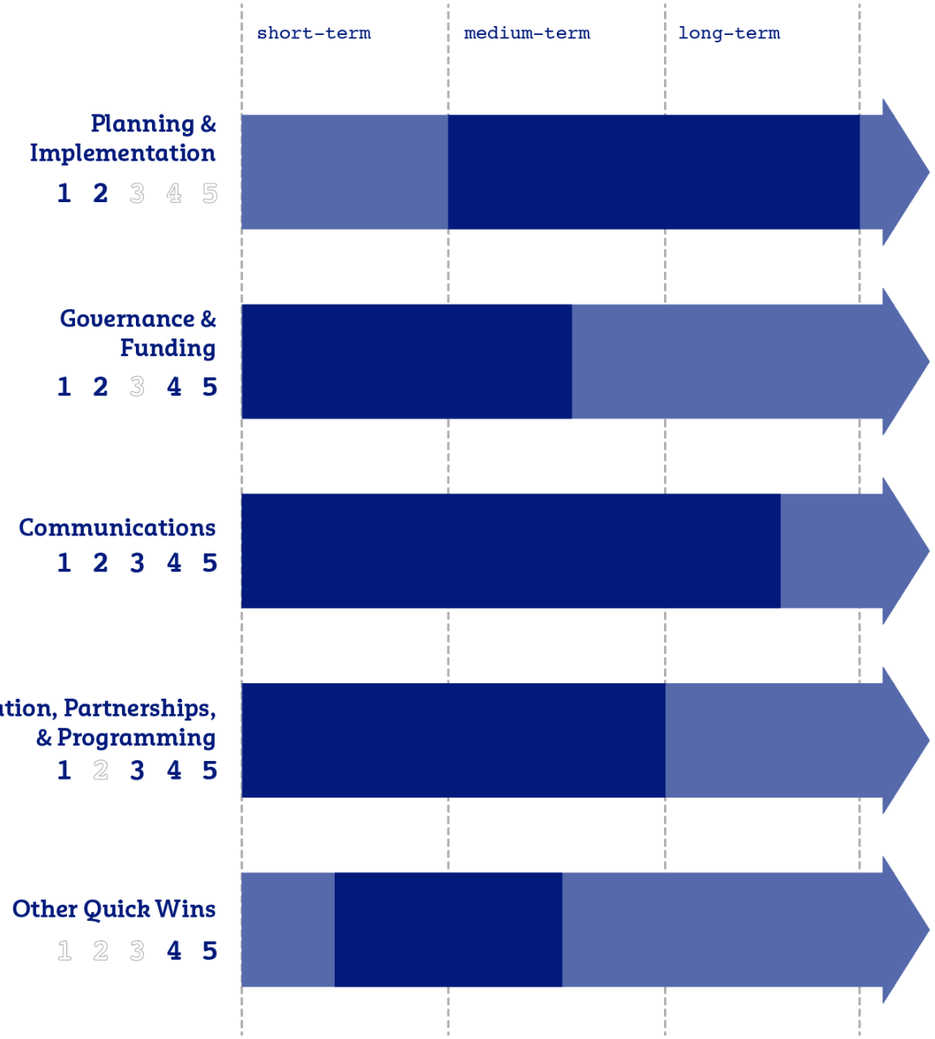


Fig. 4-11: The phasing of strategies implementation
Drawn by author

I. Create Partnerships among Farmers, Government and NGOs.

GOVERNMENT

- Provide policy support and appropriate incentives
- Provide financial and material support
- Complement technical and facilitation needs
- Facilitate marketing link
- Encourage diversification of agricultural production

NGO

- Share information on appropriate technologies
- Provide expertise in multiple fields
- Launch community-level campaign or advocacy
- Link local knowledge and scientific knowledge systems

FARMER

- Share knowledge, skills, and low-cost material
- Committed to resource conservation
- Share experience and draws local supports
- Adapt and innovate agroforestry technologies

As analyzed before in planning and policy context, open burning and forest fire have always existed because farmers lack of expertise, technology and public awareness regarding health impacts of open burning and haze, and inadequate and inefficiently implemented policies.

Therefore, by building partnerships, a consensus can be reached to stop open burning and deliberate fires in the forest. In return, the government could provide policy support and incentives to support farmers financially. And NGOs could share information on technologies and provide expertise in multiple fields.

Reference:
An agroforestry guide for field practitioners. World Agroforestry Centre (2013). Xu, Jianchu, et al.

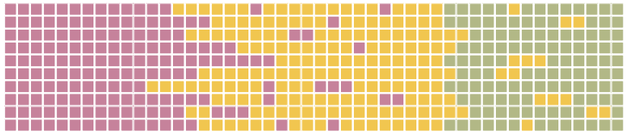
Fig. 4-12: Contributions from farmers, government and NGOs to reach cooperation and build the partnership
Drawn by author

II. Reconfigure Relationship between Farmland and Urban Development

Develop a comprehensive land use plan that balances the need for urban development with farmland. Define the boundary of urban area and agriculture area to limit urban expansion and prevent encroachment onto agricultural areas.

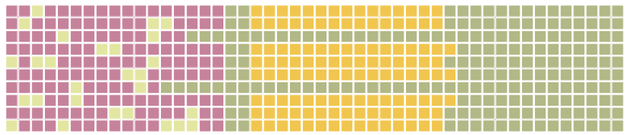
Continuing the pattern of the forest, bringing more green into urban area. Encourage mixed-use development patterns that integrate residential, commercial, and agricultural elements. Incorporate urban farming, urban greening into monotonous living conditions to improve green cover in urban area.

CURRENT
Scenario



Urban area and agriculture area are merging, and farmlands are invading forest

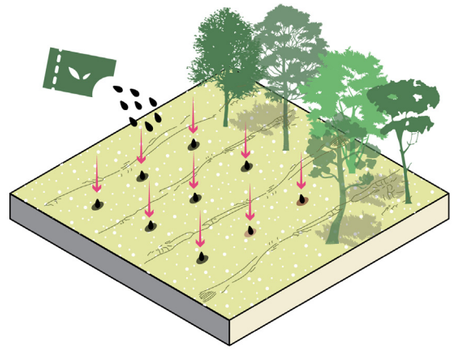
INTEGRATED
Farming Scenario

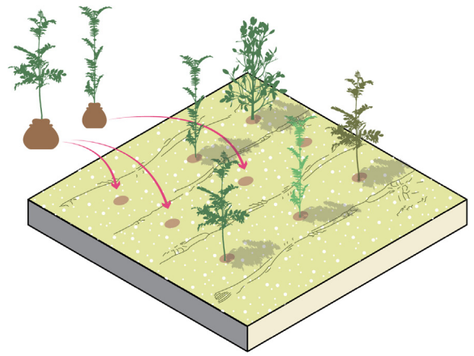


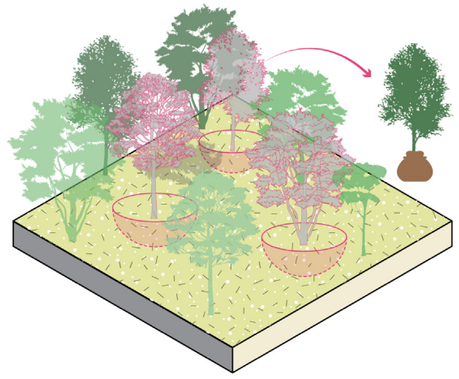
Introducing agroforestry and urban farming, more green in urban area

Fig. 4-13: Current situation of relationship among urban development, farmland and forest
Drawn by author

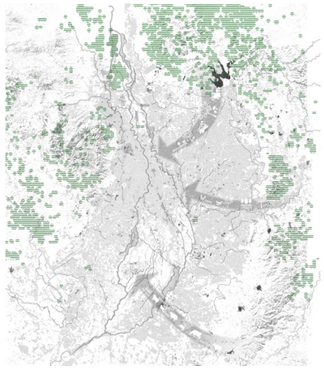
Fig. 4-14: Proposed scenario of relationship among urban development, farmland and forest
Drawn by author







III. Apply Active Restoration Methods for Biodiversity Recovery



For forest layer, direct seeding, tree seedling planting and tree transplantation from old-growth forest will be implied to restore damaged forest and recover biodiversity.

- Direct seeding

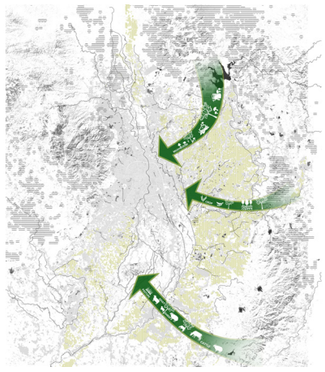
- Tree seedling planting

- Tree transplantation from

Fig. 4-15 (right): Strategy III implementation area
Drawn by author

Fig. 4-16 (left): 3 strategy toolboxs in forest area: Direct seedin, Tree seedling planting, Tree transplantation from old-growth forest

IV. Rehabilitate with Agroforestry as an Alternative to Agriculture



For agriculture layer, introducing three different kinds of agroforestry, forestry + livestock, forestry + mushroom farming, forestry + agriculture, which is also a link with the elements in previous analysis in problem statement. Use these kinds of agroforestry as an alternative to traditional agriculture.

- Forestry + Agriculture

- Forestry + Livestocks

- Forestry + Mushroom Farming

Fig. 4-17 (left): Strategy IV implementation area
Drawn by author

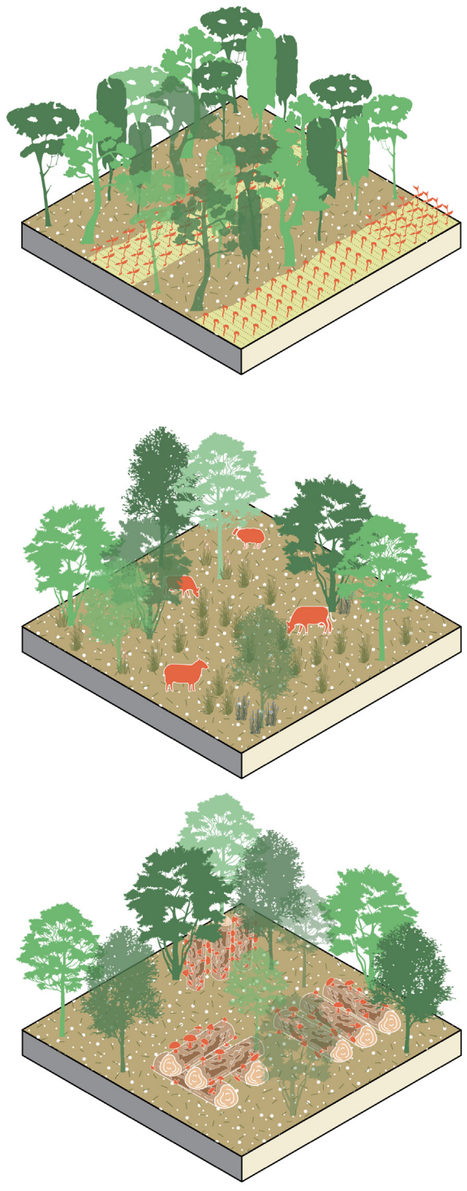
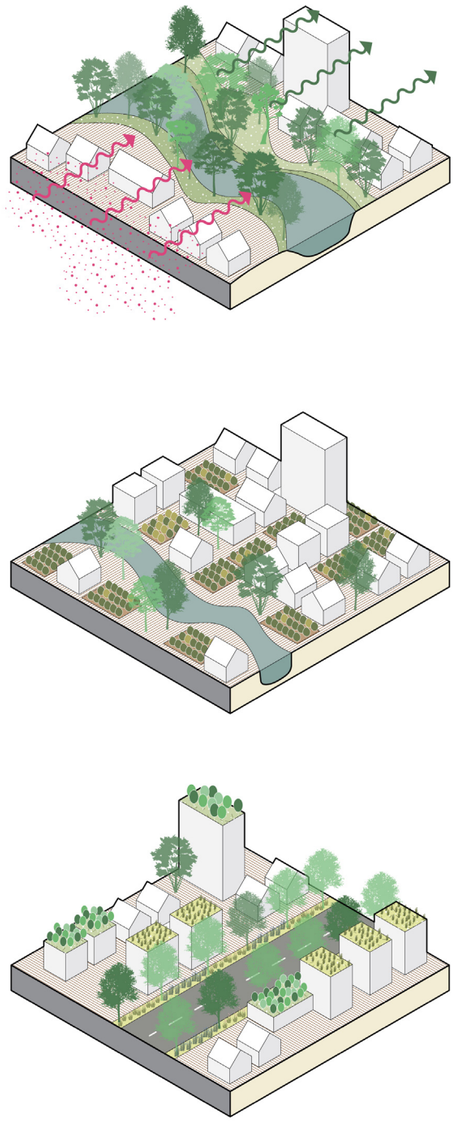
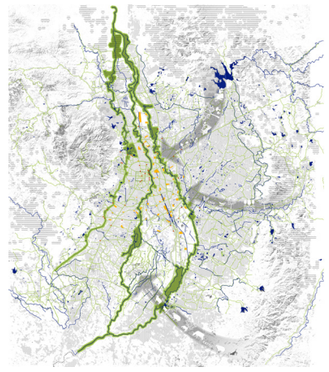


Fig. 4-18 (right): 3 strategy toolboxs in agriculture area: Forestry + Agriculture, Forestry + Livestocks, Forestry + Mushroom Farming
Drawn by authorDrawn by author

V. Improve Green Coverage and Build Green Network





For urban layer, establishing ecological green corridor as filters, in the meanwhile introducing urban farming and greener street, green roof/balcony to improve green coverage to deal with air pollution in the urban environment.

- Green corridor as filter

- Urban farming

- Green street/roof/balcony

Fig. 4-19 (right): Strategy V implementation area
Drawn by author

Fig. 4-20 (left): 3 strategy toolboxs in urban area: Green corridor as filter, Urban farming, Green street/roof/balcony
Drawn by author

STRATEGIES
SYNTHESIS OF STRATEGIES

Strategy three, four, five correspond to forest, agriculture and urban layer.

Besides, agroforestry can be used as pollinator corridor to bring pollinators from forest to the urban area, which will be quite beneficial to urban farming.

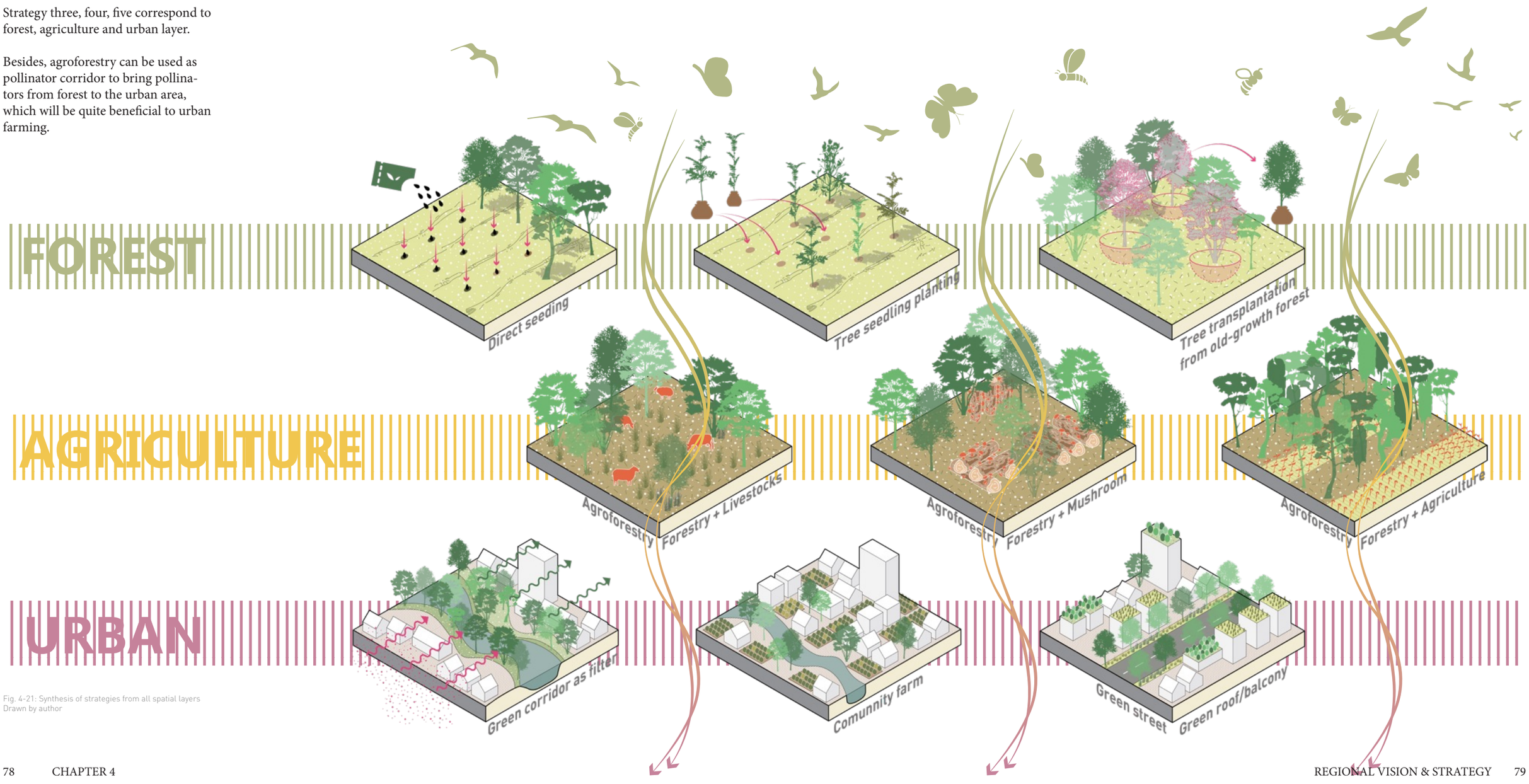


Fig. 4-21: Synthesis of strategies from all spatial layers
Drawn by author

STRATEGIC POSITIONING AND PHASING

CURRENT SITUATION

PROPOSED SCENARIO - 5 YEARS

Improvements have been made in reducing fragmentation, leading to a potential enhancement in air quality. This progress can be attributed to the decrease in open burning and forest fires.

PROPOSED SCENARIO - 20 YEARS

The ongoing efforts to address fragmentation have resulted in further improvements. As a result, air pollution has become a thing of the past, even during the burning season.

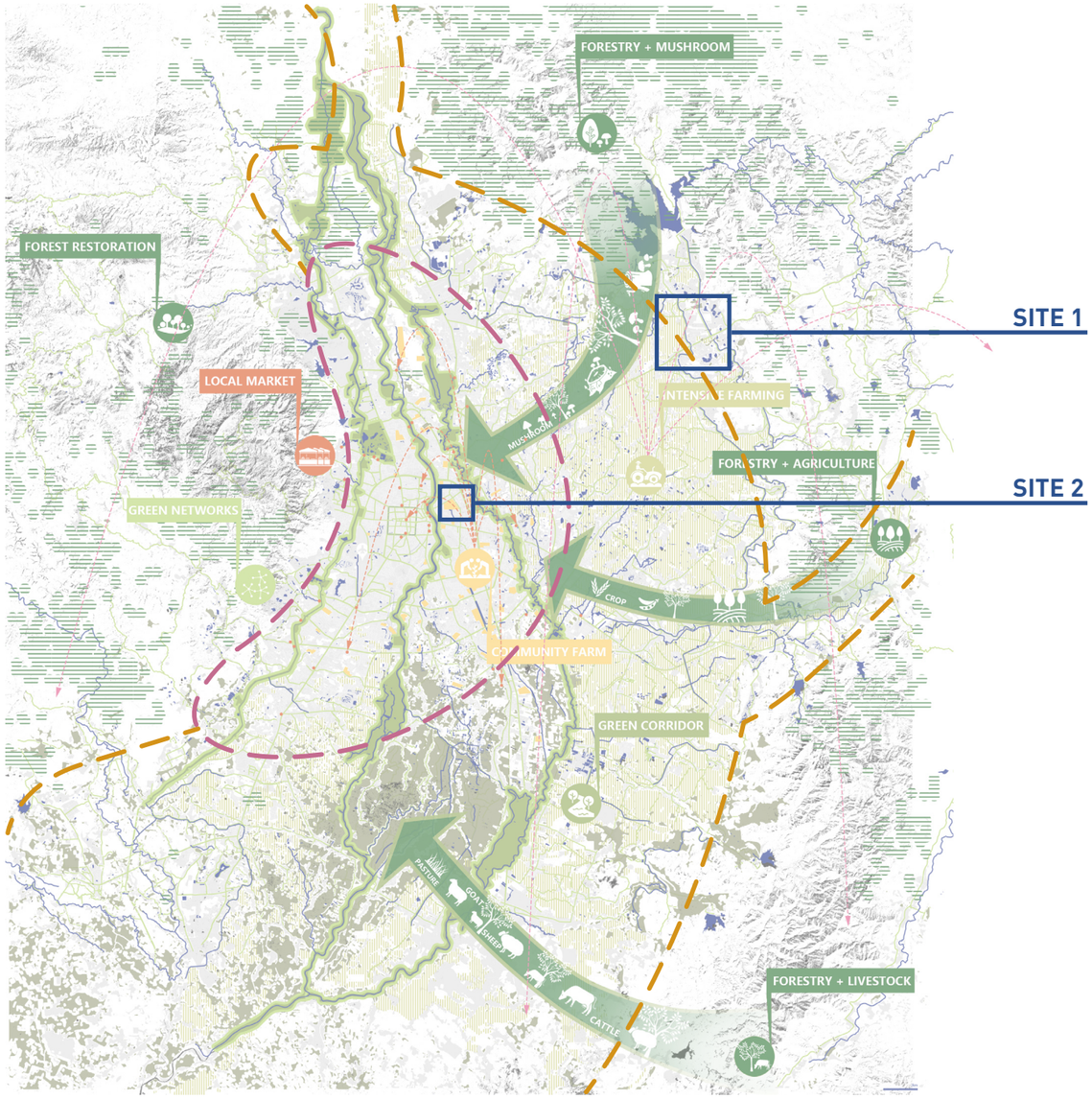
Fig. 4-22: Strategic positioning and phasing (current situation and proposed scenarios in 5 years and in 20 years)
Drawn by author

5

DESIGN EXPLORATION

In this chapter, a rural site and an urban site have been selected to serve as pilot projects, representing an agricultural and urban area respectively. These projects will further elaborate on the top-down strategies proposed in the regional vision, while also incorporating site-specific strategies tailored to each location's unique characteristics. The aim is to develop these two projects as models that can be showcased to other sites within Chiang Mai, demonstrating effective approaches to mitigate air pollution in a sustainable way in the region.

5.1 Site selection
5.2 Pilot project 1: A Self-sufficient Agro-ecosystem
5.3 Pilot project 2: A Vibrant Social-ecosystem



RURAL

SITE 1

Forestry + agriculture (Agroforestry)
Forestry + livestock (Agroforestry)
Forestry + mushroom farming (Agro-forestry)

URBAN

SITE 2

Local farmer market (Sustainable production mode)
Community farm (Urban farming)
Streetscape (Urban farming and greening)

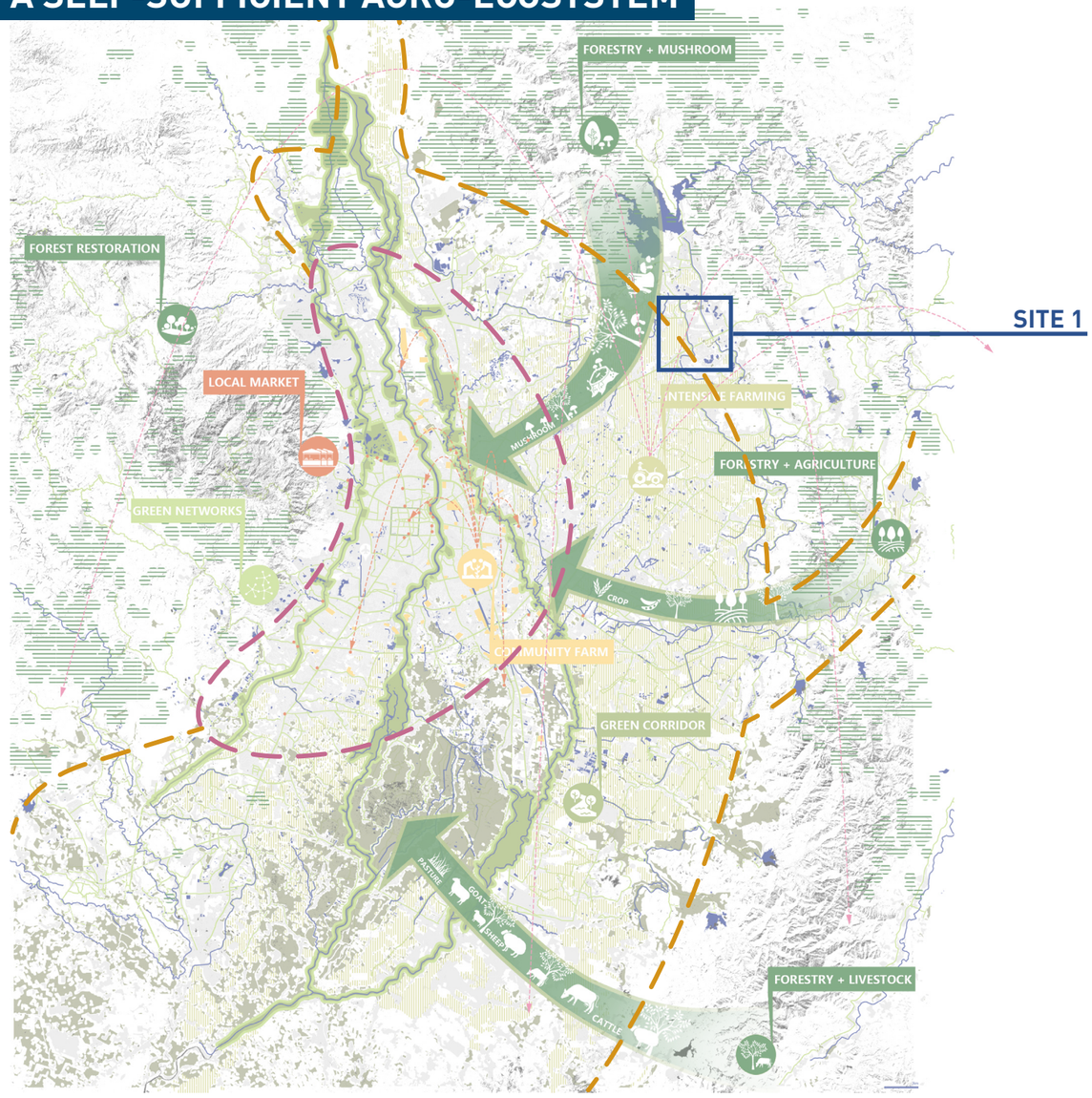
SITE SELECTION

In vison and strategy part, corresponding strategies are presented at each level of the forest, agricultural and urban areas.
But in the case of forests, except for the active restoration methods at the beginning, it is common sense that minimal human intervention is often the most effective approach. Let time and nature do the work.

In the other two layers, a rural site and an urban site have been picked out, corresponding to an agricultural and an urban area respectively. These two sites will serve as the pilot project to further elaborate the top-down strategies proposed in vision, while also incorporating some site-specific strategies depending on the specificity of the site.

The ultimate aim is to achieve an integrated agricultural scenario and a haze-free urban scenario, aligning with the overall vision.

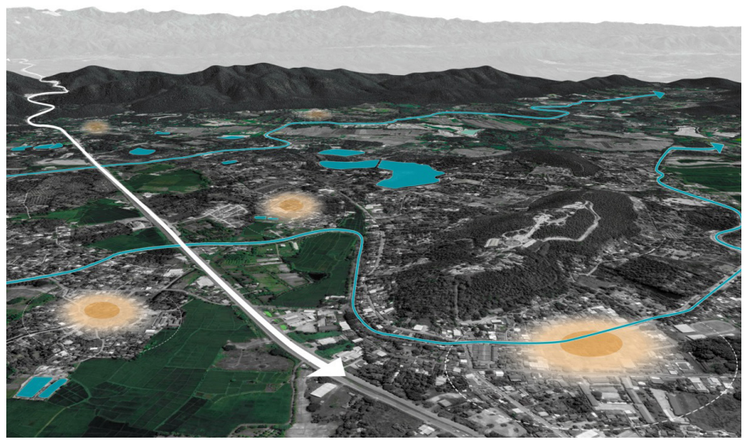
PILOT PROJECT 1
A SELF-SUFFICIENT AGRO-ECOSYSTEM











CONTEXT
FRAGMENTATION

The site is located in Choeng Doi, Doi Saket District, a rural context, just adjacent to the mountainous border. Highway 118 runs through the site and several villages are scattered along the highway, while the villages are surrounded by farmland. It is clear from the pattern of the satellite map that a highly fragmented residential areas are gradually occupying the remains of agricultural land.

The farmland on the site is mainly paddy field, therefore, during the rice growing season, most of the farm areas are waterlogged. While in the harvest season, farmers tend to burning agricultural residues in the field which has caused severe air pollution.

Fig. 5-1: A series of photos to show current situation of villages and agricultural lands within the site
Photos from Google Map

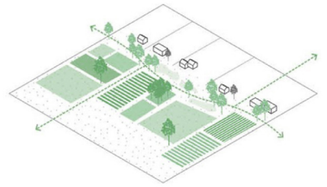
Fig. 5-2: A bird's eye view satellite view to show fragmentation of landscape and farmlands
Basemap from Google Earth Pro

DESIGN PRINCIPLE
ACTORS & ACTIVITIES

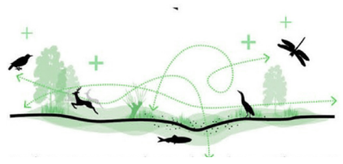
Fig. 5-3: Actors and potential activities in the site
Drawn by author

DESIGN PRINCIPLE
Enhance Ecological Environment for Actors

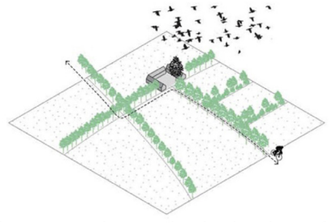
Link green space with residential area.



Define and activate the border of agriculture land and villages.



Canal structure as ecological corridor with space for water and biodiversity.



Increase the ecological value of agriculture area.

Reuse organic waste for other uses, such as composting and energy production.

Make the landscape more accessible by introducing a recreational pedestrian and cycling network.

Fig. 5-4: Design principle made to improve ecological value for different actors
Retrieved from Groenplan Roeselare + Buur

STRATEGIES

RICE-BASED AGROFORESTRY

Native Shade Trees

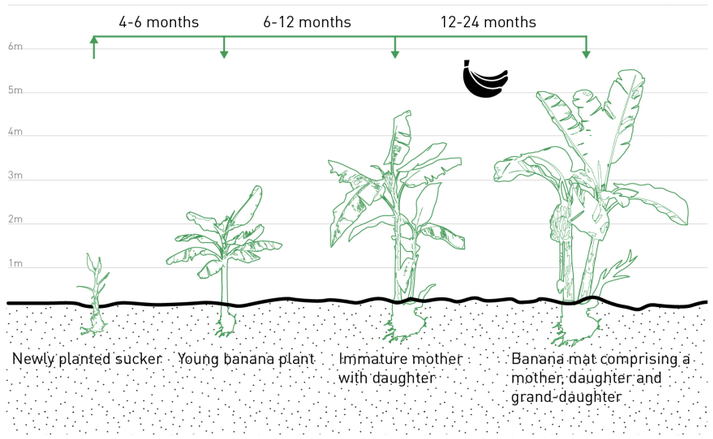
Air filtration
CO2 removal
Nutrient cycling
Water retention
Soil retention

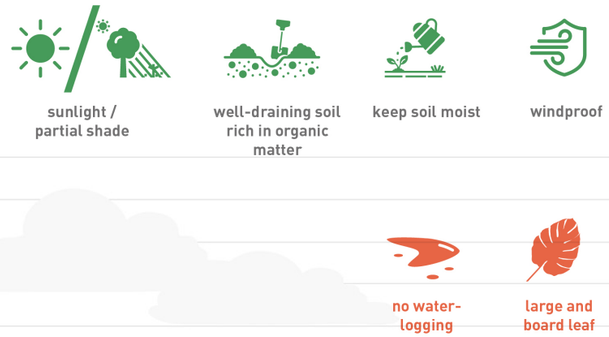
Banana

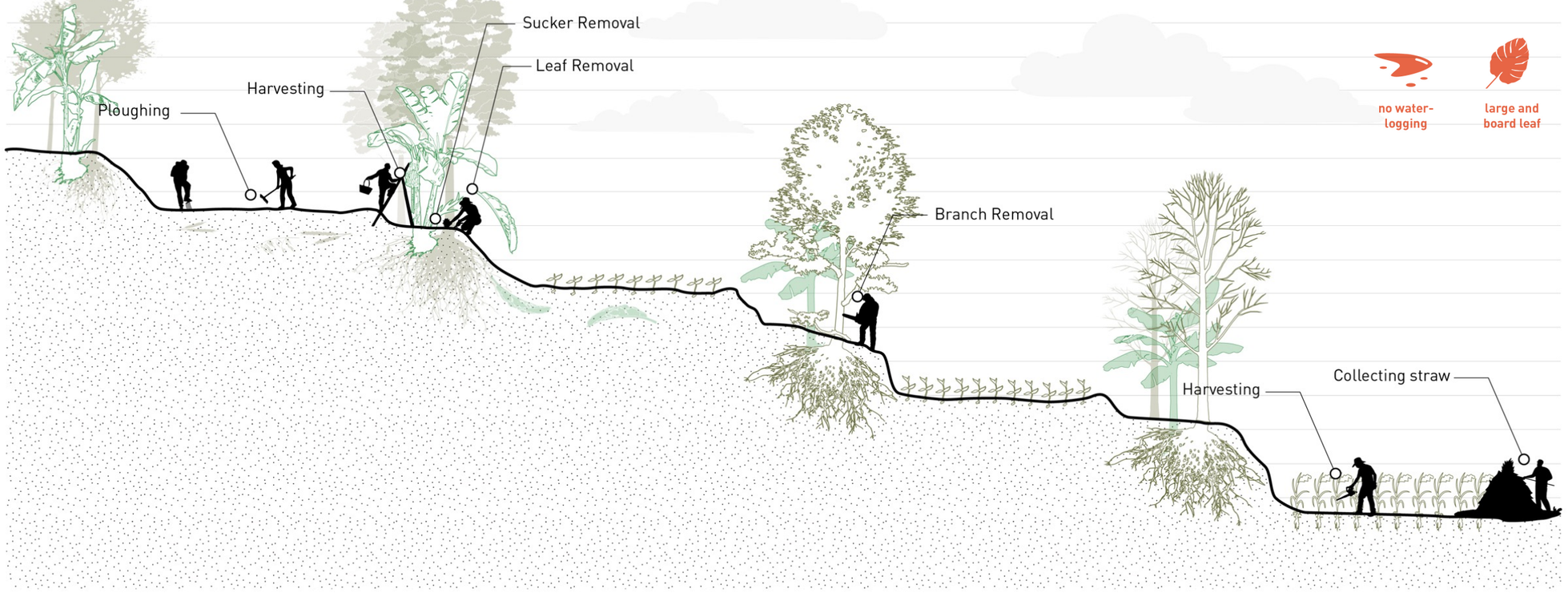
Air filtration
Sustainable revenue stream
Local food source

Crop

Sustainable revenue stream
Local food source







Rice-based agroforestry system involves growing rice and banana plants together with shade trees.

Banana Tree: Growth stages

A newly planted sucker takes approximately 4-6 months to grow into a young banana tree. It then takes another 6 months to reach maturity. Once mature, the banana tree can produce bananas for a period of 12 months. A mature banana tree ranges in height from 3 meters to 7 meters, with an average height of 5 meters.

Growth conditions

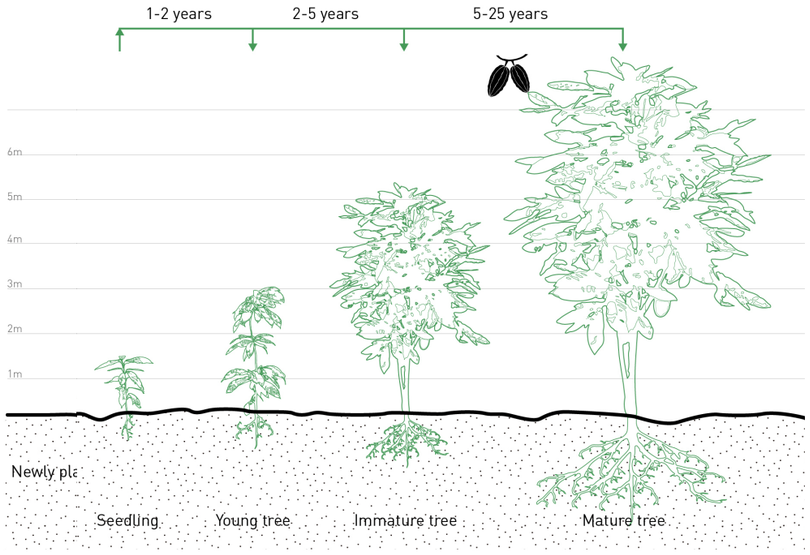
Sunlight: Banana trees require sunlight to thrive and produce fruit. It can also tolerate partial shade. It is ideal for banana trees to receive 6 to 8 hours of sunlight daily.

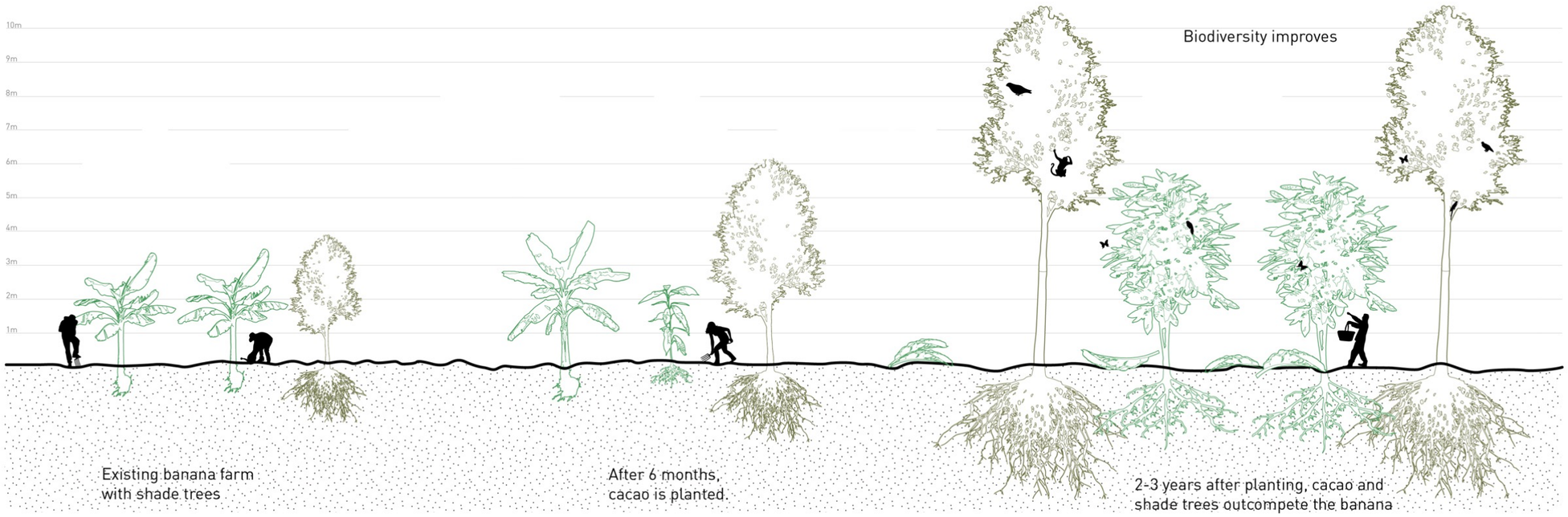
Soil: The soil should be well-draining and rich in organic matter. The ideal soil condition is loamy or sandy soil with good water retention capacity.

Watering: Banana trees have high water requirements and prefer moist soil. They should be watered regularly, providing deep irrigation to ensure the root system stays moist. However, excessive waterlogging should be avoided, as it can lead to root rot.

Wind Protection: Strong winds can damage banana plants because of their large and broad leaves. It is important to consider planting banana trees near a windbreak.

STRATEGIES
CACAO AGROFORESTRY





Cacao trees will be cultivated together with compatible local shade trees.

Cacao Tree: Growth stages

A cacao seedling takes approximately 1-2 years to grow into a young cacao tree. It then takes another 1-3 years to reach maturity. Once mature, the cacao tree can produce cacao nuts in the following 20 years. Cacaos are evergreen trees that usually grow to about 4 to 8 meters tall, although they sometimes reach heights of 12 meters.

Growth conditions

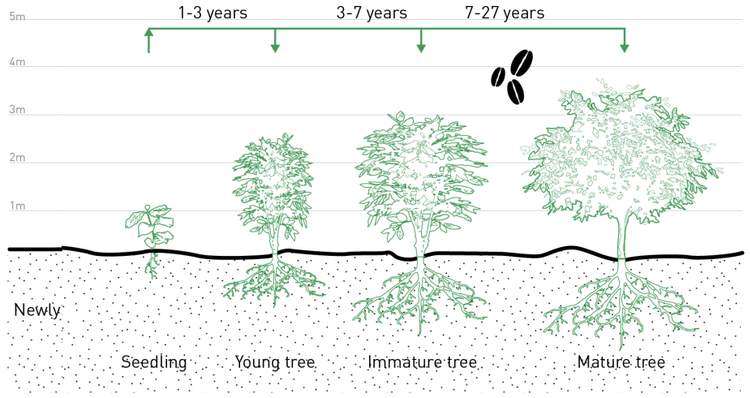
Sunlight: Cacao trees are shade tolerant and prefer partial or dappled shade. They usually grow under the canopy of taller trees, providing them with ideal shade.

Soil: Cacao trees thrive in well-draining, fertile soils with good water retention capacity. The ideal soil type is loamy or sandy soil rich in organic matter. Avoid clay soils or areas prone to waterlogging, as they can cause root rot.

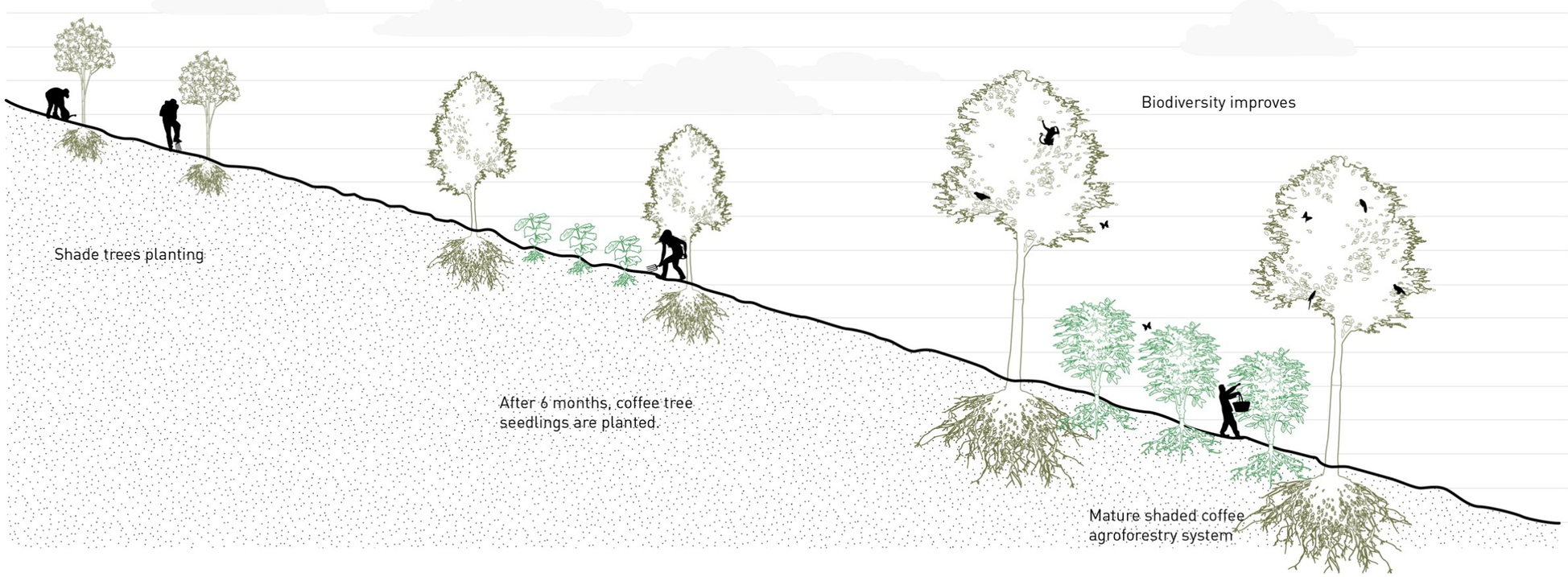
Watering: Cacao trees need regular watering, especially during dry periods or when rainfall is insufficient. It is important to keep the soil moist but not waterlogged, as too much water can lead to root rot.

Wind protection: Cacao trees are sensitive to strong wind because of their shallow roots. Planting windbreaks or providing natural barriers can help protect the trees from strong winds.

STRATEGIES
COFFEE AGROFORESTRY



Coffee agroforestry on slope



Coffee plants will be integrated with suitable shade trees on slopes.

Coffee Plant:
The coffee plant is a woody perennial evergreen shrub. The white flowering plants produce fruits called 'cherries' which contain two seeds, called coffee beans.

Growth stages
A coffee seedling takes approximately 1-3 years to grow into a young coffee tree. It then takes another 2-4 years to reach maturity. Once mature, the coffee tree can produce coffee fruit in the following 20 years. A typical commercial coffee plant will grow up to 5 meters tall. Many producers prune their coffee trees to about 2 meters to promote a more concentrated growth of coffee fruit and make them easier to harvest.

Growth conditions
Sunlight: Coffee trees require a balance of sunlight and shade. They typically thrive in dappled shade or partial sunlight. The ideal condition is filtered sunlight or about 4 to 6 hours of direct sunlight per day.

Soil: Coffee trees thrive in well-draining, fertile soils that are rich in organic matter. The ideal soil type is loamy soil with good water retention capacity.

Altitude: Coffee trees have different altitude preferences based on the species. Generally, Arabica coffee grows best at higher altitudes between 600 to 2,000 meters above sea level, while Robusta coffee can tolerate lower altitudes between 200 to 800 meters above sea level.

STRATEGIES
COMMUNITY SUPPORTED AGRICULTURE

Fig. 5-5: Integrating Community Supported Agriculture into Agroforestry system to provide multiple ecosystem services
Drawn by author

PRODUCTION:
Improve Sustainability and Resiliency of Agriculture
Agroforestry
Experiment and sharing experience and knowledge

RECREATION:
Improve Well-being
Green open space
Agro-tourism

DISTRIBUTION:
Shorten Industry Chain,
Increase the Income of Local Farmers
No transportation
No packing and no storage

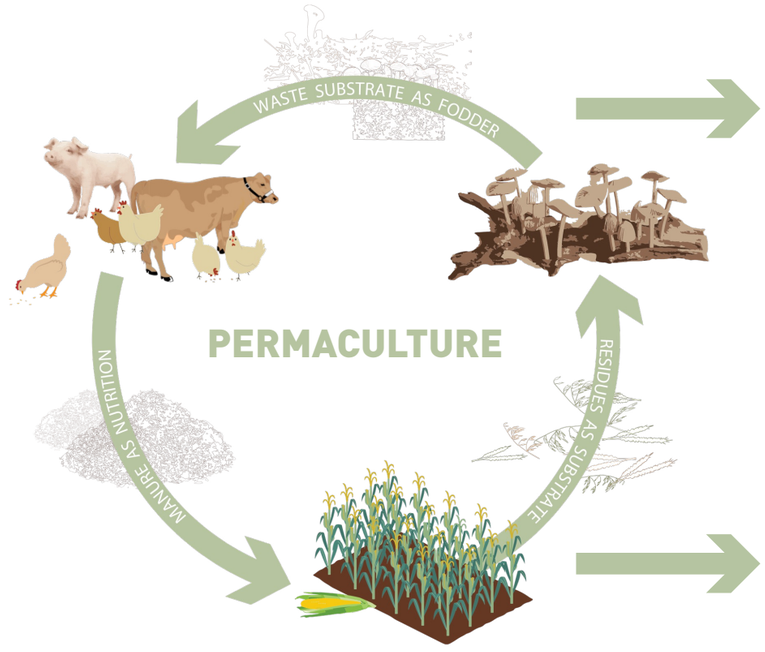
CONSUMPTION:
Guarantee Food Safety
Organic Food
Local farmer market

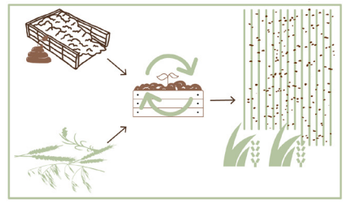
RECYCLING:
Close the Resource Loop
Composting
Recycling for energy production

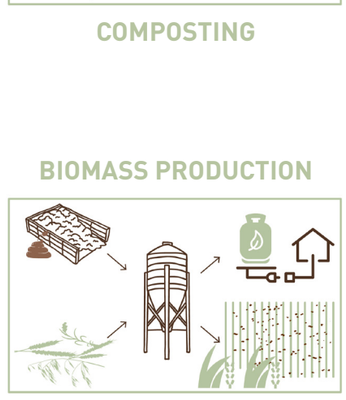
STRATEGIES
ORGANIC WASTE MANAGEMENT

Fig. 5-6: Permaculture process involving crop cultivation, livestock and mushroom production
Drawn by author

Fig. 5-7: Composting and biomass production toolbox-
Drawn by author







PERMACULTURE:
The waste straw after rice harvesting can be collected and recycled as substrate of mushroom cultivation.

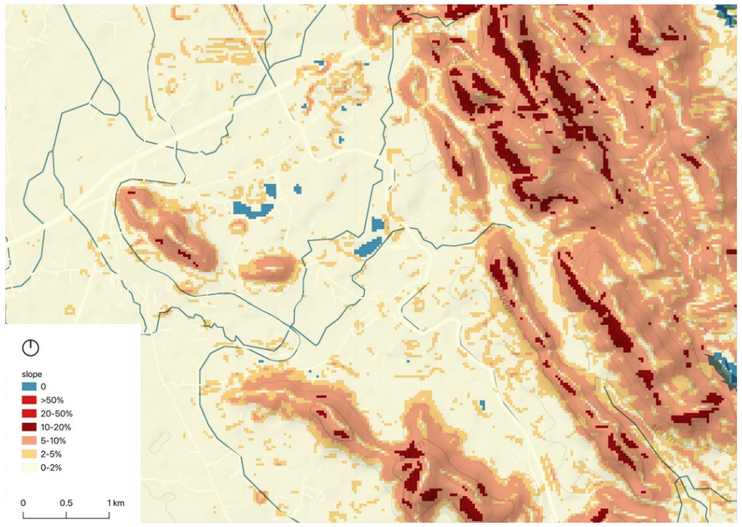
The waste substrate from mushroom production is useful as fodder for cows, chickens, & pigs.

Organic waste generated from livestock, such as manure or bedding material, can be directly recycled into the soil, improving soil fertility and providing nutrition for crops.

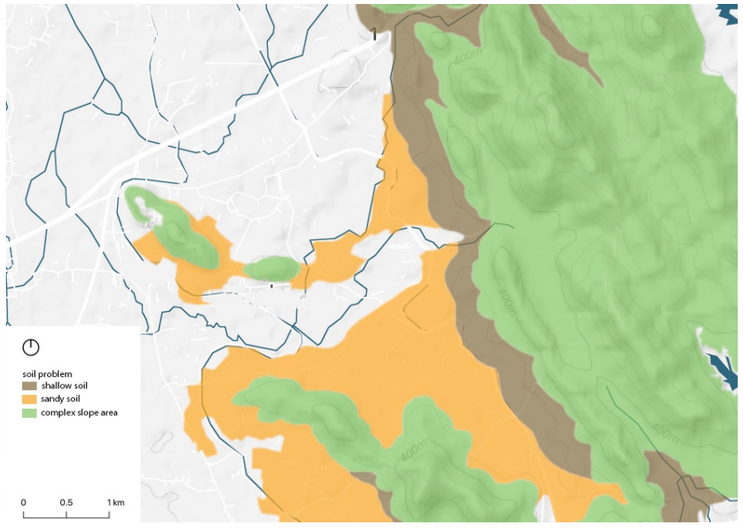
COMPOSTING:
Composting is a natural process that converts organic waste, including crop residues and shade tree trimmings into nutrient-rich compost. Integrating composting systems within agroforestry systems offers an effective solution for managing straw and other agricultural residues after harvesting. It enhances soil fertility and promotes efficient nutrient cycling within the agroforestry system.

BIOMASS ENERGY PRODUCTION:
Organic waste can be utilized as a renewable energy source through the process of anaerobic digestion. It can break down organic waste, such as crop residues or animal manure, producing biogas, which can be used for energy generation. The residual digestate from the process is a nutrient-rich fertilizer that can be applied back to the agroforestry system.

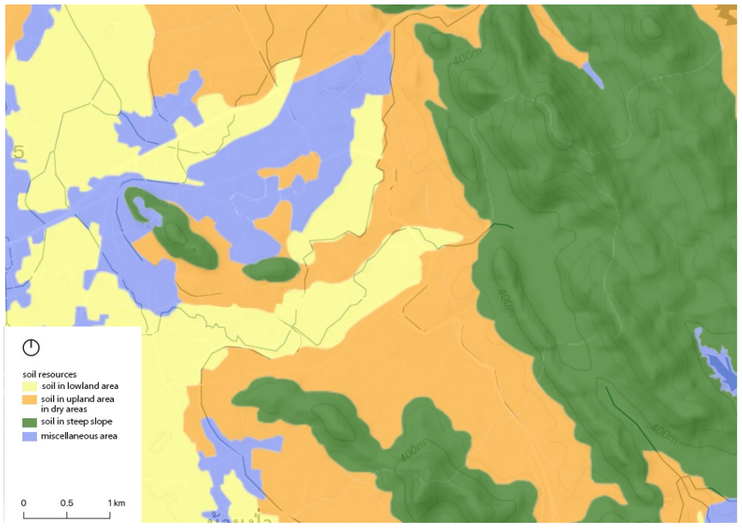
Slope analysis



Soil problem



Soil resources



Land use

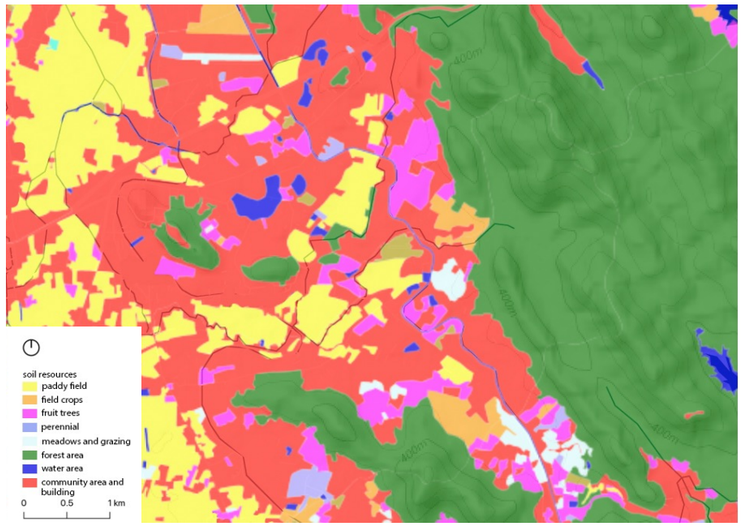


Fig. 5-8: Slope analysis
Drawn by author, data souces: https://www.arcgis.com/home/item.html?id=5f0f00a15d7f47d093c096b27a9c3b8c

Fig. 5-9: Soil problem
Drawn by author, data from agri map online: https://agri-map-online.moac.go.th/

Fig. 5-10: Soil resources
Drawn by author, data from agri map online: https://agri-map-online.moac.go.th/

Fig. 5-11: Land use
Drawn by author, data from agri map online: https://agri-map-online.moac.go.th/

MASTERPLAN
Towards a Self-sufficient Agro-ecosystem

Aligned with the regional vision, the implementation of a sustainable agriculture system, specifically agroforestry, will be the focus of this site. It is fundamental to tailor the agroforestry system to the specific characteristics of the area.

With a defined crop as the basis for agroforestry, the topography(in this case, slope) and soil condition are presented to show the suitability of three types of agroforestry, based on the design principle of ideal growing conditions.

This approach guides the planning of the most suitable areas for the each type of agroforestry and ensures that the agroforestry practices are well adapted to the site-specific conditions and promote sustainable and productive agricultural practices.

1 rice-based agroforestry
2 cacao agroforestry
3 coffee agroforestry
4 tree nursery
5 pavilion in field
6 recycling & composting center
7 waste-to-energy facilities
8 recreational corridor
9 ecological corridor
10 community plaza (farmer market)
11 recreational trails

MASTERPLAN
A Self-sufficient Agro-ecosystem

Three different types of agroforestry practices are applied based on suitability within the site. Additionally, tree nursery located at the forest border can supply tree seedlings for agroforestry and ecological restoration in the forest.

To address organic waste sustainably, recycling and composting centers are established in the field, while waste-to-energy facilities can handle organic waste after harvesting.

The villages are surrounded by forests, defining the boundary between villages and agricultural lands. The integration of recreational corridors and canal ecological corridors creates a network for residents to enjoy recreational activities.

Overall, the implementation of agroforestry, community-supported agriculture, and organic water management aims to establish a self-sufficient system. The management of waste, energy, food, and pedestrian flow is all conducted in a sustainable way.

MASTERPLAN
FLOW
THE RESPONSIBLE CITY

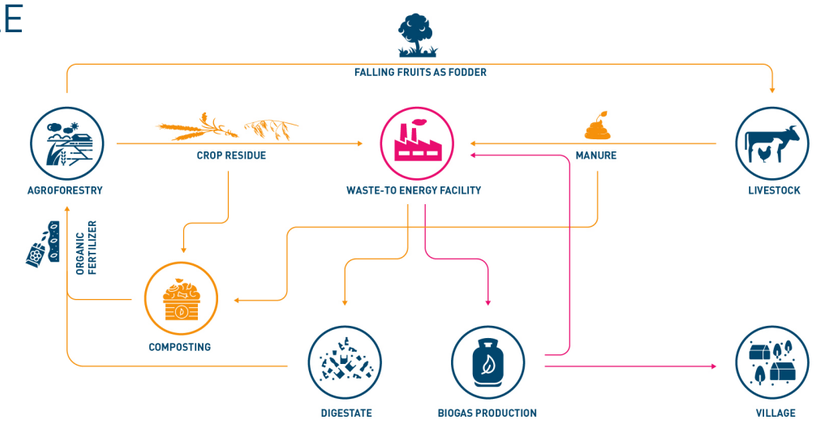
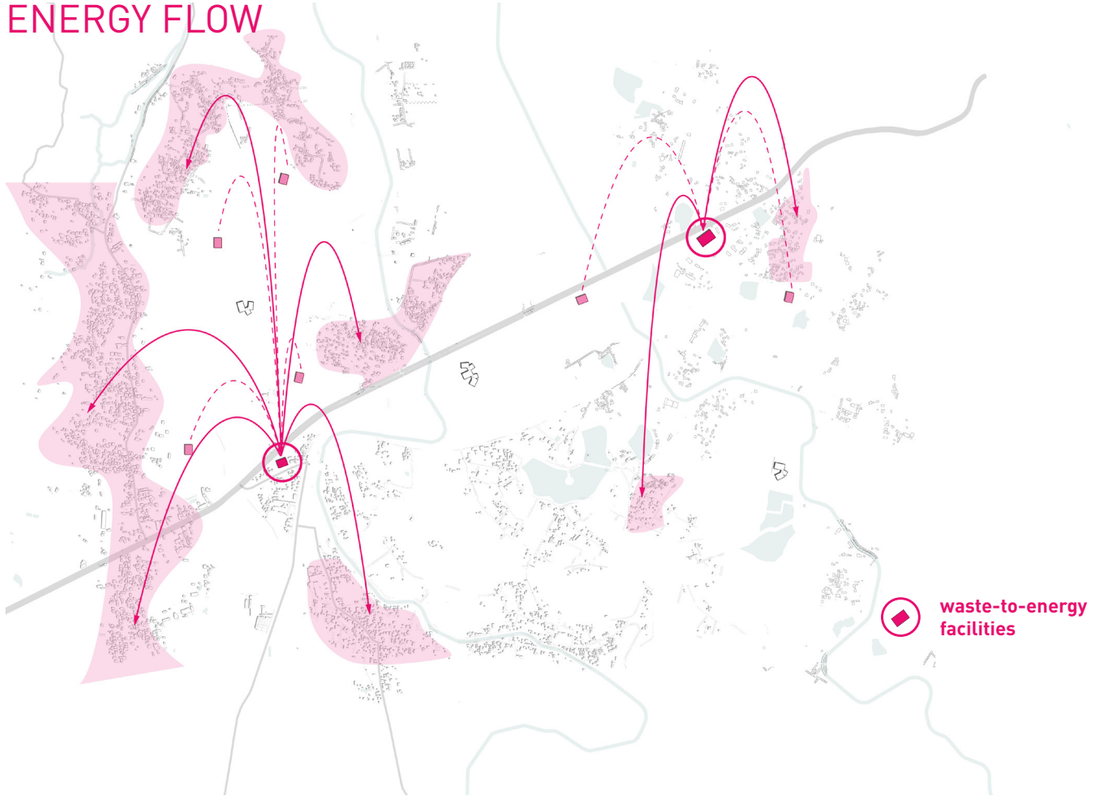
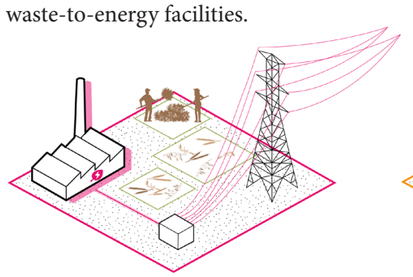


Fig. 5-12: Energy and waste flow diagram
Drawn by author

ENERGY FLOW



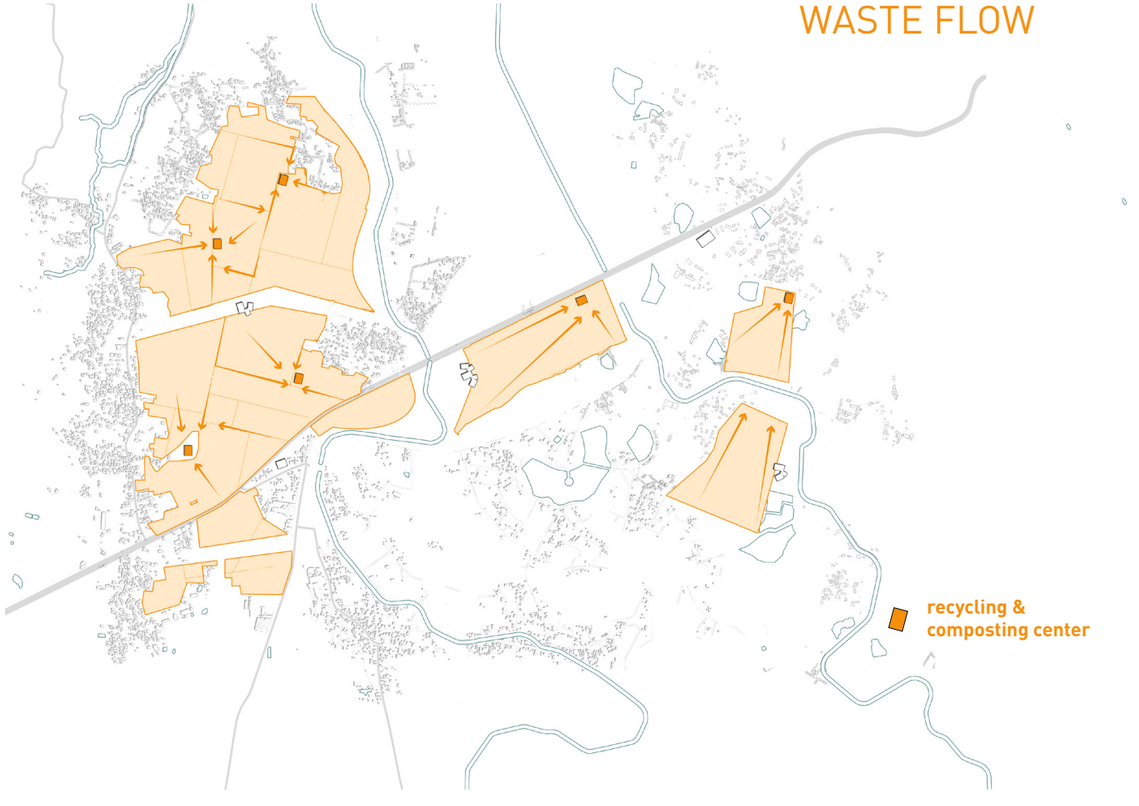
The agricultural residues after harvesting are recycled instead of open burning. By establishing a closed-loop system, the flow of waste and energy can be effectively managed through the implementation of composting and waste-to-energy facilities.



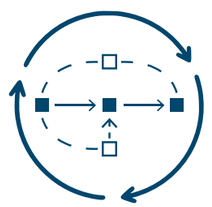
waste-to-energy facilities

composting

WASTE FLOW

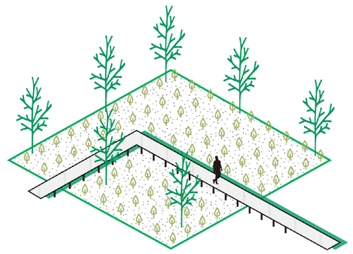


MASTERPLAN
FLOW
THE RESPONSIBLE CITY

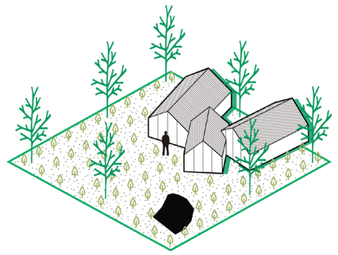


SUSTAINABLE FLOW MANAGEMENT

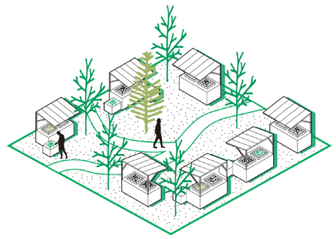
MASTERPLAN
SITE/AREA
THE LIVING CITY



boardwalk in field

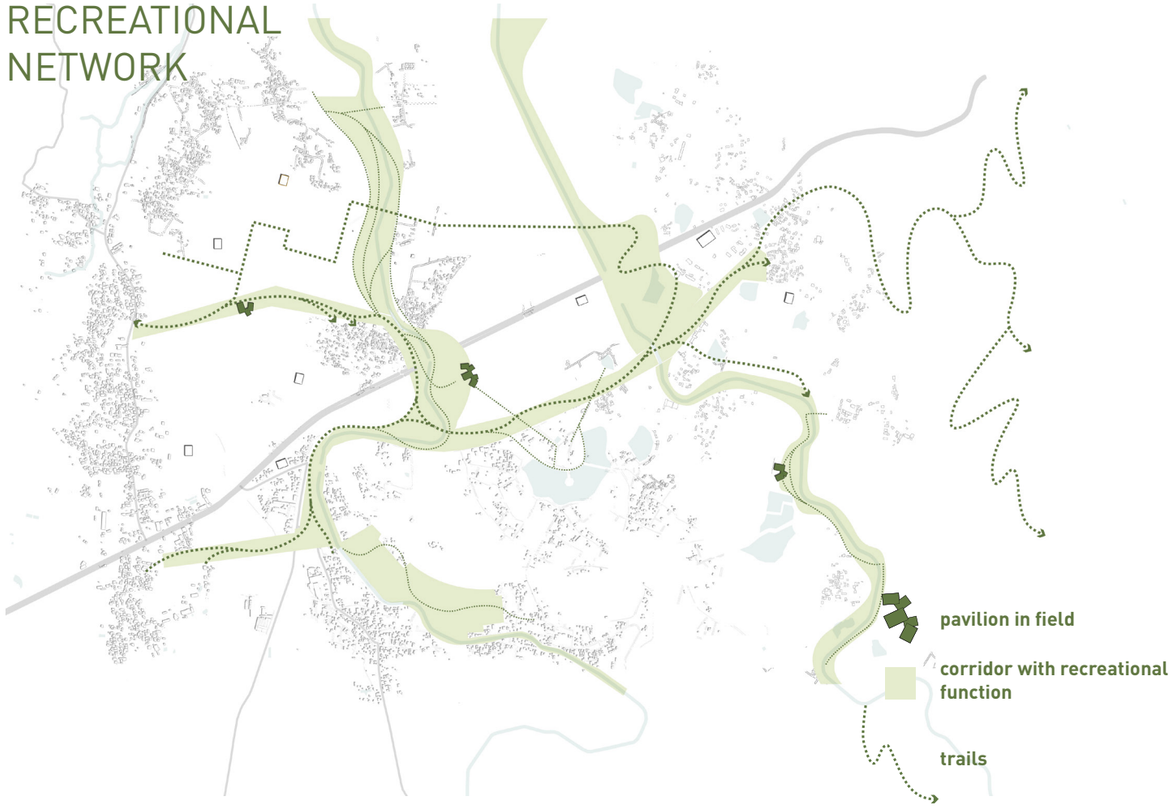


pavilion in field



farmer market

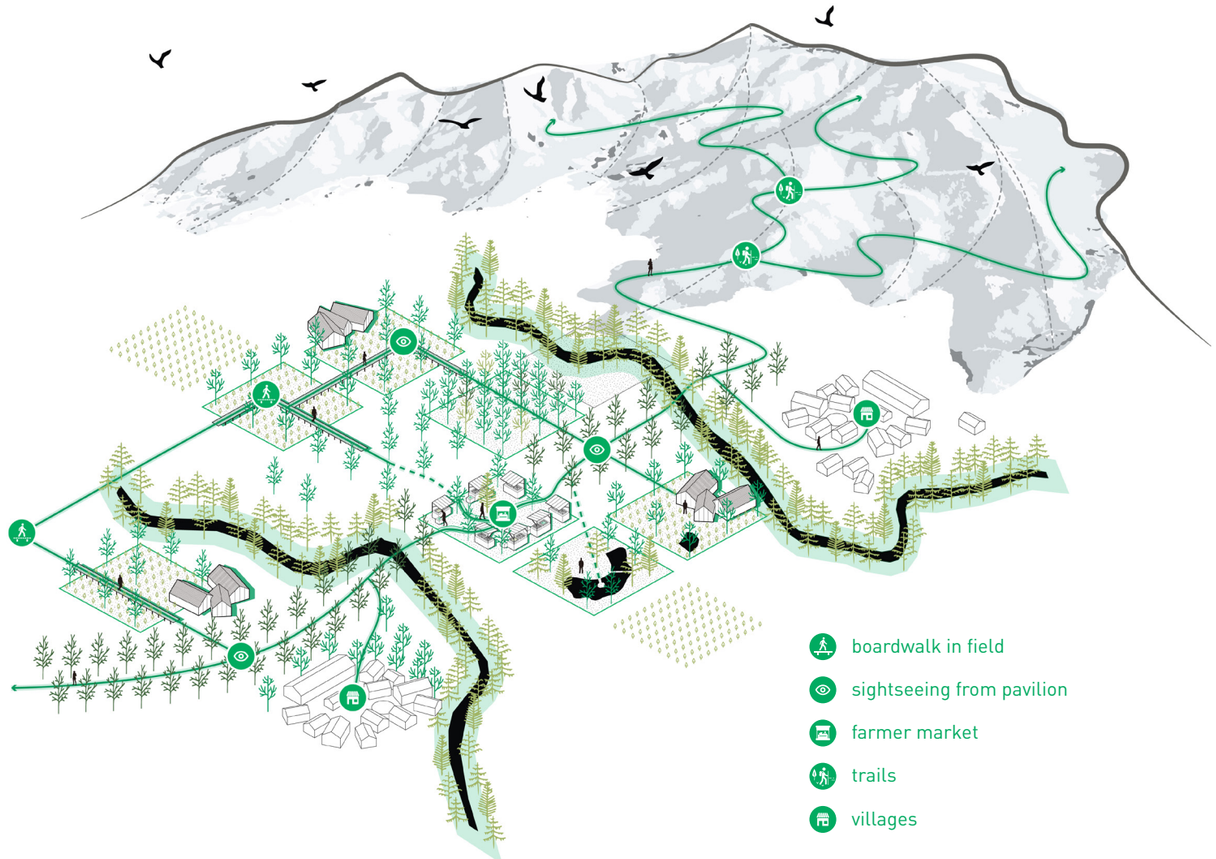
RECREATIONAL NETWORK



The villages are surrounded by forests, defining the boundary between villages and agricultural lands. These trees serve as a buffer, providing a transition between the farmlands and the villages. In addition, the integration of recreational corridors and canal ecological corridors has resulted in a well-connected network that offers residents opportunities for leisure and recreation. They can go sightseeing along the productive landscape on boardwalks, enjoy panoramic views from pavilions in the fields, and purchase locally sourced produce from farmer market. The ecological enhancement not only ensures the overall well-being of the local residents and other visitors, but also promotes the flourishing of flora and fauna in the area.

MASTERPLAN
SITE/AREA
THE LIVING CITY

SUSTAINABLE USE OF AREA WITH POTENTIAL



Engaging farmers in transforming traditional agriculture requires a participatory and bottom-up approach, involving farmers in decision-making processes and tailoring interventions to local contexts. Building trust, providing ongoing support, and demonstrating the tangible benefits of sustainable agriculture are key to encouraging farmers to embrace these practices and contribute to a more sustainable future.

Implementing sustainable agriculture is a long-term process that requires ongoing commitment, collaboration, and adaptation. It is crucial to involve farmers as active participants in the implementation process, ensuring that their knowledge, experiences, and needs are taken into account.

MASTERPLAN
PARTICIPANTS
THE PARTICIPATING
CITY

SUSTAINED COMMITMENT TO ECOLOGICAL RELATIONSHIP

HOW TO IMPLEMENT IT IN CHIANG MAI?

participatory design guideline and bottom-up approach

Incentives and Policy Support:

Advocate for supportive policies, regulations, and incentives, and involve all stakeholders especially **farmers** in decision-making processes to ensure the implementation of agroforestry.

01

Education and Awareness

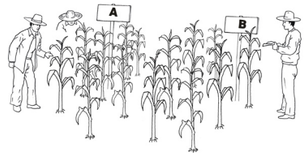
Collaborate with local research institutions and university such as Chiang Mai University to provide farmers with up-to-date information, best practices, and case studies related to agroforestry.

02

Field Demonstrations

Organize workshops, training programs, and to educate farmers about the principles and benefits of agroforestry.

03



Pilot Projects

Establish demonstration plots or pilot projects in collaboration with willing farmers to showcase the potential of sustainable agricultural practices such as agroforestry.

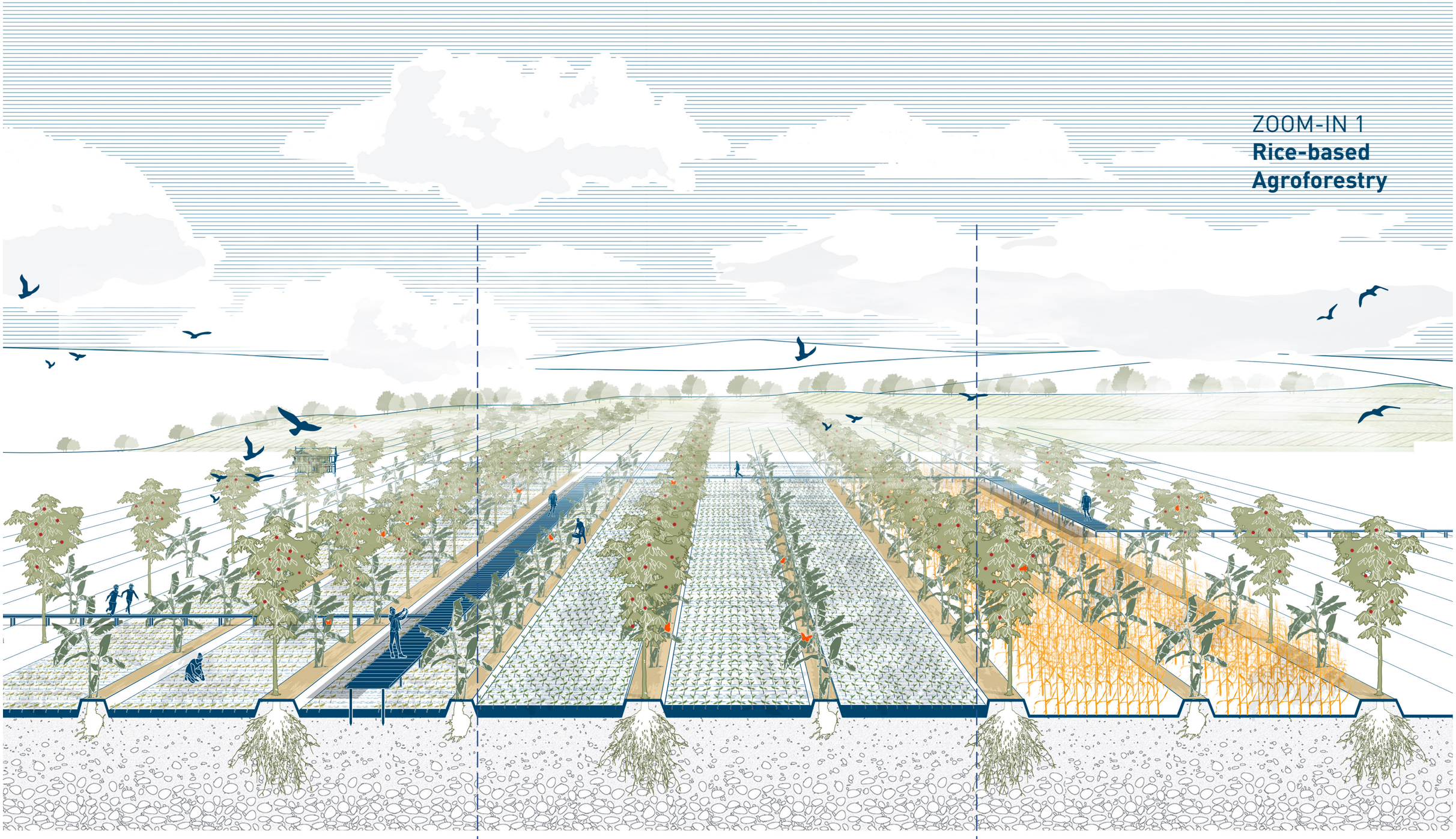
04

Community Engagement

Promote the sharing of success stories and highlight the economic benefits of agroforestry, such as increased crop yields, and additional income streams from timber, fruits, or mushroom from farmers who have successfully transitioned to agroforestry, serving as role models for others.

05

ZOOM-IN 1
Rice-based Agroforestry



PLANTING SEASON
wet season

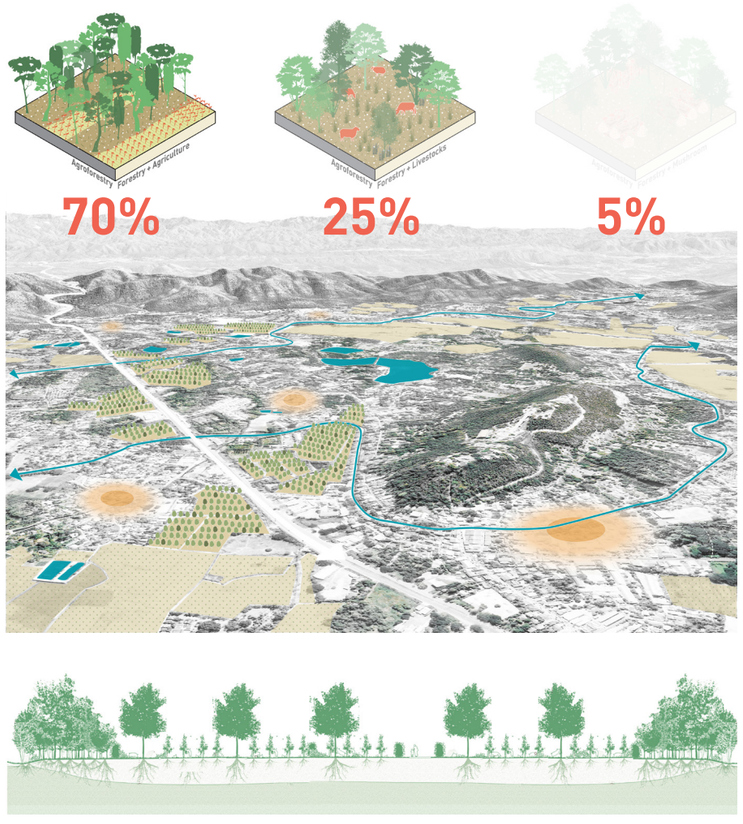
GROWING SEASON
wet season

HARVESTING SEASON
dry season

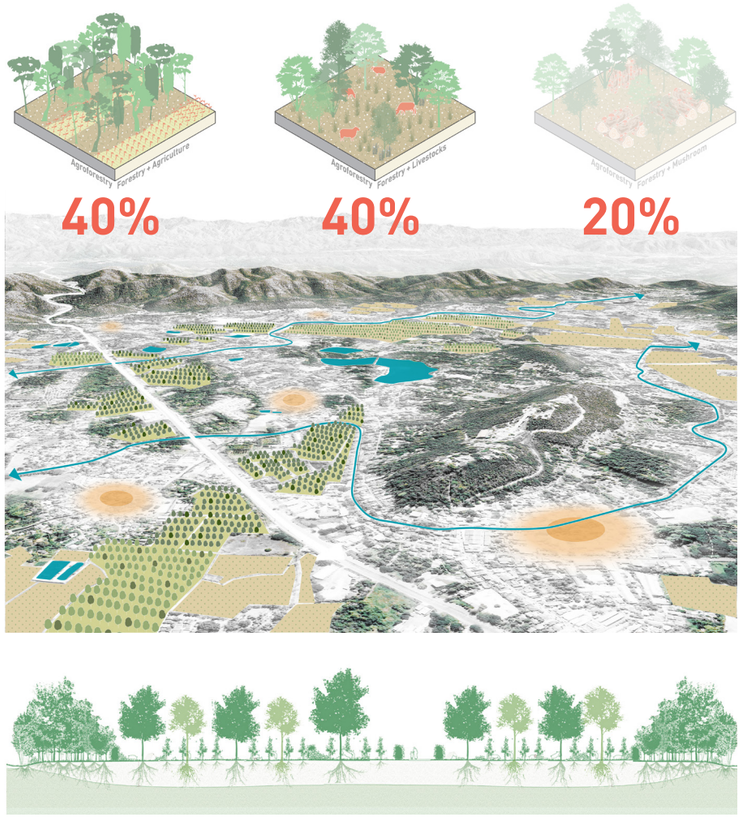
Rice-based agroforestry is a typical implementation of agroforestry within the site. The perspective section shows different stages of this productive landscape within a year. In rice planting season, farmers will work in shallow water to plant the rice. In rice growing season, the field will be filled with more water and it is the time for banana harvesting as well. In harvest season, which is dry season, the color of the whole scene would change from green to yellow. And all year round, residents and tourists can walk on boardwalk to be above the rice field to experience the change of the landscape.

PHASED PLANNING

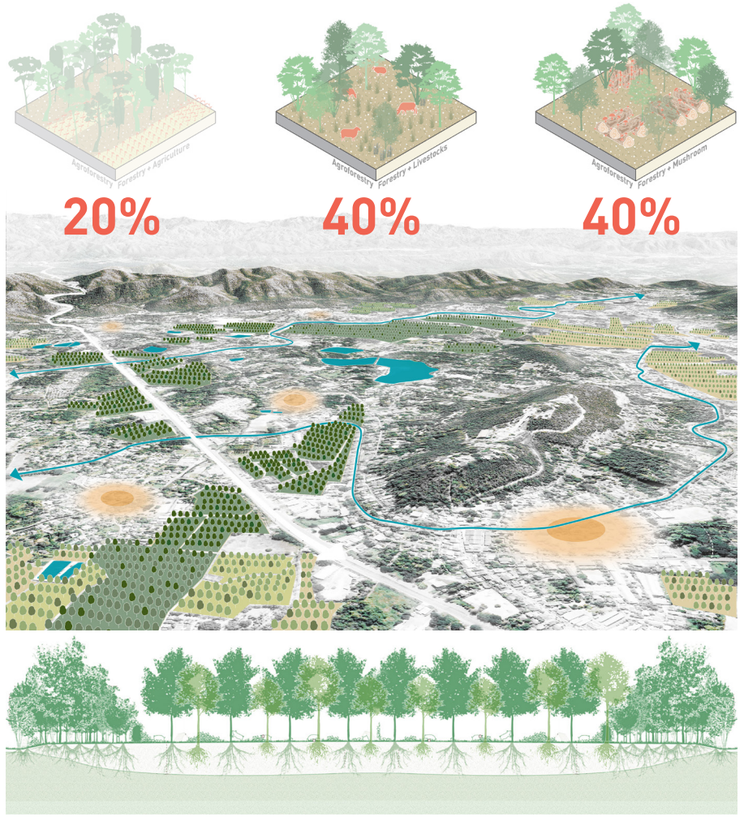
Overall, the phased implementation of agroforestry and sustainable agriculture practices, will bring about ecological, economic, and social benefits to entire area. The integration of diverse agricultural practices and the expansion of green covering will enhance biodiversity, increase productivity, and contribute to a more sustainable and resilient agricultural system.



In the first phase, the site will be transformed from traditional monocrop agriculture to a sustainable agroecological system through the implementation of agroforestry. This transition will be facilitated by the collaboration between farmers, NGOs, and government support. The agroforestry system will involve integrating main crops and companion crops, thereby increasing biodiversity of the area. While the yields of main crops may be reduced, the overall ecological sustainability will be improved. In addition, agricultural residues will be recycled and reused for composting or energy production, avoiding air pollution caused by open burning.

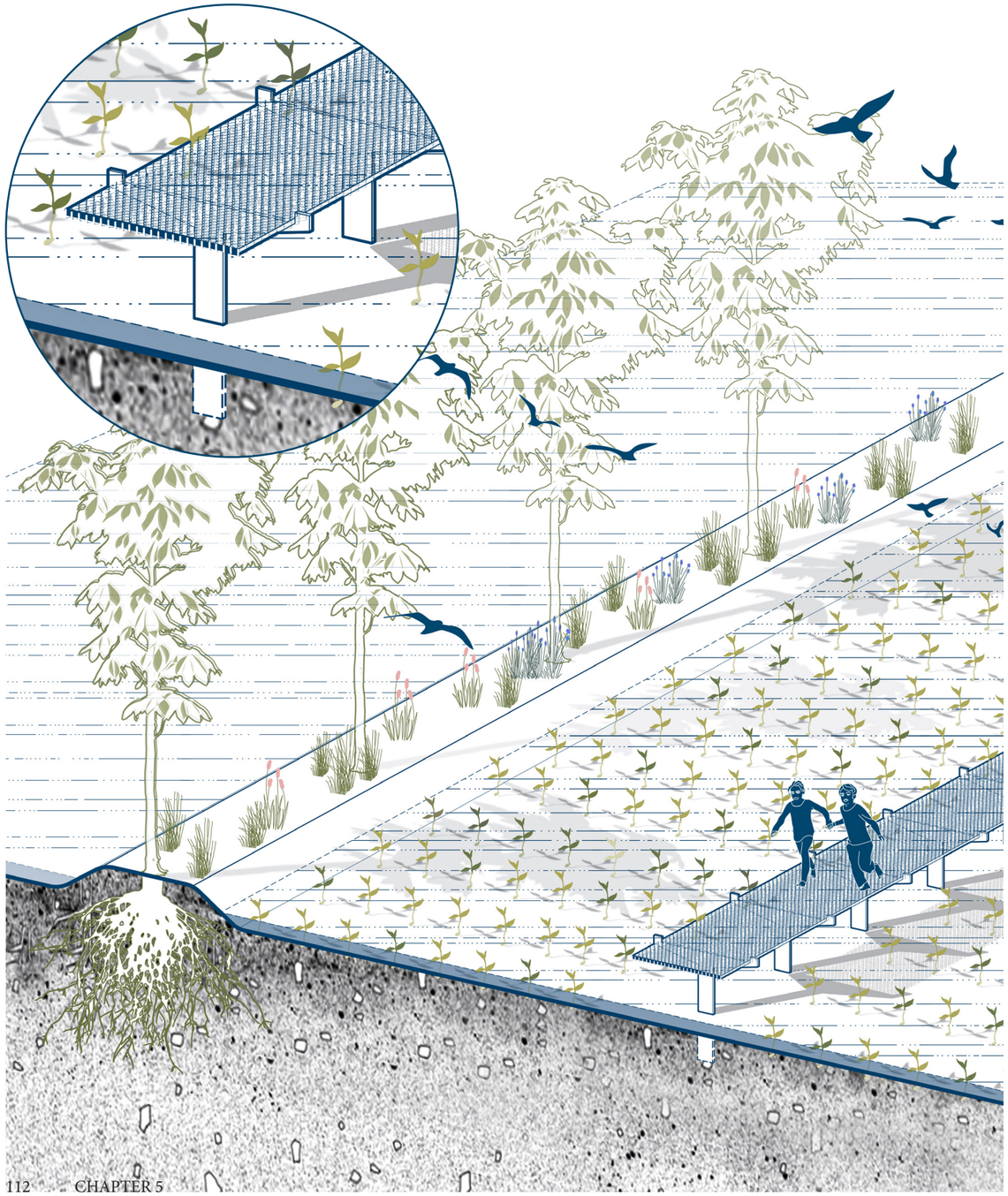


In the second phase, the sustainable production model implemented at the site will be promoted to the surrounding areas as a pilot project. As the trees grow and the canopy becomes denser, a new model of agroforestry, combining forestry and livestock, will be introduced. The presence of trees will provide shade and diverse food sources for livestock, meanwhile reducing soil erosion. Additionally, organic manure from the livestock will contribute to soil fertility. The introduction of agroforestry (forestry + livestock) systems will promote biodiversity by creating habitats for various plant and animal species, fostering a more resilient and sustainable ecosystem.



In the third phase, the production model of sustainable agriculture will continue to expand to the surrounding area. As the canopy becomes denser, traditional agriculture (crop cultivation) may no longer be suitable for the site due to limited sunlight. To compensate for this, shade mushroom farms will be introduced. The advantages of mushroom farming are low maintenance, high yield and space efficient. Besides, mushroom cultivation has potential to contribute to a more sustainable and environmentally-friendly way of farming, using an agricultural waste as a growing medium. During this phase, the fragmentation within the entire area is filled with ecological greenery. The increasing green cover will help to improve the air quality.

SCENARIOS
THE FIRST PHASE



Scenario 1: Above the Rice

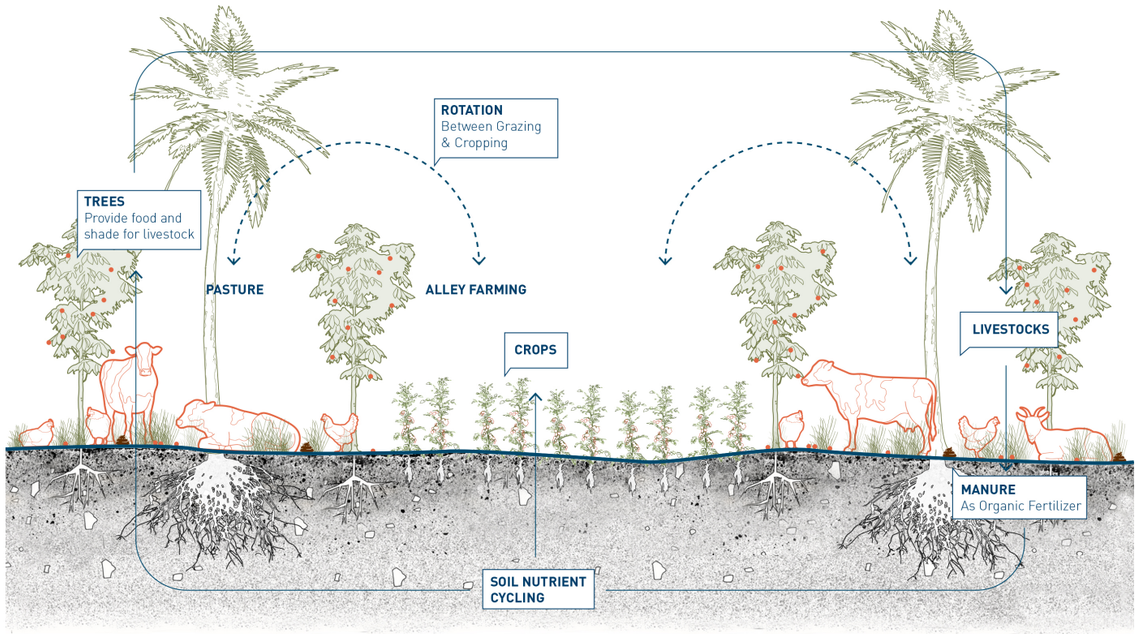
SCENARIOS
THE SECOND PHASE

The agroforestry, which integrates trees and shrubs into grazing systems, plays a vital role in resolving the conflict between livestock and the environment.

It offers a sustainable approach to promote soil nutrient cycling while simultaneously conserving trees and other natural ecosystems.

This approach not only brings additional sources of income for farmers but also facilitates the ecological restoration of degraded land, improves the quality of life for rural communities, enhances animal welfare, and generates valuable ecosystem services.

NUTRIENT CYCLE

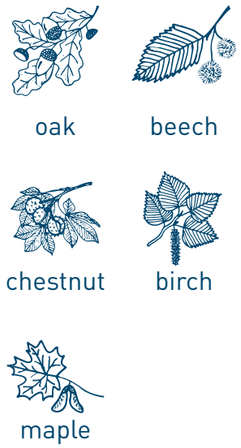


Scenario 2: Livestock Observation

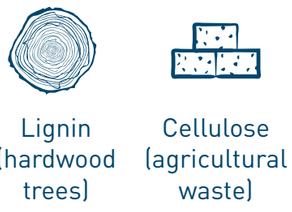
SCENARIOS
THE THIRD PHASE

MUSHROOM FACTSHEET

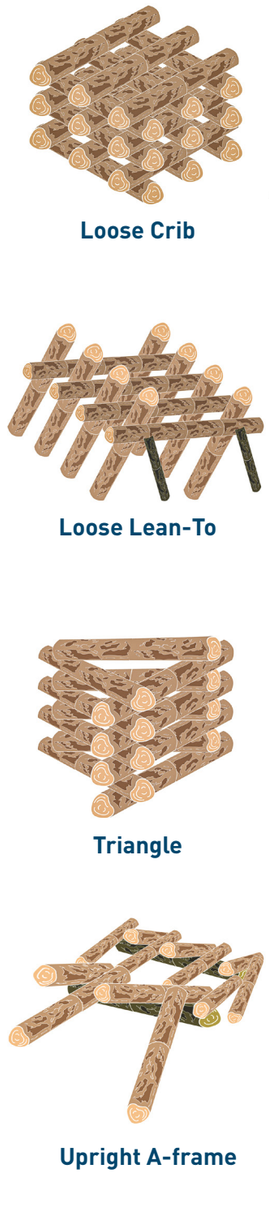
Plant Associates



Wild Nutrient Sources



MUSHROOM CULTIVATION STRUCTURE



Scenario 3: Mushroom Safari

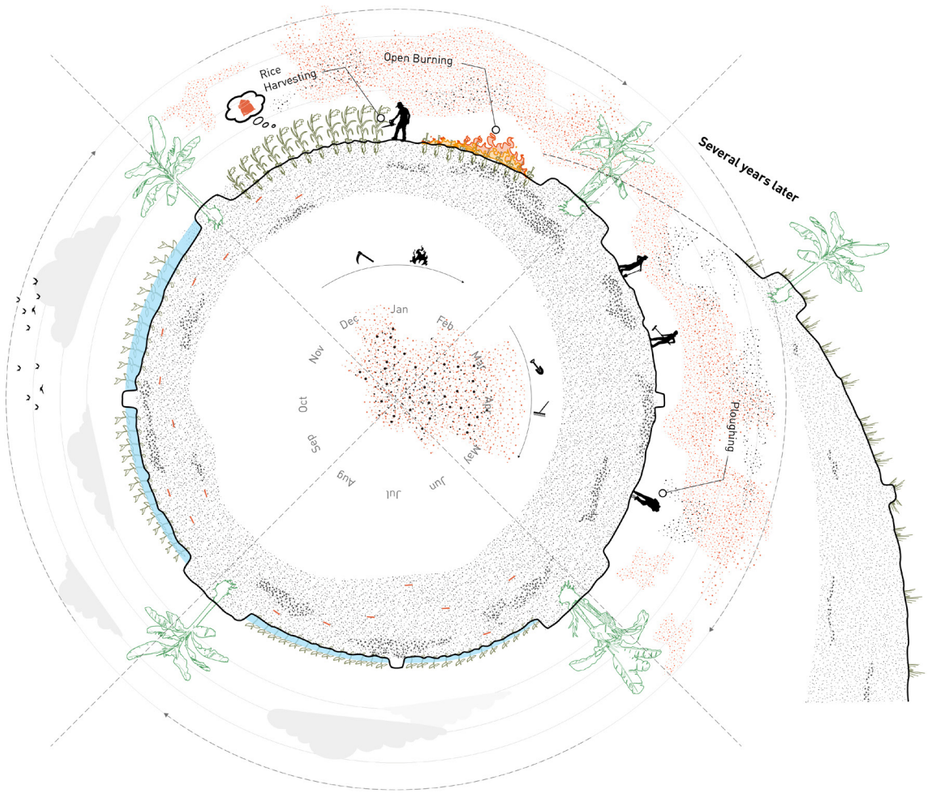
SCENARIOS
THREE PHASES

Scenario 1: Above the Rice

Scenario 2: Livestock Observation

Scenario 3: Mushroom Safari

SYSTEM
Existing Situation



In the existing situation, farmers typically start with preparing the land and planting crops. However, during the harvesting period, farmers often resort to burning the residues of rice, leading to the emission of pollutants into the air. Several years later, the fertility of the soil declines, eventually causing farmers to abandon the land.

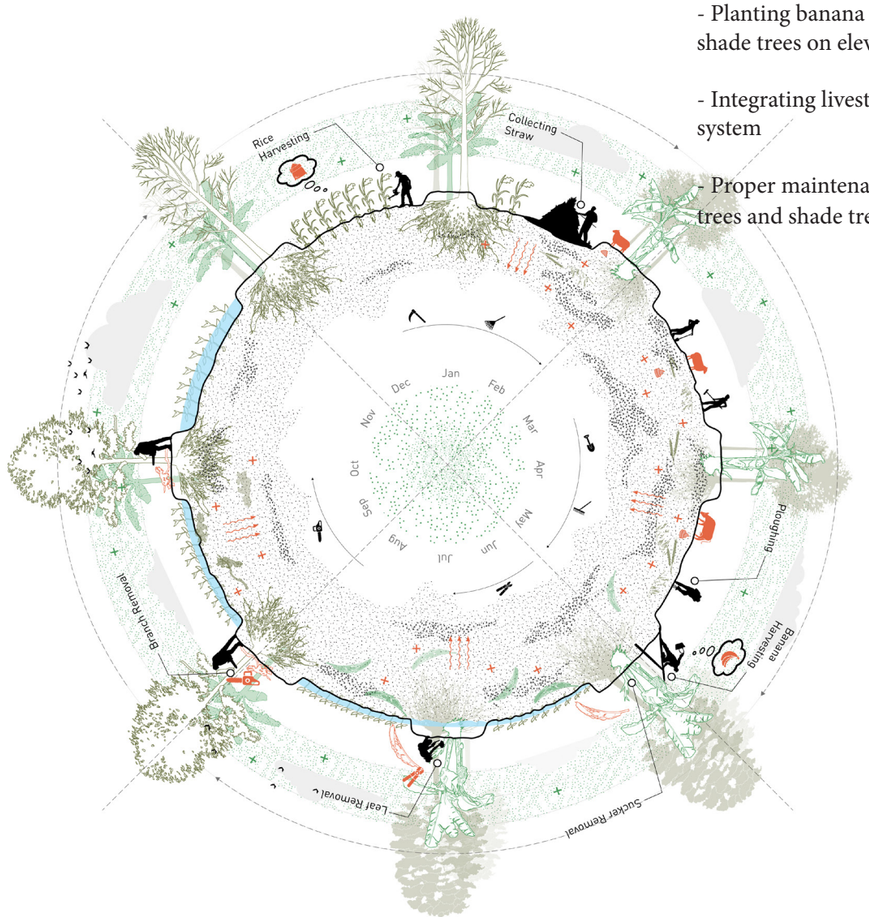
SYSTEM
With Intervention

Intervention:
- Widening the elevated land in agriculture land

- Planting banana trees and local shade trees on elevated land

- Integrating livestock into the system

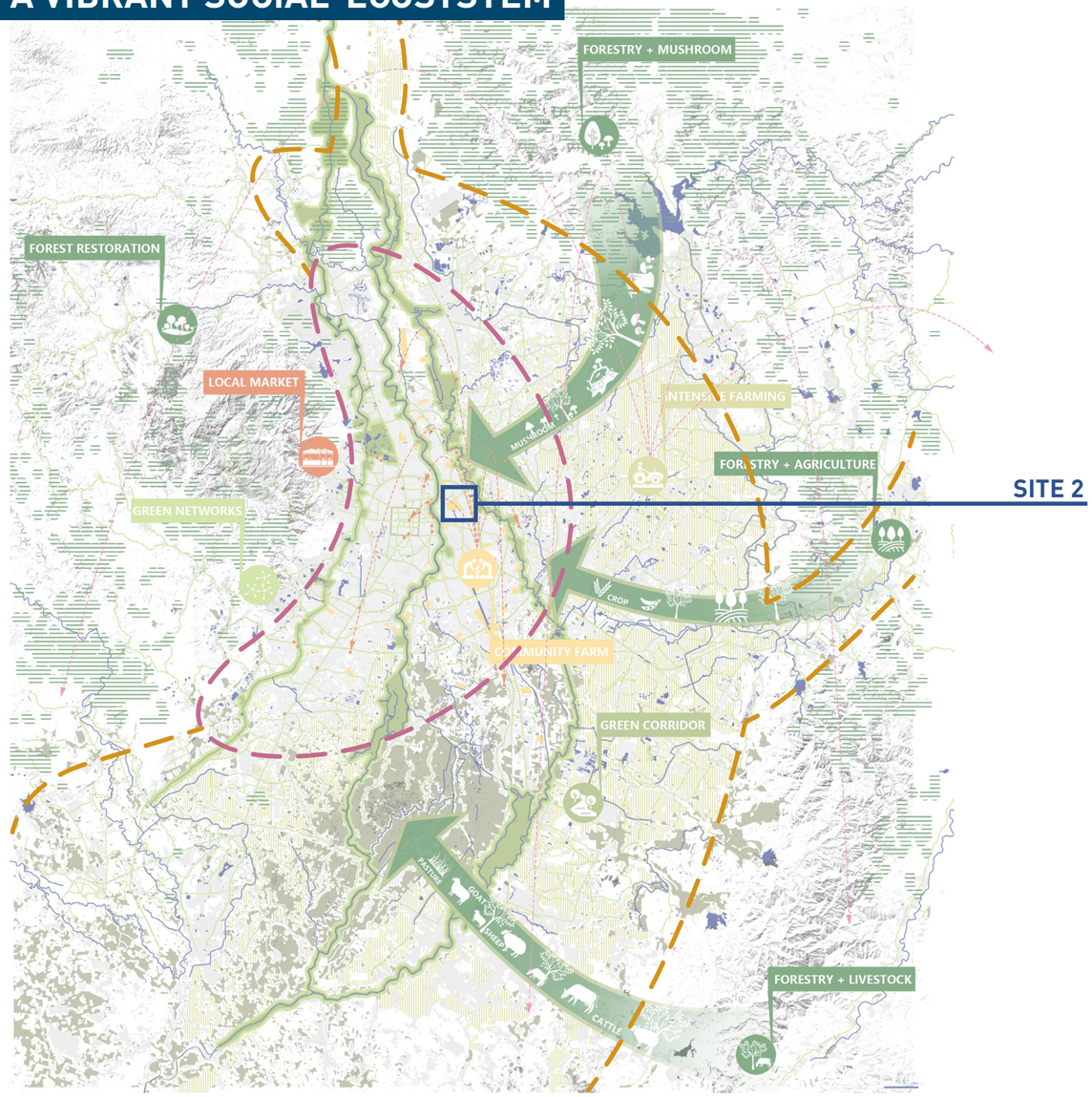
- Proper maintenance of banana trees and shade trees

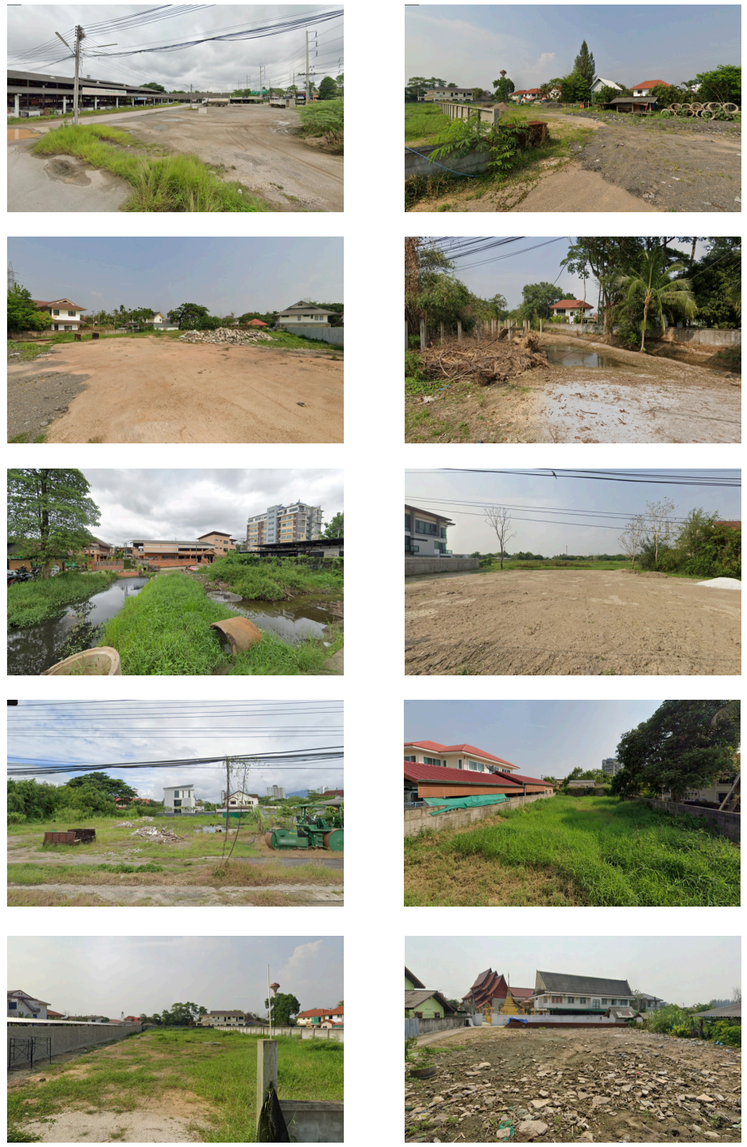


With the intervention, the traditional agricultural system has been transformed into sustainable agriculture, incorporating agroforestry practices with a combination of crops, banana trees, and local shade trees. Each species plays a specific role at different stages of growth. In this case, soil fertility does not decline as organic manure from livestock and pruned branches and leaves contribute to its enrichment. With proper maintenance, this system runs smoothly in a sustainable way, ensuring good air quality all year round.

Ecologically, the ideal outcome will be the mitigation of air pollution, improvement in soil fertility, and enhancement of biodiversity. Economically, farmers can benefit from increased profits due to production from different sources.

PILOT PROJECT 2
A VIBRANT SOCIAL-ECOSYSTEM



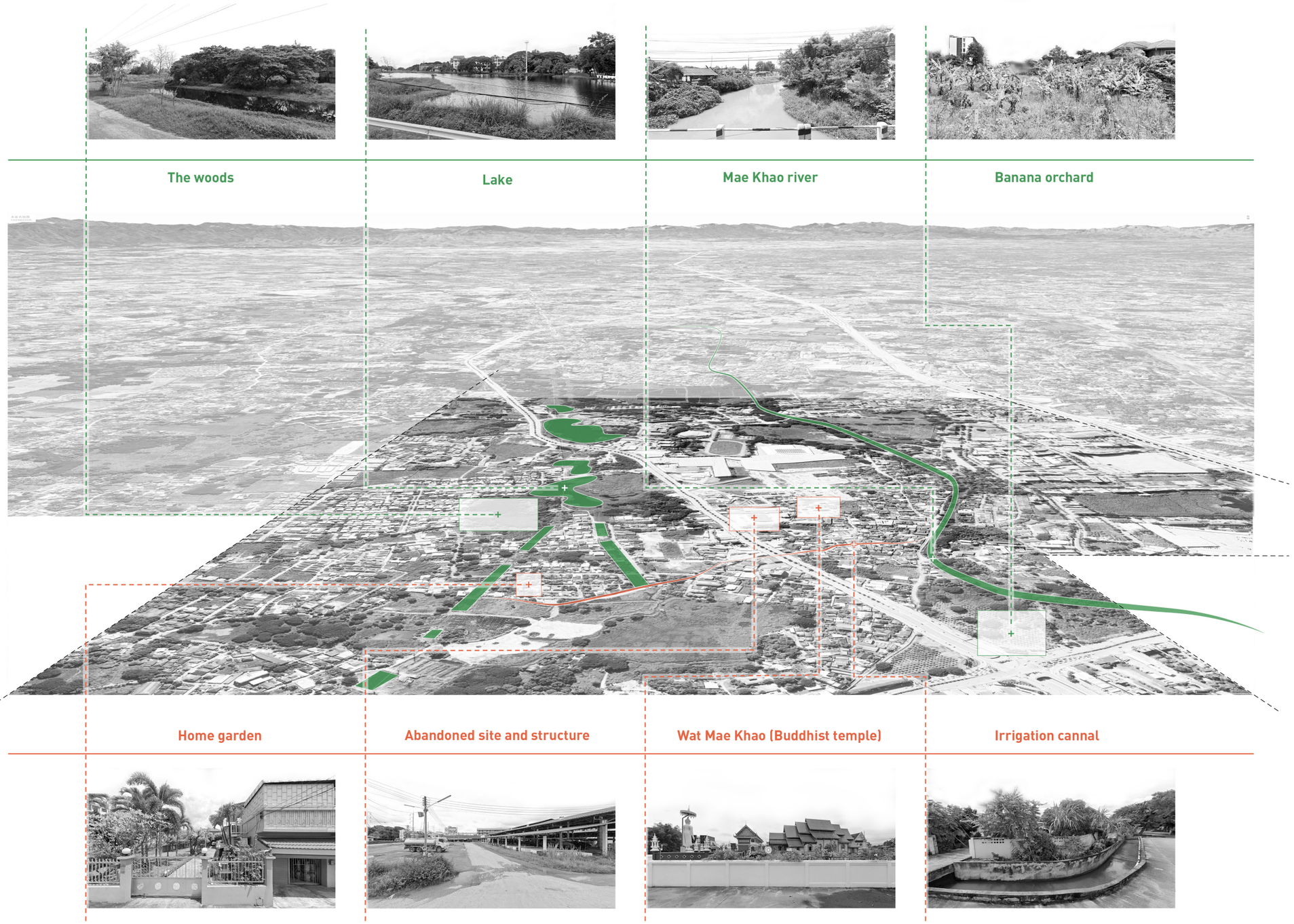


CONTEXT
Under-utilized Urban Voids

The site is situated in San Phranet, San Sai District, with the Mae Khao River flowing through it. The main vegetation is found along the water's edge, providing a natural green cover. However, the individual yards of households in the residential areas primarily consist of shrubs or small trees, lacking a cohesive system of street trees and green networks.

Besides, there are numerous urban void that are often overgrown or filled with debris, where space is not fully utilized. These abandoned spaces show an opportunity for revitalization.

Fig. 5-13: A series of photos to show urban voids within the site, including edge and buffer voids, infrastructural voids and vacant plots.
Photos from Google Map



CONTEXT
Landscape Resources and Potentials

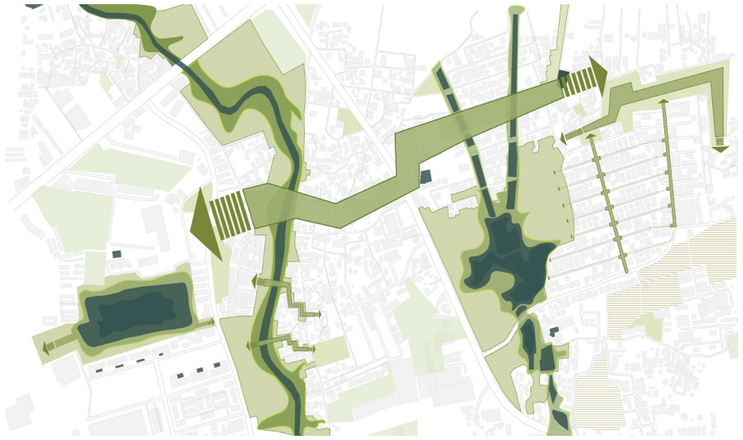
The site is filled with a variety of landscape resources, including the woods, lakes, Mae Khao River, and banana orchards. These natural elements contribute to the unique character of Chiang Mai. Additionally, the presence of a community Buddhist temple and home gardens adds to the cultural richness of the area.

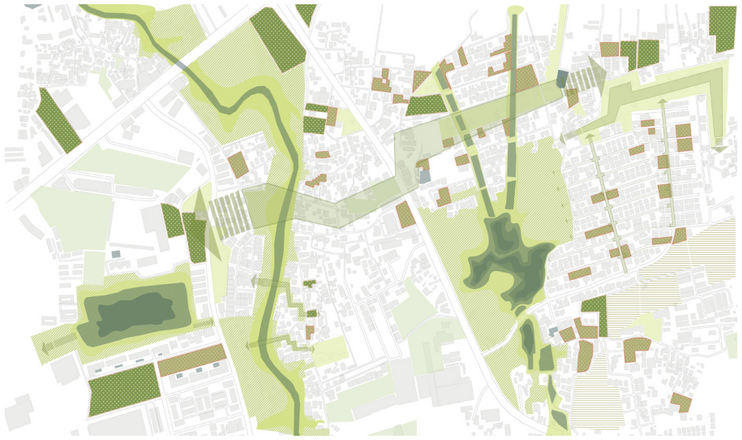
Besides, the abandoned sites and structures scattered throughout the site, along with the irrigation canals, have great potential to become important features of the landscape. By Reprogramming and redesign, these underutilized elements can be transformed into attractive functional spaces that maximize the value of the landscape.

STRATEGIES
Spatial Structure

The overall objective is to enhance overall green coverage with the strategy of urban farming and urban greening. The proposal will be realized gradually with three steps:

Fig. 3 steps to establish spatial structure
Drawn by author





GREEN NETWORKS

Step 1: Create Green Networks

Improve functionality and connectivity of green space by preserving the ecological function and building vibrant recreational green corridor.

URBAN FARMING

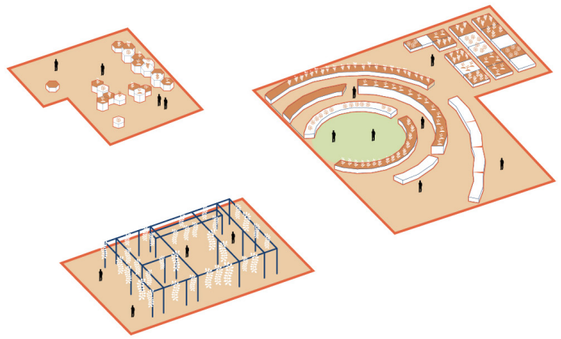
Step 2: Urban farming and Urban Greening

Introduce urban farming system to activate urban void and enhance overall green coverage in urban area with urban greening.

COMMUNITY CONNECTIVITY

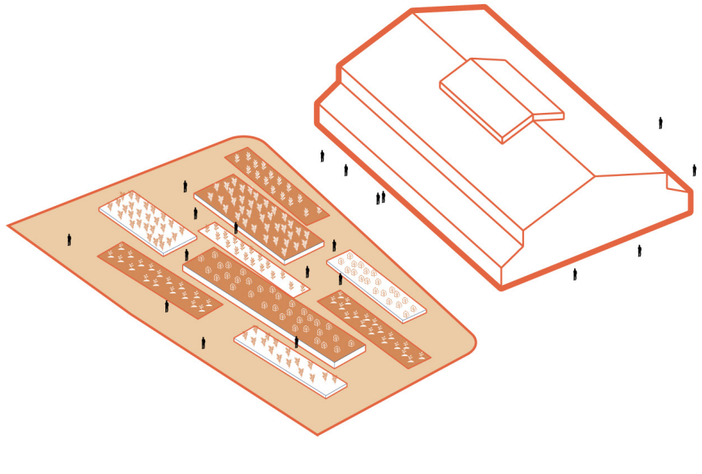
Step 3: Enhance Community Engagement and Connectivity

Enhance Community engagement by introducing diversity urban farming programs and events, incorporating recreational function.
Enhance community connectivity by improving mobility system and connecting urban farming areas with open space.



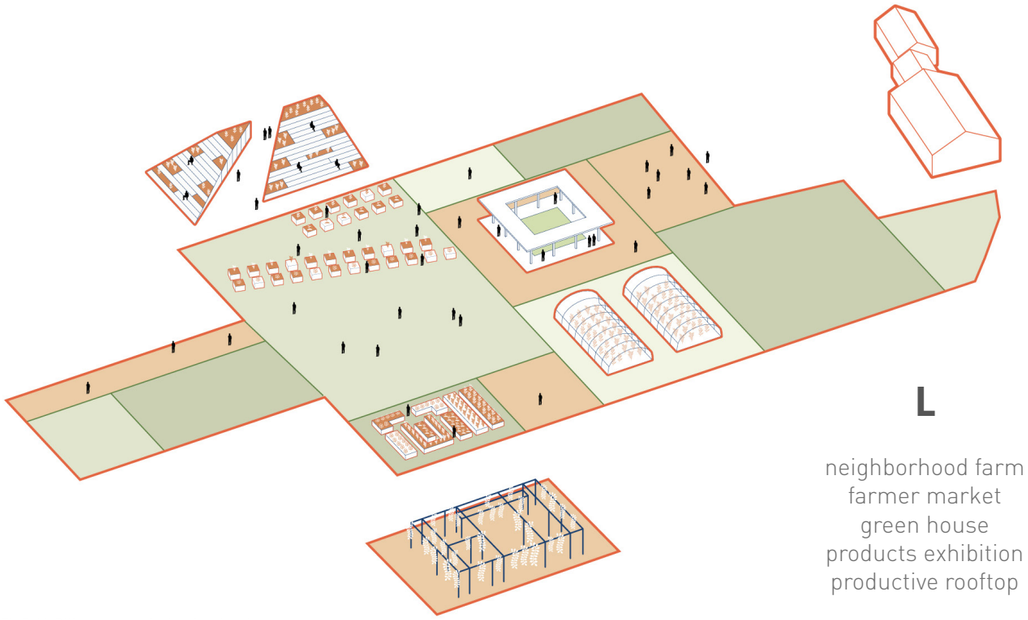
S

planting box
community garden
home garden
productive streetscape



M

learning center
experimental farming
workshop
local market



L

neighborhood farm
farmer market
green house
products exhibition
productive rooftop

Fig.5-14: Different types of urban farming elements
Drawn by author

STRATEGIES
Urban Farming Elements

Urban farming elements can be categorized based on their scale, with a range of possibilities:

Small-scale elements include planting boxes, home gardens, and productive streetscapes. These smaller interventions allow individuals to engage in urban farming practices on a personal level, whether it is cultivating plants in containers, tending to gardens in their own homes or using the available space along the street to grow productive plants.

Medium-scale elements include community garden, experimental farming, urban farming workshop and learning center, and farmer's market. These initiatives provide a platform for collective cultivation, experimentation, and education, and help establish a sense of community involvement and knowledge-sharing.

Large-scale elements include neighborhood farm, greenhouse, product exhibitions, productive rooftop, and local market. These larger initiatives provide channels to establish a sustainable and localized food system.

By incorporating these various scales of urban farming elements, a more sustainable, resilient, and inclusive community and productive urban landscape can be created. In the natural ecosystem, urban farming contributes to the greening of community. In the social ecosystem, urban farming enhances food system and community engagement.

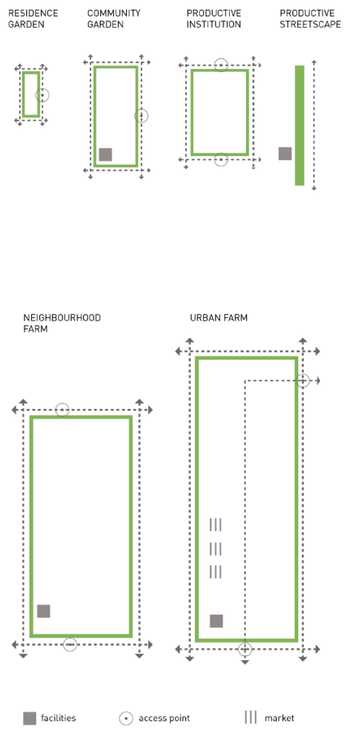
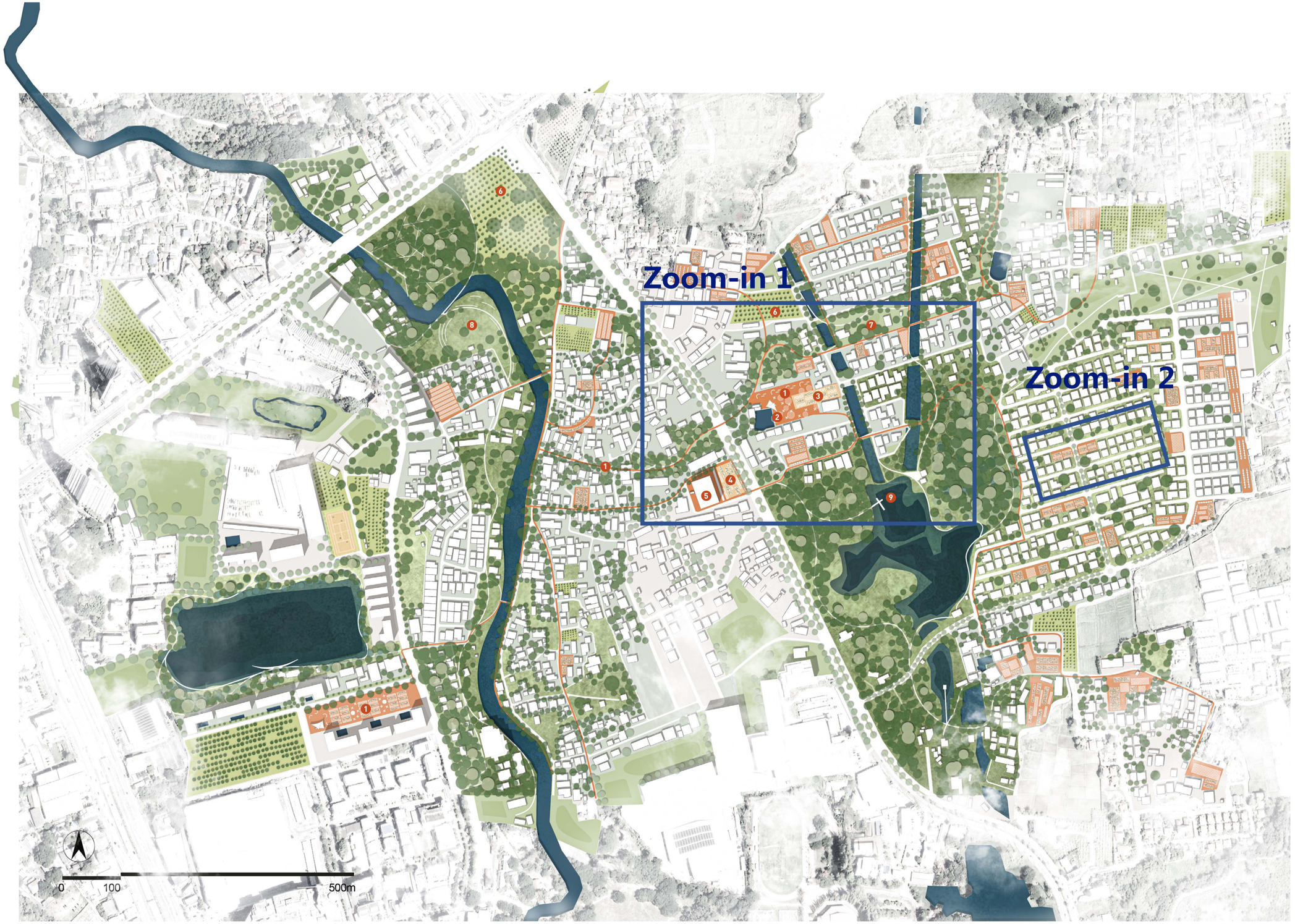


Fig.5-15: Urban farming elements based on scale
Redrawn by author, source from AA Landscape Urbanism

MASTERPLAN

A Vibrant Social-ecosystem



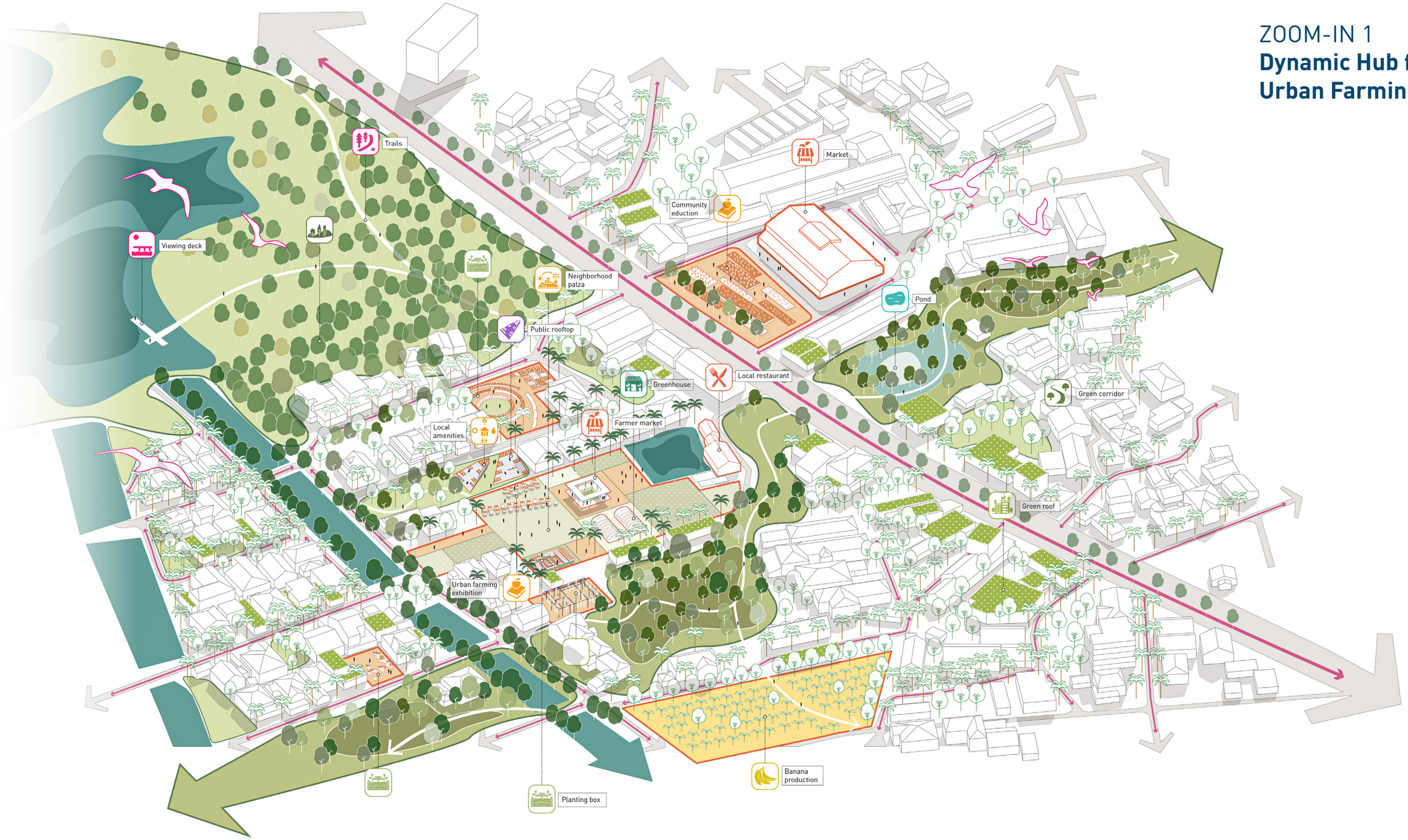
1 neighborhood farm
2 farmer market
3 urban farming exhibition
4 community education center
5 market & farm lab
6 banana orchard
7 recreational corridor
8 riverside open space
9 viewing deck

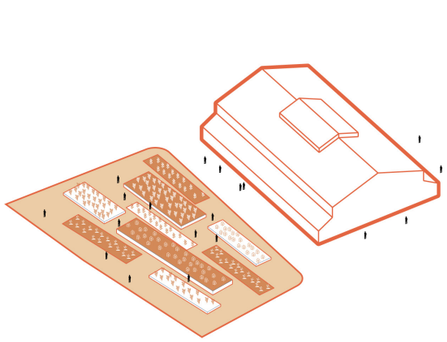
Urban farming

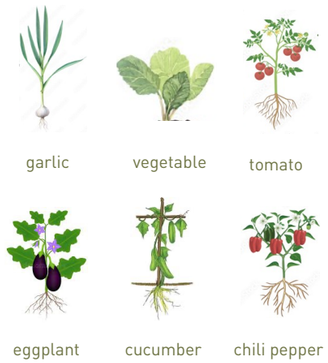
Orchards

ZOOM-IN 1

Dynamic Hub for Urban Farming







Pine
Pinus kesiya & merkusii

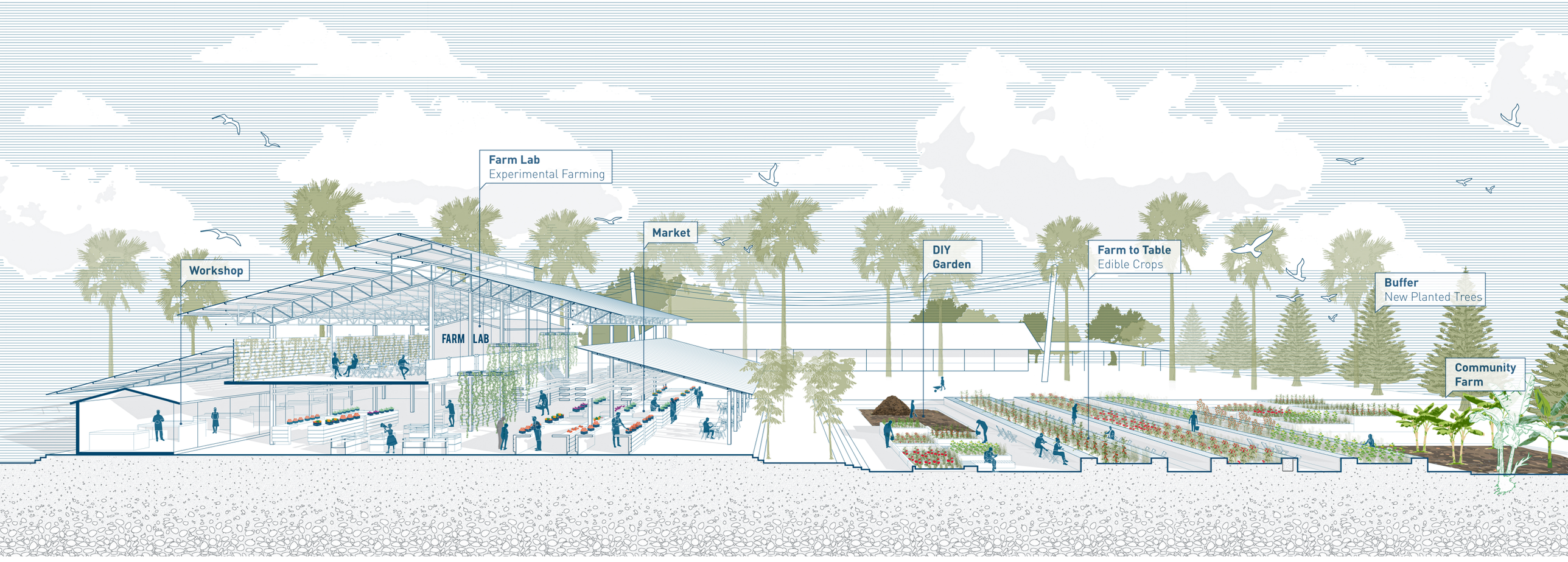
Australian pine
Casuarina equisetifolia

Ciper
Cupressus Sempervirens(a.o.)

Yellow trumpet flower
Tecoma stans

Banana
Musa sp.

ZOOM-IN 1
Activator of Open Space



The transformation of the abandoned structure redefines the identity of the site by incorporating new structures and assigning them new functions, including a farmer's market, workshop and farm lab. Meanwhile, the surrounding open space was transformed into a community farm, which serves as a model to showcase.

Visitors can immerse themselves in diverse programs and events in this site, for instance, tasting the produce harvested from the community farm. They can also adopt a plot of land for urban farming practices, fostering a sense of ownership and involvement in sustainable farming.

ZOOM-IN 2

Productive Streetscape in Residential Area

Integrate residents' front and back yards and some open space in the neighborhoods for urban farming. Planting native trees that are effective in eliminating air pollution for urban greening, and functioning as shade trees for some crops as well.

Ecologically, it creates a favorable microclimate, and enhancing overall green coverage within urban areas, thus creating a more visually appealing and ecologically diverse landscape, where increased green coverage also helps mitigate the air pollution. On a social level, through participation in urban farming activities, residents have the opportunity to interact, communicate, and collaborate, strengthening community bonds.

6 CONCLUSION & REFLECTION

In this chapter, the design proposals are evaluated over time, and conclusions are drawn by answering all sub-questions. Furthermore, a reflection is presented on the position of this graduation project, the personal process throughout the project, and the transferability of the project results. It allows for a comprehensive review of the design decisions from multiple perspectives, offering valuable insights and lessons learned.

6.1 Conclusion & Recommendation
6.2 Discussion
6.3 Reflection

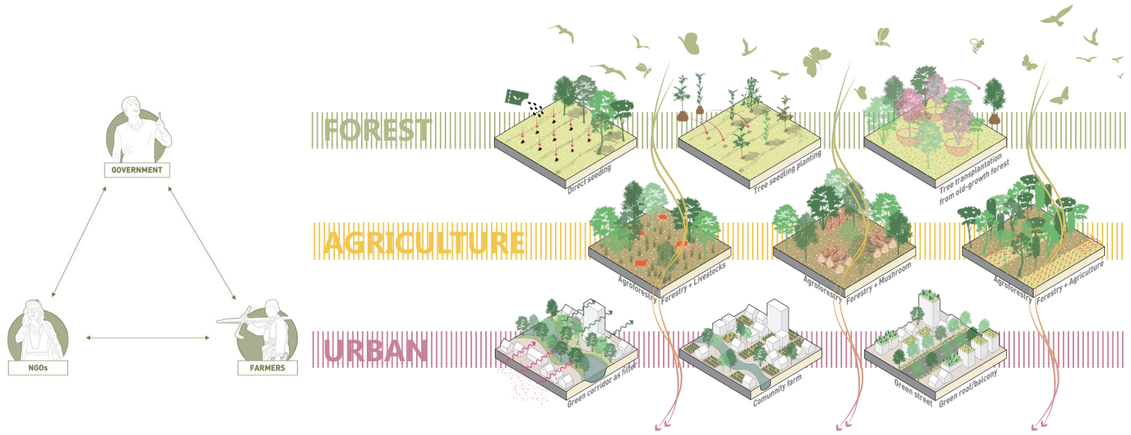
Conclusion

The graduation project has gone through the research and design process aiming at increasing the sustainability of the agriculture and landscape system, and therefore mitigating air pollution issue in Ching Mai and enabling people to lead healthy lives. In this section, the answers to the sub-questions are presented.

1. How does a regional strategy framework incorporate regional landscape system and local agricultural system to control air pollution?

Building partnerships between farmers, governments and NGOs is fundamental. With the active involvement of NGOs and government support, the transition from traditional agriculture to sustainable agriculture can occur gradually, effectively controlling the source of air pollution from open burning.

Through partnerships, a consensus can be reached among stakeholders to stop deliberate fires in the forest. By providing farmers with alternatives for making profit, other than practices that contribute to air pollution, the frequency of forest fires can be significantly decreased.

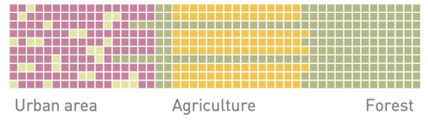


2. How to cultivate a new relationship between farmland and urban expansion that provides a sustainable crop production network?

Develop a comprehensive land use plan that balances the need for urban development with farmland. Define the boundary of urban area and agriculture area to limit urban expansion and prevent encroachment onto agricultural areas.

Encourage mixed-use development patterns that integrate residential, commercial, and agricultural elements. Incorporate urban farming, and urban greening into monotonous living conditions to improve green cover in urban area and community engagement.

Promote urban farming and urban greening in Chiang Mai as a means of incorporating sustainable agriculture into urban areas. Encourage residents to take advantage of unused spaces for food production.



Define the Boundary of Urban and Agriculture Area

Encourage Mixed-use Development

Promote urban farming and urban greening

3. What kind of sustainable production mode can improve the living conditions of local residents without harming the ecological environment?

Agroforestry: Promote the implementation of agroforestry systems that integrate tree planting with agricultural crops, livestock, and mushroom farming. This approach not only enhances soil fertility, biodiversity, and other ecological services but also creates additional income sources from diverse products. Furthermore, agroforestry provides local residents with recreational benefits, contributing to overall well-being.

Community-Supported Agriculture (CSA): Establish CSA programs where local residents directly support local farmers by subscribing to regular deliveries of fresh produce. The system reduces the environmental impact of packing, storing, and transporting food over long distances. At the same time, it ensures local food security and enhances community engagement.

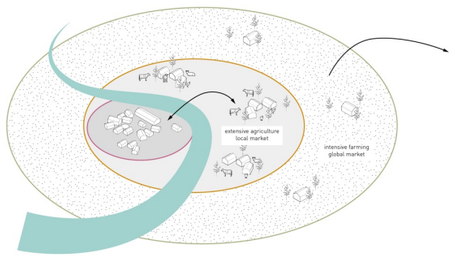
Organic Waste Recycling: Establishing a composting network and set up waste-to-energy facilities to treat agricultural residues towards a self-sufficient system.

4. What kind of sustainable cultivation pattern of crops can be practiced in farmland in the context of Southeast Asia?

Crop Rotation: Implement a crop rotation system in which different crops are grown in a specific order over a period of time. Crop rotations help prevent soil erosion, improve soil fertility, reduce pests and diseases, and improve the overall health of the crop.

Intercropping: Intercropping is an agricultural practice by growing two or more different crops together in the same field. Intercropping maximizes land use efficiency, reduces pest and disease, and enhance biodiversity.

Agroforestry (Forestry + Agriculture): Integrating trees with crops to create agroforestry systems offers ideal growth conditions for different crops at different phases, thereby increasing overall yields. This practice enables farmers to make more profits from both crops and trees. Moreover, agroforestry systems provide multiple ecological benefits, including enhanced soil structure, increased biodiversity, and improved air quality.

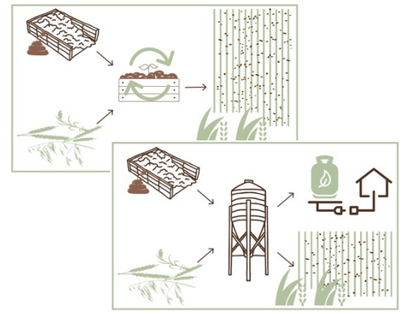


Agroforestry + Intensive Farming

- *Agroforestry —> local market*
- *Intensive farming —> global market*

Community Supported Agriculture (CSA)

- **Short chain**
- **Distribution point**



Organic Waste Recycling

- **Composting network**
- **Waste-to-energy facility**

5. What is the most efficient local vegetation species and planting pattern to remove air pollution in urban area?

Vegetation species

Evergreen Trees: Evergreen trees provide year-round leaves and are effective in improving air quality.

Broadleaf Trees: Broadleaf trees have large, wide leaves that can capture and trap pollutants effectively.
Examples include:
- Rain Tree (Samanea saman)
- Chengal (Hopea odorata)
- Devil tree (Alstonia scholaris)
- Moonlight Tree (Pisonia grandis)
- Water Rose apple (Syzigium aqueum)

Coniferous Trees: Conifers have needle-shaped leaves that provide a larger surface area for capturing pollutants.
Examples include:
- Coastal She-oak (Casuarina equisetifolia (a.o.))
- Khasi Pine (Pinus kesiya)
- Merkus Pine (Pinus merkusii)
- Norfolk Island Pine (Araucaria heterophylla)

Shrubs and Hedges: Dense shrubs and hedges planted along roadsides and in open spaces can act as barriers to trap and filter pollutants.
Examples include:
- Pride of Barbados (Caesalpinia pulcherrima)
- Pink powder puff (Calliandra haematocephala)
- Oriental Thuja (Platycladus orientalis)
- Yellow trumpet flower (Tecoma stans)

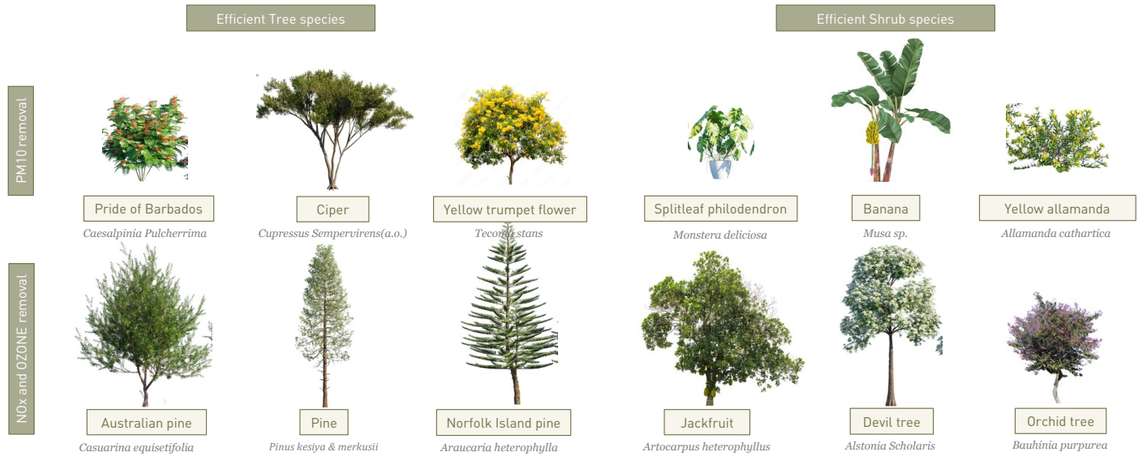
Planting pattern

Urban Farming and Edible Park: Some crop species and fruit trees can contribute to removing air pollutants. It is feasible for individuals to incorporate native plants into urban landscapes to help improve air quality. Examples include Banana Tree (Musa sp.), Spinach (Spinacia oleracea), Lettuce (Lactuca sativa), Ginger (Zingiber spp.)

Massive planting: Establish ecological core areas and ecological corridors for massive planting. Meanwhile, a mixed planting pattern, including a combination of trees, shrubs and groundcovers, is used to maximize the efficiency of air pollutant removal.

Vertical Greening Systems: Implementing vertical greening systems, such as green walls or green facades, can maximize the use of limited space in urban areas.

- Splitleaf Philodendron (Monstera deliciosa)
- Banana (Musa sp.)
- Sanchezia (Sanchezia speciosa)
- Yellow allamanda (Allamanda cathartica)



Recommendation

This graduation project is based on research, howerver due to the limitation of time, there are some research and design can be further explored to provide a more comprehensive solution to air pollution issue in Chiang Mai.

Additionally, a set of recommendations is proposed to engage relevant stakeholders more effectively and facilitate their collaborative efforts in shaping a refreshing future.

For follow-up research/design

Prevent Bushfires

In this urban ecology graduation project, human-conducted forest fire are presented, however, there are also some naturally-led bushfires.

- Investigate the causes of bushfires to develop strategies for fire management.
- Explore the potential of nature-based interventions to prevent bushfires.

Apply Urban Ventilation Corridor

- Conduct research on how the implementation of urban ventilation corridors can effectively dissipate air pollutants and improve air quality in the city.

- Make plan for the implementation of urban ventilation corridors within the urban planning framework of Chiang Mai.

Enhance Green Infrastructure:

- Improve the filter capacity of green corridors through ecological interventions.

- Identify areas with low tree canopy cover and prioritize them for strategic interventions to increase green cover and enhance air purification processes.

Create Protective Vegetation Barriers:

- Utilize vegetation to shield these areas from pollution sources and improve air quality for the well-being of residents and vulnerable populations.

- Encourage the implementation of dense vegetation as protective barriers, particularly around residential areas, schools, hospitals, and other sensitive locations.

For stakeholders

- Government agencies:

Research the effectiveness of existing policies and regulations on open burning in Chiang Mai and identify gaps or areas for improvement.

Develop evidence-based policy to strengthen air pollution control measures, including stricter regulations on open burning, enforcement mechanisms, and economic incentives.

Enhance air quality monitoring systems in Chiang Mai and conduct detailed data analysis to understand pollution patterns, hotspots, and trends. Analyze the collected data to identify pollution sources, evaluate the effectiveness of interventions, and inform evidence-based decision-making.

- NGOs

Provide training sessions and workshops to equip farmers with the necessary knowledge and skills to implement sustainable agricultural effectively.

Conduct educational campaigns to raise awareness among farmers about the negative impacts of open burning on air quality and human health and the benefits of alternative residue management techniques.

Start with the pilot project with willing farmers to showcase the potential of sustainable agricultural practices.

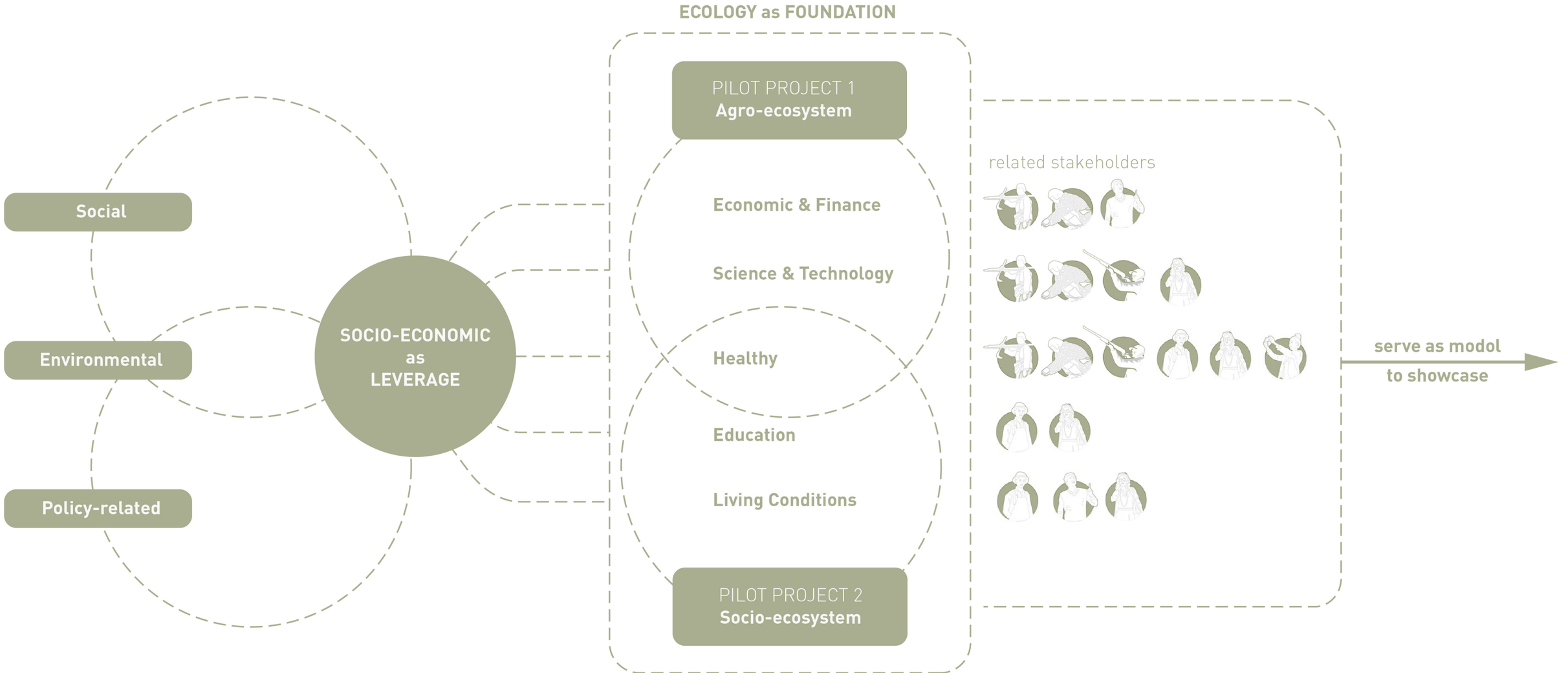
- Farmers/residents

Actively participate in the decision making and implementation process, ensuring that knowledge, experiences, and needs are taken into account. Building trust in government and local NGOs, and follow their pace to contribute to a more sustainable future.

Facilitate farmer-to-farmer knowledge exchange through field visits, study tours, and farmer-led workshops. Encourage experienced farmers who have successfully transitioned to sustainable agriculture practices to serve as mentors and share their experiences with their peers.

Discussion

How to engage farmers as active participants in transition to sustainable system?



Reflection

1. What is the relation between your graduation project topic, your master track (Ar, Ur, BT, LA, MBE), and your master programme (MSc AUBS)?

Along with urbanization, urban ecology has been becoming more and more important in the field of landscape architecture. Urban ecological design aim at promoting a more sustainable and resilient approach to the design and management in the built environment. It involves ecology, aesthetics, socio-economics, etc. Urban ecological design is not just about designing for people, but designing for ecological and environmental health, and even for social and economic justice. All factors from different fields work synergistically to improve the environmental conditions and the people's quality of life in urban area.

My graduation thesis is about exploring sustainable solutions to air pollution. The environmental pollution has been serious due to urbanization; however, some existing approaches cannot address the root cause of the problem. As an interdisciplinary subject, landscape architecture can provide sustainable and resilient approaches that are applied at the spatial level. Eventually, all the outcomes would benefit humans and the environment in which they live. In my case, by cultivating a new paradigm of urban farming as mitigation of air pollution in Chiang Mai through tailoring sustainable agriculture system and landscape framework, farmers and related people would reach their goal of earning high profits, local residents and tourists would be able to breathe fresh, pollution-free air, local environment would improve, local flora and fauna would flourish, and all element would be in harmony with each other.

2. How did your research influence your design/recommendations and how did the design/recommendations influence your research?

Generally speaking, when dealing with an unfamiliar site for the first time, research helps me to better understand the site, its context, and its history, and to identify opportunities and constraints. Research can involve data collection, desktop study, and analysis of existing situation to know natural features, cultural significance, historical context, and environmental conditions of the site.

The design process then bases on this research, using it to develop a design concept that responds to the characteristics and specificity of site. As the design evolves, further research may be needed to refine and validate design interventions. Sometimes, even new way of research needs to be explored to support the design. This mutually supportive process of design and research ensures that the entire design process runs smoothly.

3. How do you assess the value of your way of working (your approach, your used methods, used methodology)?

The multi-scale analysis and stakeholder engagement approach ensures the capability to address complex issues in unfamiliar context and deliver a comprehensive and effective solutions.

Due to the complexity of the project, the analysis framework and design process will be done in multi-scale: regional scale, local scale, small scale. At the same time, through the analysis of stakeholders from different fields, the main research question can be decomposed to several sub-questions, which can be handled in a more focused way because different stakeholders have different positions on the same issue and can provide different ideas and skills from different perspectives and fields. To be specific, in my case, I need to consider the needs of Government/NGOs, Farmers/Foragers/Hunters, Local residents/Tourists. A complex problem can be solved more effectively by breaking it down into several manageable problems.

4. How do you assess the academic and societal value, scope and implication of your graduation project, including ethical aspects?

Academic:

This project deals with developing strategies and policies, agriculture, ecology, and economic and social factor, with stakeholders from public, institutional, and academic sectors involved. Through the interaction of different stakeholders, three scales of design proposals and landscape interventions

will be applied in spatial level. Besides, people's awareness of sustainability and nature-based principle would be raised during the process of developing solutions to air pollution issue.

Landscape architects play a key role in the design and management of urban landscapes, and my thesis project could help to advance the profession's understanding of how to create sustainable and livable cities. It could also provide valuable insights for landscape architects looking to incorporate principles of urban ecology into their work.

Social:
Air pollution is a serious health concern that affects millions of people in the region, particularly in urban areas. Urban ecology can have significant impacts on the quality of life for people living in cities, including through the provision of green spaces, the promotion of sustainable development, and the reduction of environmental health risks. My graduation work in urban ecology could therefore contribute to a better understanding of how to design and manage urban landscapes in a way that benefits both people and the natural environment.

The scope and implication of my project can vary, from small-scale intervention such as community farming and GROW street to larger-scale intervention like agroforestry. This intervention can be implemented in both urban and rural areas, and can have multiple benefits beyond air pollution mitigation, such as improving biodiversity, reducing heat island effects, and providing recreational space for the community, which can have positive effects on the well-being of local communities.

5. How do you assess the value of the transferability of your project results?

Urban ecology is an interdisciplinary field that draws on a range of scientific disciplines, including ecology, geography, urban planning, and environmental science. My graduation project could contribute to the body of scientific knowledge in this field and help to inform the development of more sustainable and resilient urban landscapes with the familiar methodology.

As one of the world's largest health and environmental problems, air pollution has been becoming a threat to health of people all over the world. The aim of my graduation thesis is to create a new paradigm of integrated farming as mitigation of air pollution. The proposed sustainable agriculture system and landscape framework can be replicated elsewhere within southeast Asia to handle environmental issue.

6. What is the difference between conducting academic project and professional landscape architecture project?

In an academic project, the main goal is often to explore new knowledge from research and apply them to the field. While, the practical application of research results may not be implemented immediately. In contrast, a professional project will take more practical factors into consideration and aim to address real-world challenges. And it involves the implementation of design strategies, construction management, and monitoring to realize the proposed landscape design.

Besides, you can define stakeholders of an academic project, basically with limited stakeholder engagement. But for a professional project, it requires extensive stakeholder engagement, including clients, community members, government agencies, and other relevant people. Collaboration and communication with stakeholders are crucial for understanding their needs, incorporating their perspectives in a profession project.

Understanding the differences is necessary for effectively transitioning from academic background to professional practice in landscape architecture.
I also took into account some of the factors that would be considered in a professional project during my graduation project to help me get used to the working mode in a professional way.

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Appendix

Trees for removing PM10 (very efficient)
Casuarina equisetifolia (a.o.) coastal she-oak_ 6–12 m Evergreen Trees Conifer
Pinus kesiya Khasi pine_30-35 metres Evergreen Trees Conifer
Pinus merkusii Merkus pine _25-45m Evergreen Trees Conifer
Araucaria heterophylla Norfolk Island pine_50-65m Evergreen Trees Conifer

Trees for removing PM10 (efficient)
Callistemon lanceolatus (Syn. Callistemon citrinus) Crimson Bottlebrush_1-3m Evergreen Trees
Chrysophyllum cainito Star Apple_1-3m Evergreen Trees
Chrysophyllum oliviforme Satinleaf_3-5m Evergreen Trees
Delonix regia Flamboyant tree_9-12m Deciduous trees
Hopea odorata Chengal_25-30m Evergreen Trees (shade tree)
Jacaranda mimosaefolia Jacaranda_5-15m Deciduous trees
Lagerstroemia tomentosa Crape myrtle_20-30m Deciduous trees
Lagerstroemia villosa Crape myrtle_10-15m Deciduous trees
Peltophorum pterocarpum Copper pod_10-25m Deciduous trees
Samanea saman Rain Tree_15-25m Evergreen Broadleaved trees
Spathodea campanulata African tulip tree_10-20m Evergreen Trees
Cupressus sempervirens (a.o.) Mediterranean cypress_ 35 m Evergreen Coniferous tree
Podocarpus podostachyus Sea teak_15-20m Evergreen, coniferous trees

Trees for removing NOx & Ozone (very efficient)
Alstonia scholaris Devil tree _15-20m Evergreen trees (Roadside Tree, Shade Tree)
Arctocarpus heterophyllus Jackfruit _10-20m Evergreen trees
Bauhinia purpurea & variegata (a.o.) Orchid tree_6-10m Deciduous trees
Cananga odorata Perfume tree_10-20m Evergreen trees (Roadside Tree, Parks & Gardens)
Ficus elastica Indian rubber fig_15-30m Evergreen trees (Roadside Tree, Parks & Gardens)
Garcinia sp. Mexican Mangosteen_ 10-15m Semi-Deciduous trees
Litchi chinensis Lychee_10-15m Evergreen trees
Pisonia grandis Moonlight Tree_5-7m Evergreen Broadleaved trees (Roadside Tree)
Syzigium aqueum (Eugenia aquea) Water Rose apple__6-15m Evergreen Broadleaved trees
Syzygium grande Sea Apple _25-45m Evergreen Broadleaved trees (Roadside Tree)

Shrubs for removing PM10 (efficient)
Caesalpinia pulcherrima Pride of Barbados_3-6m Evergreen shrub
Calliandra haematocephala Pink powder puff_3-5m Evergreen shrub
Platycladus orientalis Oriental Thuja_ 1.2-1.8m Evergreen Coniferous shrub
Tecoma stans Yellow trumpet flower_ to 2.5m Evergreen shrub

Shrubs for removing NOx & Ozone (efficient)
Monstera deliciosa Splitleaf Philodendron (very efficient) _ 1-1.2m Evergreen shrub
Musa sp. Banana (very efficient) _ 3-7m Evergreen shrub
Sanchezia speciosa Sanchezia_ 1-3m Evergreen shrub
Allamanda cathartica Yellow allamanda_ 3-6m Evergreen shrub
Ardisia elliptica (a.o.) Marlberry_ 3-5m Evergreen shrub
Streblus asper Toothbrush tree_ 1-3m Evergreen shrub