LIVING WITH WATER

Creating a vision and integrated landuse strategy to improve water and soil conservation and quality of life aspect.

Jui Vivek Deuskar
Landscape Architecture MSc. 2019

LIVING WITH WATER

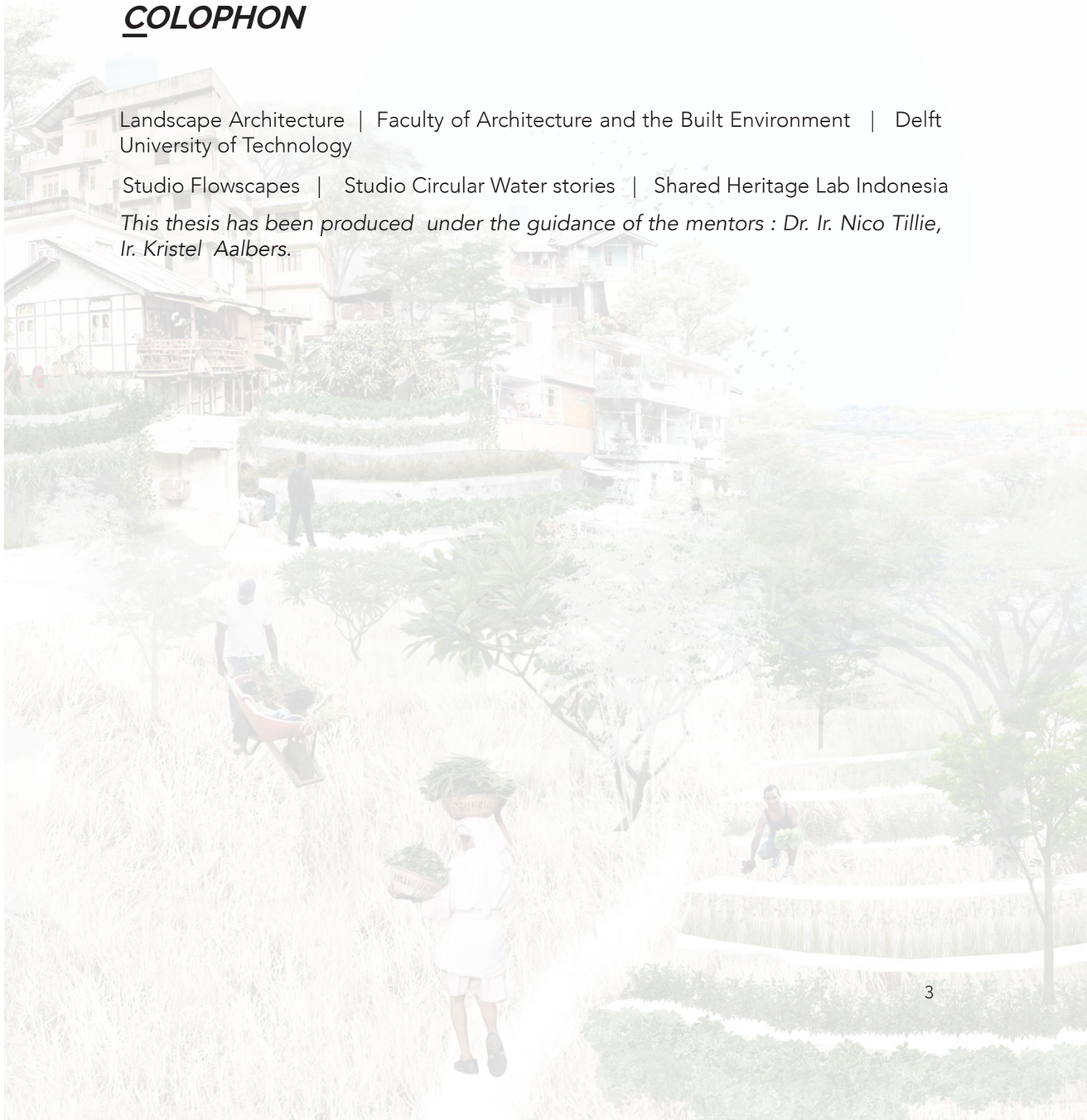
Creating a vision and integrated landuse strategy to improve water and soil conservation and quality of life aspect.

COLOPHON

Landscape Architecture | Faculty of Architecture and the Built Environment | Delft University of Technology

Studio Flowscapes | Studio Circular Water stories | Shared Heritage Lab Indonesia

This thesis has been produced under the guidance of the mentors : Dr. Ir. Nico Tillie, Ir. Kristel Aalbers.



ACKNOWLEDGEMENT

This thesis is a result of my Master's Graduation project in the track of Landscape Architecture at the Faculty of Architecture and the Built Environment at Delft University of Technology.

Firstly, I would like to express gratitude towards my mentors. I would like to thank my first Mentor Dr.Ir. Nico Tillie for the constant encouragement and support, for helping me sharpen my ideas as a professional of Landscape architecture. I am extremely grateful to my second Mentor, Ir. Kristel Aalbers for being so patient with me and for making sure I organise my thoughts and information clearer and better everytime. I am also thankful to Dr.Inge Bobbink for her valuable insights, constructive criticism and for ensuring that I really do my best in the project.

I thank TU Delft, the Dutch Embassy and Bandung Institue of Technology for the opportunity to work on this project in Indonesia and for partially funding my study. I am grateful to Mo Smit and Agung Indrajit who always offered new insights for the project. I sincerely wish that the database compiled through this project becomes a valuable resource and case study for Catchment rehabilitation efforts in Indonesia and India as well.

I thank all my peers, for the encouragement and guidance. I am grateful for my very loving family who gave me the confidence, and Aakash for the constant support, motivation and all that chocolate cake!

ABSTRACT

The city of Bandung is representative of the destiny of many cities in the tropical developing world. Demand driven population influxes combined with a lack of planning and infrastructure leads to massive problems of sustainability. The city faces the twin paradoxical problems of flash floods and the chronic lack of access to drinking water. Land use changes in the Bandung catchment are largely responsible for these water issues. The climate change dynamics only hasten the process of humanitarian disaster. Within this context, it is extremely important to find cost- efficient, sustainable solutions that can alleviate these problems and enable human activity to sustain without suffering. Research suggests that spatial solutions with circular systems may allow for the appropriate channelling of rain water and use it for sustenance. Landscape interventions aim to improve the hydrological order in the catchment, whereby sustained efforts are made to convert hard surfaces resulting from unregulated growth into water absorbing surfaces appear promising.

Besides water retention and prevention of floods, these interventions have aesthetic appeal and spatial relevance to intervention through landscape design. They also achieve goals of more sustainable agriculture that further contributes to the appeal of the city and its aesthetic aspects. The efforts have the possibility of promoting eco-tourism for a city that already has abundant natural beauty owing to a volcanic terrain and evergreen rainforest cover (albeit covered under a layer of pollution today). Thus, proposed efforts through phased spatial interventions can create a positive circle of reinforcement where the benefits are much more far-reaching and sustainable beyond the primary goals of the project.

Strategies for living with water need great innovation in developing countries where the fast pace of city expansion and population growth cannot keep up with the very slow pace of infrastructure development.

—

Solving these issues also plays a vital role in poverty eradication and sustainable socio economic development.

The city can be restored to its former glory through a series of affordable hydrological and bio- engineered strategies in such challenging circumstances, creating case study for vulnerable catchments around the world. There is great promise that landscape infrastructural solutions and circular systems can transform the developing world.

People and water

Fig 1.2. The usual scenario of the settlements blocked to the river full of sewage. Photo Credits : Author, Oct. 2018, Bandung City.

Fig 1.3. Locals having to purchase drinking water through the flooded city. Photo Credits : Antara , Dec. 2018, Bandung City.

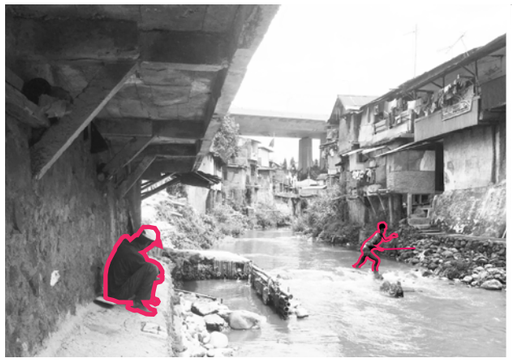
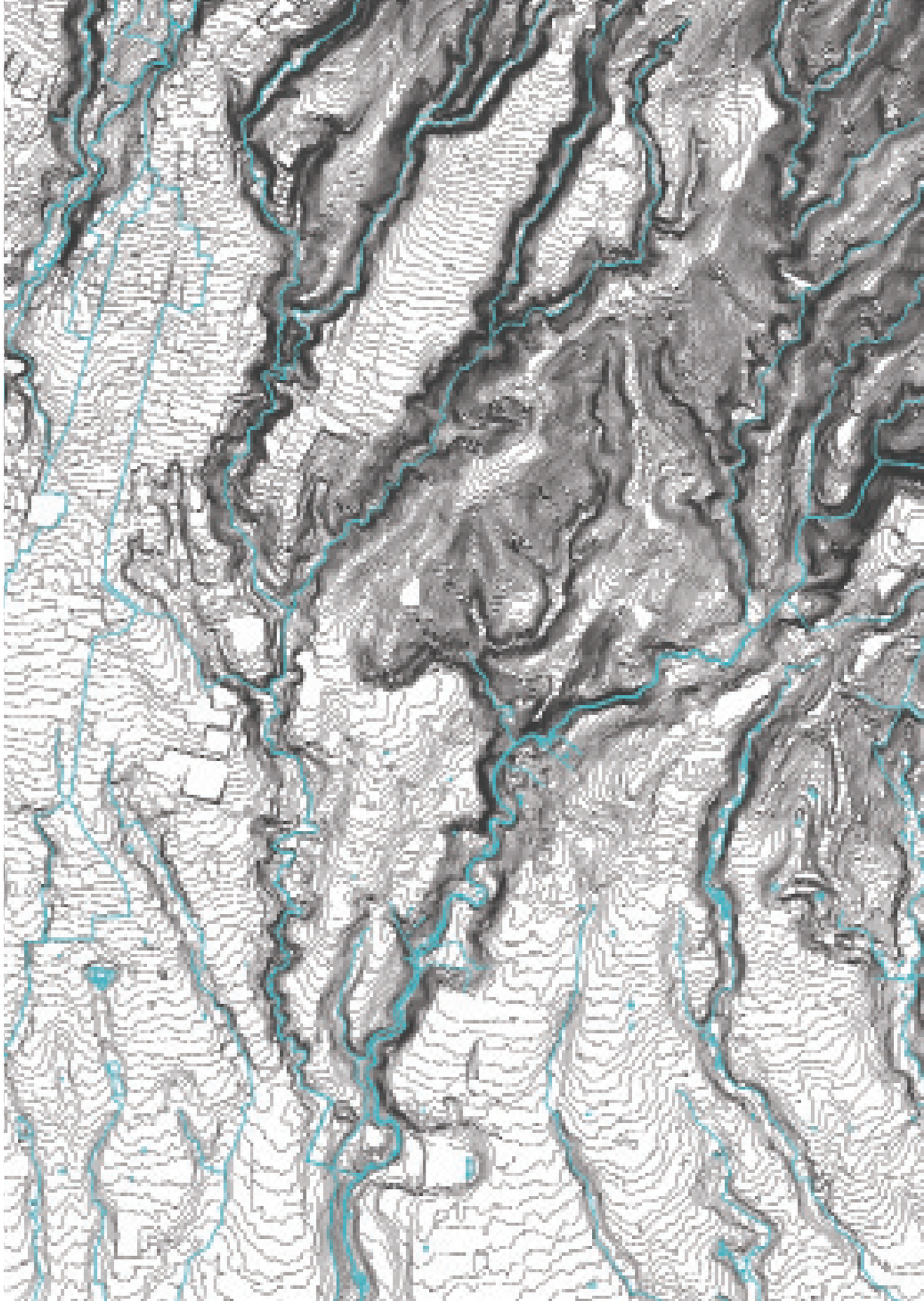


Fig 1.5 It is very rare to find anybody at the remnant of the riverfront. Photo Credits : Author, Oct. 2018, Bandung City.

Fig 1.4. Locals have accepted the floods as their way of life. Photo Credits : Dicko Armas, Oct. 2018, Bandung City.



To the right : Topographic map of Bandung city
Source : Author

SECTIONS

01 INTRODUCTION

02 METHODOLOGY

03 REGIONAL VISION FOR SOIL WATER CONSERVATION: DAGO REGION

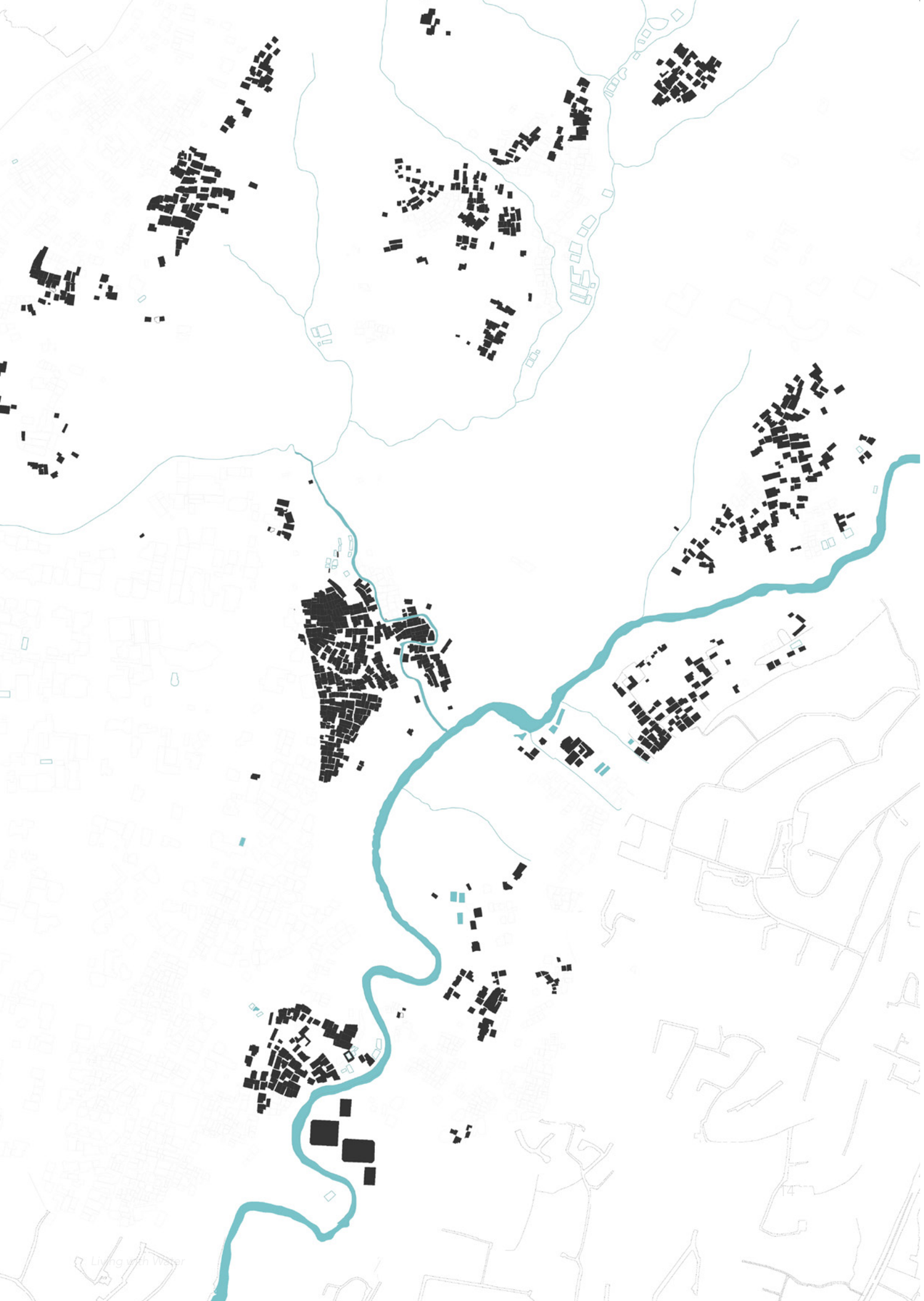
04 DETAILS OF LANDUSE IN MIDLAND ZONE: DEVELOPMENT OF AGROFOREST COMMUNITY

05 DESIGN EVALUATION and REFLECTION

06 GLOSSARY, REFERENCES

07 ANNEXURE

01 INTRODUCTION



To the left : Spatial representation of informal settlements in peri-urban area of Bandung, pointed out in black. Source : Author

01.01 Fascination

Unsustainable urban developments in the catchment area of Bandung city

Bandung city shows high dependence on ground and spring water resources- 76% of the city's population is dependent on spring groundwater reserves as only 40% of the city has access to piped water supply. The Dutch Government laid out water infrastructure during their 130 year long reign by installing water hydrants, two water reservoirs and water supply pipelines.

Since then, Bandung has evloved from a medium sized town with 18000 inhabitants in 1840 to a dense metropolitan city of 4 million inhabitants. As a result, the groundwater resources have been exploited heavily, with over 2500 recorded borewell connection within the main city itself.

The city is surrounded by a ring of mountains and is of a volcanic terrain. The topography makes it a challenge to have a centralised water system that could reach newer limits of the city as the city grew. So there has been continous dependence on ground and spring aquifers. Also there are large numbers of informal settlements known as *Kampungs*, sprawling all over in the city, that are responsible for further groundwater extraction.

Population increase has led to overexploitation of resources and massive deforestation in the catchment area of Bandung- known as the Cikapundung Catchment. Urban development is replacing the forests. As a result, the sponge function of the catchment has been steadily neglected over the past 70 years.

The fact that it is an agrarian economy is an added reason for deforestation - with the mixed tropical and deciduous forests replaced with dryland agriculture. In case of Bandung city, the urban area relies on the water supply on the peri urban and rural areas located outside its administrative boundaries. Hence the catchment area needs to be rehabilitated and its environmental health needs to be improved in order to manage the water resource better. The city experiences now the problem of severe drought and flood for 4-6 months of the year.

In summary, unsustainable practices in real estate, agricultural, domestic and industrial sectors over the years, now necessiates catchment rehabilitation.

The vision of an integrated landuse, is founded on the concept of informal settlements designed around Agroforests in the Dago region of the Cikapundung catchment, implemented with relatively cheap rainwater harvesting infrastructure. They provide for clean water and sanitation locally, at different scales in the Dago region, allowing possibilities of a new, integrated landuse. Water sufficiency makes water available for the growth of agroforest, pastureland cultivation, different scales of farming- like home garden, community orchards, etc. This enables food and water sufficiency in the agroforest community, which is actually the informal settlement zone. People realise a new meaningful environment, as they value their natural resources, thereby associating better with their surroundings.

Fig 1.7. Landuse changes in peri - urban Bandung - forests replaced by farms and informal settlements
Credits : Author, Oct. 2018, Bandung City.

My fascination lies in envisioning expansion of the Peri- urban realm in symbiosis with nature.

Fig 1.8. Location of Indonesia on World Map
Credits: Author

Fig 1.9. West Java Province on Island of Java
Credits: Author

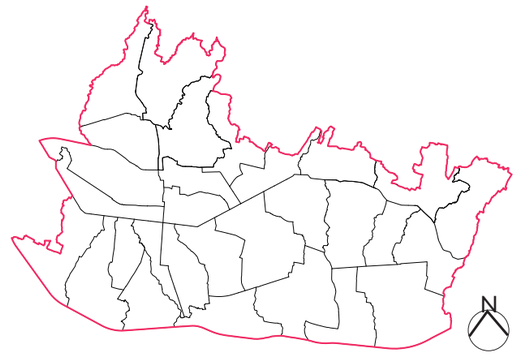


Fig 1.10. Bandung city Profile
Credits: Author

Country scale
INDONESIA

Indonesia, a Southeast Asian nation, is an archipelago made up of more than 17000 volcanic islands.
It ecompasses myriad landforms, such as *lowlands, mountains and volcanoes, nested within dense rainforests.*

Province scale
WEST JAVA

West Java landscape is of steep terrain, volcanic mountains, mountains rivers, forest, and fertile agricultural land .Fertile soil from volcanic deposit + natural rivers and streams + tropical climate with high rainfall are conducive to agriculture.

Area : 37.174 km^2
Population : 46.71 M.

City scale
BANDUNG

Bandung, capital of the West Java province, is a large city set amid volcanoes and tea plantations. The city was built on a basin, at an elevation of 670 m. above M.S.L
Fastest growing city, with a GDP of 10.3%.

Area : 1876 km^2
Population : 6 M.

01.03 Growth of the city

Development of the city 1850-today.

Fig 1.11. Top Left, Bandung city in 1940s
Credits: P. Boomgard

Fig 1.12. Bottom Left, Bandung in 2000
Credits: Author

Fig 1.13. Top Right, Bandung today
Credits: Nugroho Nurdikiawan

Colonised in the early 20th Century, it became a luxurious city with Art Deco villas, plush cafes, fashion outlets, boutiques and hotels with colonial plantation estates of tea, coffee and rubber.

With rapid development of textile and business industry (pharma, telecom, IT,real estate) and educational sector, it saw great job opportunities. As a result the city transformed from an idyllic town into a polluted, unhealthy, dense metropolitan area. Due to the pressure of urbanisation due to floating population, the informal settlements/ kampungs of Bandung city sprawl all over the city today.

This has resulted in overexploitation of natural resources and the city witnesses the irony of drought and flood. Lack of water infrastructure has severely affected the health of the city. I believe that adressing the water issue will greatly improve the quality of life of the inhabitants of the city.

01.04 Problem scenario - Effects of deforestation in the Catchment

3 pressing issues related to water

Fig 1.14. Rainwater run off from Catchment. Credits: Gani Kurniawan

Fig 1.15. Drought scenario
credits : Nugroho Nurdikiawan

Fig 1.16. Fluvial floods in E. Bandung
credits : Xinhua/ banyu Biru

1

EXCESSIVE RAINWATER RUN-OFF

-Flash floods due to high precipitation (200mm) , low water infiltration, and high rate of surface water run off.

2

DROUGHT

-Lack of constant water supply by the Govt.
-Shortage of groundwater reserves due to over abstraction by industries, informal settlements, farming practices

3

FLUVIAL FLOODS

-Sedimentation of river over time and high rate of deforestation is responsible for fluvial floods

Bandung is described as home to 4 million people (2005 Census) with a density of 16,500/ km2, putting a considerable strain on the natural resources.This is due to conversion of the Forest area of Cikapundung catchment into commercial and residential areas, and dryland farming . This catchment zone, which is located in northern part of Bandung, has steadily lost most of the forest, leaving only 25% of its original 30.000 hectares. The city experiences monsoon rainfall pattern from October to February, with 2000 mm rainfall average. The precipitationn in North Bandung - the catchment zone - is above 2500mm. This makes the city very vulnerable to disasters associated with rainfall - namely flash floods. Increase in rainfall intensity combined with deforestation in catchment, increase the vulnerability further. As of today, 95% of the rainwater cannot be absorbed,with the sponge function of the catchment neglected steadily. The flash floods paralyse the road network for 4-6 months of the year, and houses are inundated with water upto 2 meter high.

Bandung has experienced water shortage since 2000. At present, nearly 70% of domestic water and approximately 60% of industrial water needs are satisfied by the use of groundwater, though groundwater (borewells) accounts for only 10–15% of the available water supply. Governance failures in drinking water provision is the reason behind heavy abstraction of groundwater reserves, Peri - urban areas of North Bandung are dependent on Spring water reserves. The local water supply company called is able to provide water to only 36% of the city's population. The topography makes it almost impossible to have a centralised water system, and local rain water harvesting and aquifer recharge are essential to provide potable water in the future.

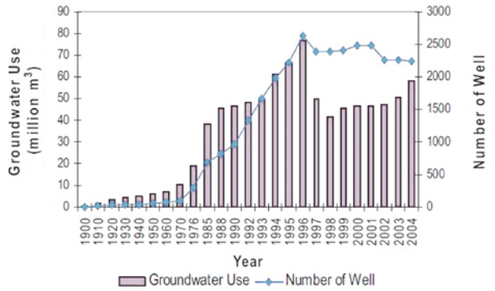


Fig 1.17 Numbers of Boreholes vs. Abstraction Period 1900 – 2004. Source: Based on Monitoring Data from the Directorate of Environmental Geology 1990 –2001, West Java Insititute of Mining Agency (2001-2004).

The city began to grow at a level of 670m elevation - which is a flat plateau, called Bandung basin - covering an area of 2348 sq.km. Surrounding the city, to its North is hilly volcanic terrain, from 670-2400 mm high. Due to the river sedimentation and incresed surface run-off rate, the water carrying capacity of the rivers steadily reduced. A result of the aforementioned factors is fluvial flooding, additional to the flash floods.In March 2018, flood water was 30- 250 cm high, affecting 5900 families / 24000 people, and displacing 13000 residents, inundating 5 sub districts. In March 2019, flood water was 40-280 cm high, affecting 22105 households / 32449 people, ununding 10 sub districts.

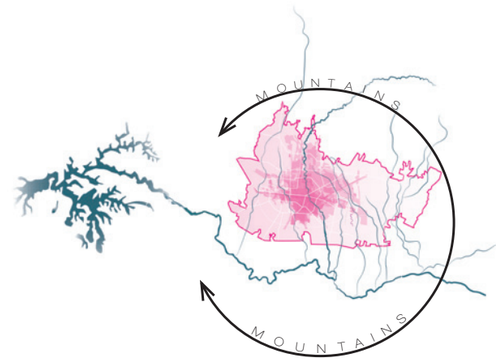


Fig 1.18 Topographic challenges leading to water related issues
Credits : Author

01.05 Water infrastructure Timeline

Fig 1.20 Circular Water system of Kampung Naga. Credits : Celine Mugica

Fig 1.21 Water tower in North Bandung
Credits : Jip Collenbander

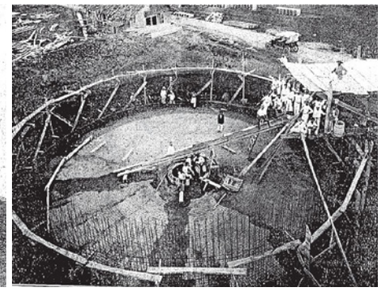


Fig 1.22 Water reservoir in Lembang, North Bandung
Credits : Jip Collenbander

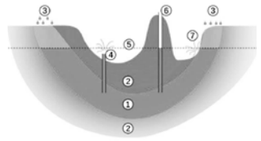


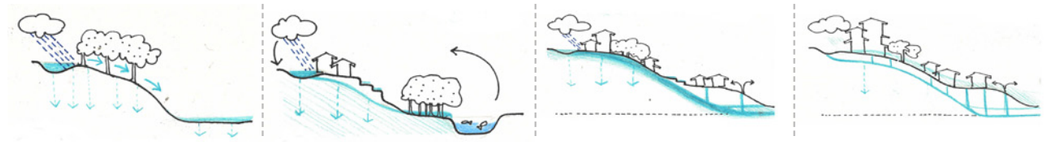
Fig 1.23 Types of Borewells
Credits : Celine Mugica

Sudden urban expansion and forests replaced by settlements and agricultural land.

Rapid industrialisation leads to heavy abstraction of groundwater reserves

Water Supply from government to 1.6 million people, which is less than 50% of population.
Strong intensity and volume of rain, yet no rainwater management considerations.

1200 1300 1400 1500 1600 1700 1800 1900 2000



In the early 1300's, traditional housing called Kampungs had community managed water irrigation and sanitation systems, that rendered it circular and sustainable. Traditional rice farming was called Sawah- rain-fed, wet farming system with a 180 day rice growing cycle, without the use of additional fertilisers. The rise of such community managed water systems regulated amount of water supplied to residences and agriculture, ensuring a sustainable system. Arteric wells and spring water were primary and secondary sources of water for the Kampungs, as illustrated in Fig. This continued till the 18th Century, till Bandung became a Dutch colony. The city was then divided into 3 Zones -

I. North zone A the zone with which is the highest. Solely makes use of springwater.

II. Central zone B is fed with a combination of arteric wells and springwater.
III. South Zone C gets its water mostly from arteric wells with a small supplementation of spring water from the east of the city.
The Dutch Govt. improved water management by laying out new pipes for water supply and drainage in 1958, and 5 water reservoirs. However sudden, unexpected growth of the city led to beginning of water shortage in the 1980's.

Since then, there has been rampant exploitation of spring and groundwater reserves due to the inability of the local water company to provide access to piped water throughout the city. Big water shortages continue as the ability for the arteric wells to obtain water again.is reduced.

01.06 Water cycle today and expected changes

Scenario by 2038

Figure 1.25 gives an overview of daily water requirement for Residential, Commercial and Industrial purposes.
In 20 years, the population is expected to grow from 4 to 10 million and climate change predicts rainfall to increase from annual average of 1200 to 1275 mm per year. Although the rate of transpiration is high in Bandung, the expected run off collected from the Catchment is estimated at 215% of the surface area, as opposed to 93% right now.
Ground and spring water reserves will continue to deplete, with the watertable lowered from approx. 150 m currently, to more than 240 m depth in the future. steady rapid population growth is responsible for shrinking green spaces in the city and the unregulated urban developments are most likely to disable aquifer recharge. Of severe concern is the land use in the Cikapundung catchment, which has changed from 47.3% forests in 2000, to 21.8% in 2015.This has led to reduction in the sponge function of the catchment.Furthermore, flood water level is estimated to rise from 2.4 m.to 4 m high.

Climate change, unregulated urban development leading to deforestation in the catchment, public tolerance and lack of water infrastructure are the reason the health of the city and its inhabitants is in a deplorable state.

Hence, possibilities to improve water flows need to be explored.

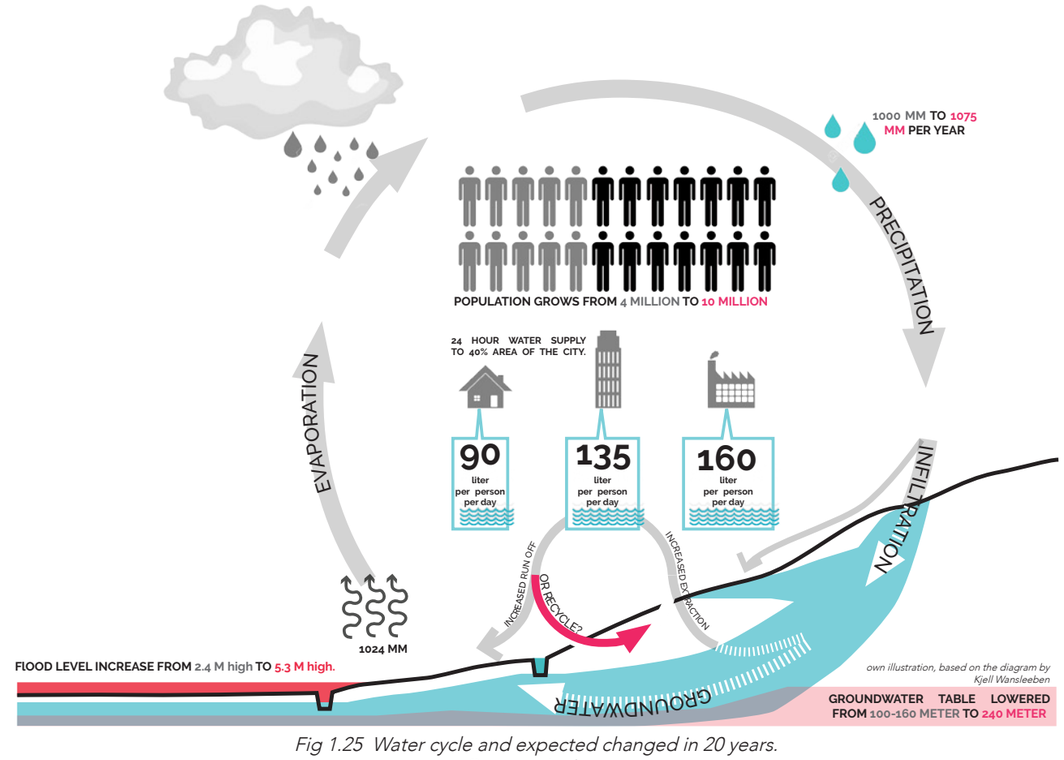


Fig 1.25 Water cycle and expected changed in 20 years.
Source : Author

01.07 Spatial Representation - landuse

Building typologies

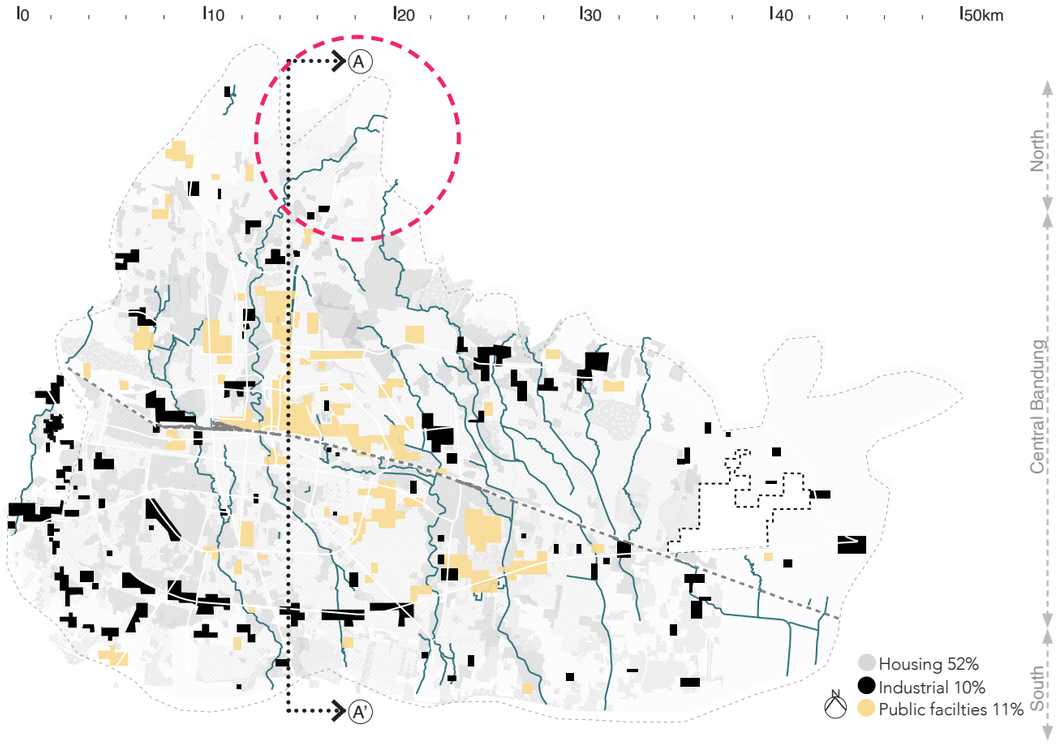


Fig. 1.29 Spatial representation : Built -Unbuilt fabric
Source : Author

From Fig. 1.29 and 1.30, The city section profile shows he centre of the city and its relative height from the north, and its density. Primary land use is of industrial, commercial buildings and nearly half of ithe built fabric is occuoied by the housing sector. followed by the industrial sector. Out of the total housing sector, informal settlements or Kampungs occupy 43% space compared to formal, planned settlements. Hence, relatively cheap water harvesting measures need to be designed for the informal settlements.

Spatial Representation -

Formal versus informal settlements and green space

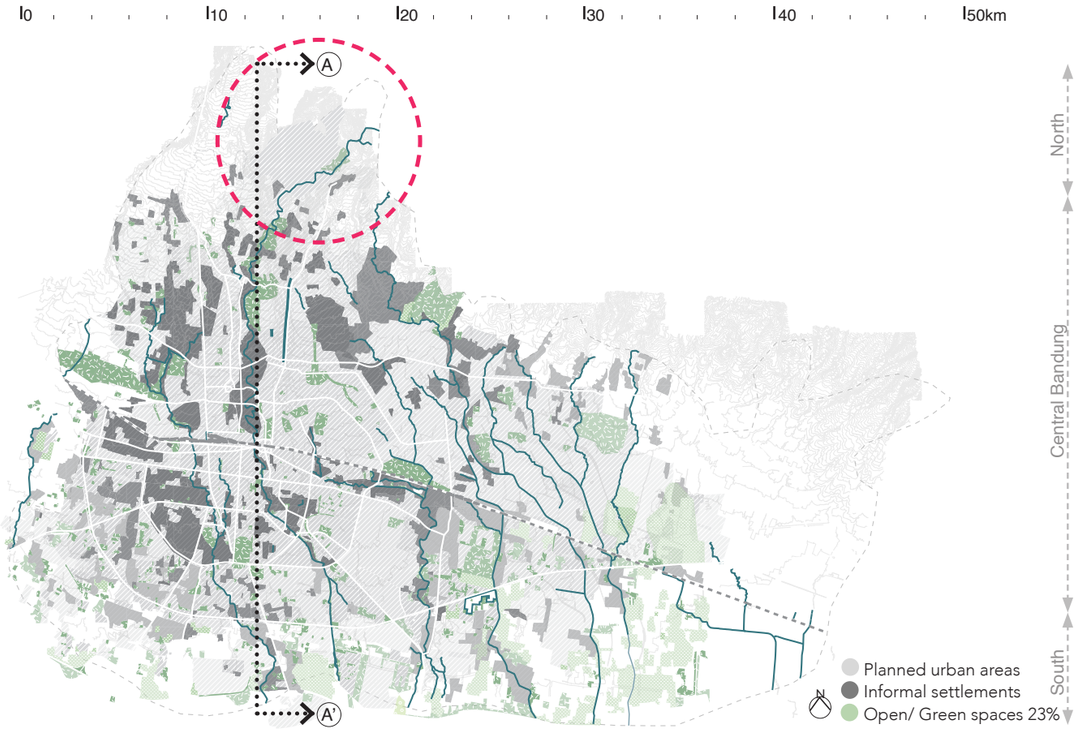
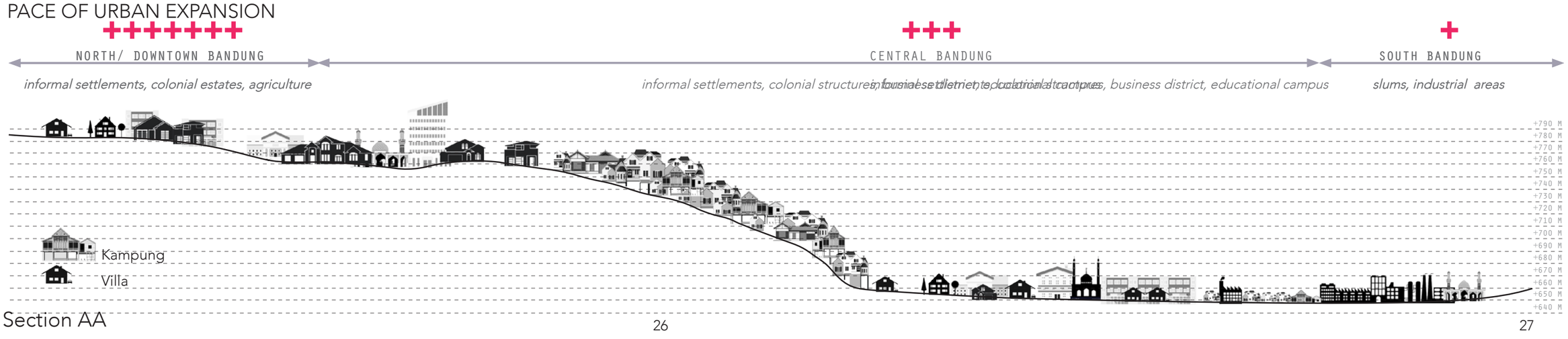


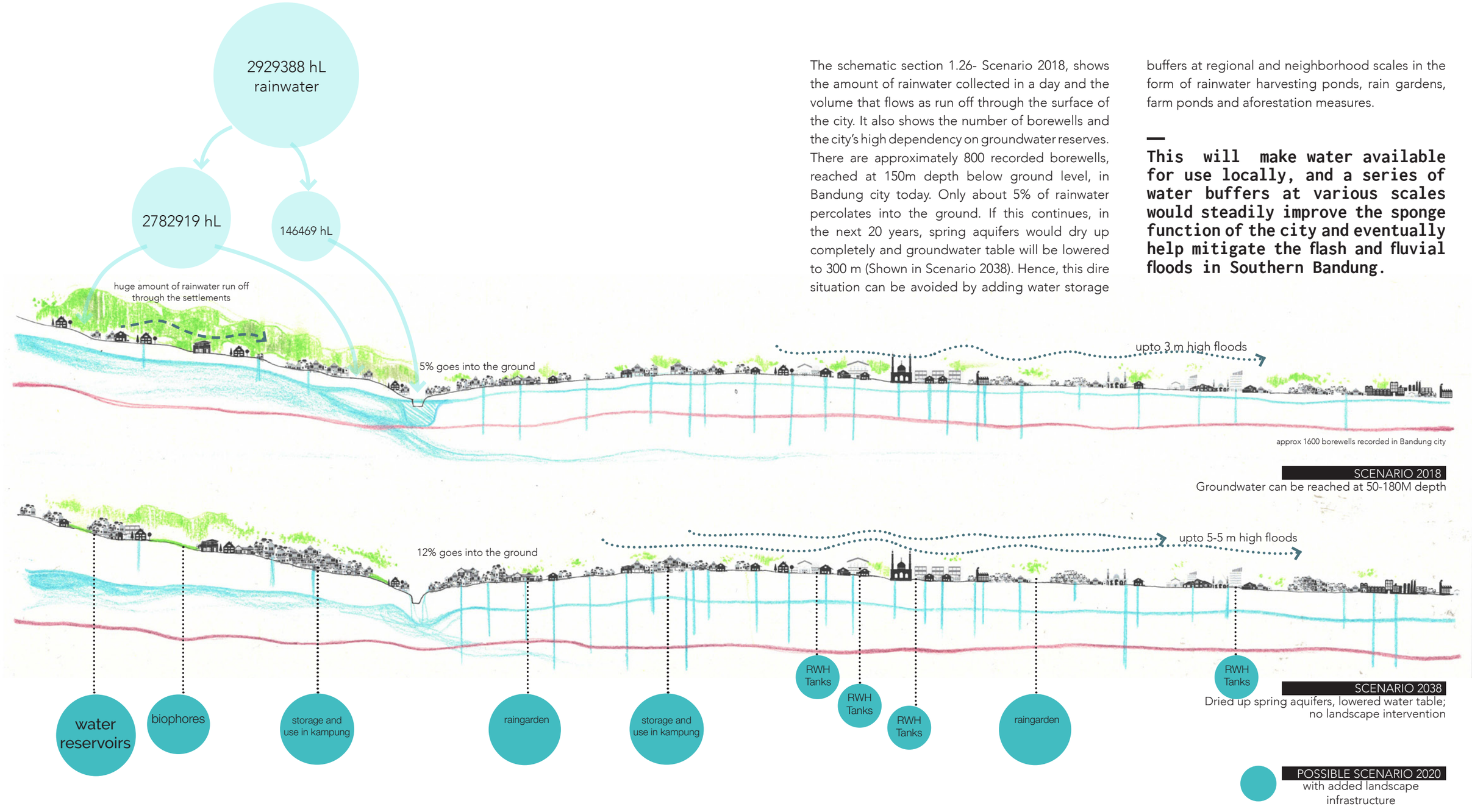
Fig 1.30. Spatial representation : Primary land-use
Source : Author

PACE OF URBAN EXPANSION



Section AA

01.08 Necessity for Rainwater harvesting at different scales in the city



The schematic section 1.26- Scenario 2018, shows the amount of rainwater collected in a day and the volume that flows as run off through the surface of the city. It also shows the number of borewells and the city's high dependency on groundwater reserves. There are approximately 800 recorded borewells, reached at 150m depth below ground level, in Bandung city today. Only about 5% of rainwater percolates into the ground. If this continues, in the next 20 years, spring aquifers would dry up completely and groundwater table will be lowered to 300 m (Shown in Scenario 2038). Hence, this dire situation can be avoided by adding water storage buffers at regional and neighborhood scales in the form of rainwater harvesting ponds, rain gardens, farm ponds and aforestation measures.

—

This will make water available for use locally, and a series of water buffers at various scales would steadily improve the sponge function of the city and eventually help mitigate the flash and fluvial floods in Southern Bandung.

Fig 1.26 Schematic sections of the city from North to South
Source : Author

01.09 Trend of urban expansion in Bandung city

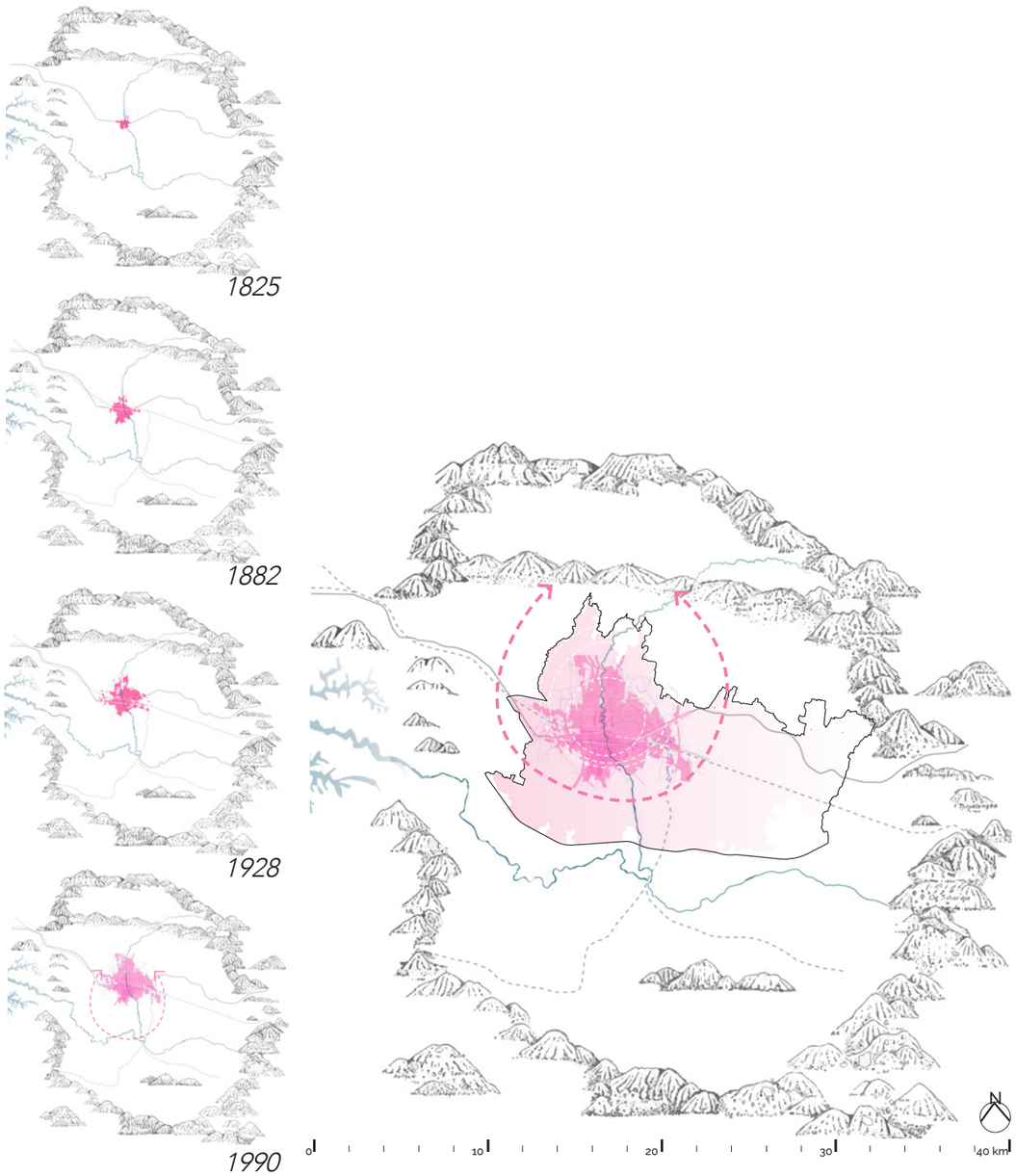


Fig 1.27 Real Estate development in the city with time. Above Left- Bandung city in 2016
Source : Author

Bandung was colonised in the late 19th Century, due to its strategic location, between a ring of mountains that gave a natural defense.

With time, infrastructure was laid out, and in 1882 the first road was built connecting East and West of Java, called Grote Postweg after which the railroad was constructed in 1885. Chinese migrants, Javanese from East Java, flocked in for service related jobs and Bandung grew from a medium sized town of 58000 inhabitants, to a full fledged city with 6,00,00 inhabitants. People from neighboring areas of the island moved to Bandung for work. Sudden growth in population led to housing shortage. This also led to a large number of informal settlements or *Kampungs* growing all over the city. The maps to the left highlight the built fabric of the city, grown over a decade.

As of today, there is large amount of unregulated urban development taking place in the peri-urban areas of North Bandung, as shown in Fig. 1.27. A large amount of people who cannot find place to live in the city itself, move to the peri urban areas, in such of farmland and establish themselves there. This is the beginning of informal settlement constructions, which multiply rapidly. They also explore opportunities for farming in their vicinity, as it is the main source of income for the peri- urban population. Besides this, North Bandung comprises largely of a hilly topography with forested areas of evergreen and deciduous nature and is beautiful and relatively remote. Hence, these areas are exploited for commercial purposes as well, due to high recreational value.
These peri urban areas have the most severed landuse change, where the forests are being replaced by unregulated constructions and farmlands. As a result, the sponge function of the city is reducing considerably.

Such various activities of urban development are responsible for high deforestation in the city itself and especially in the Cikapundung catchment zone, with its forest cover steadily being replaced by settlements and agricultural land.

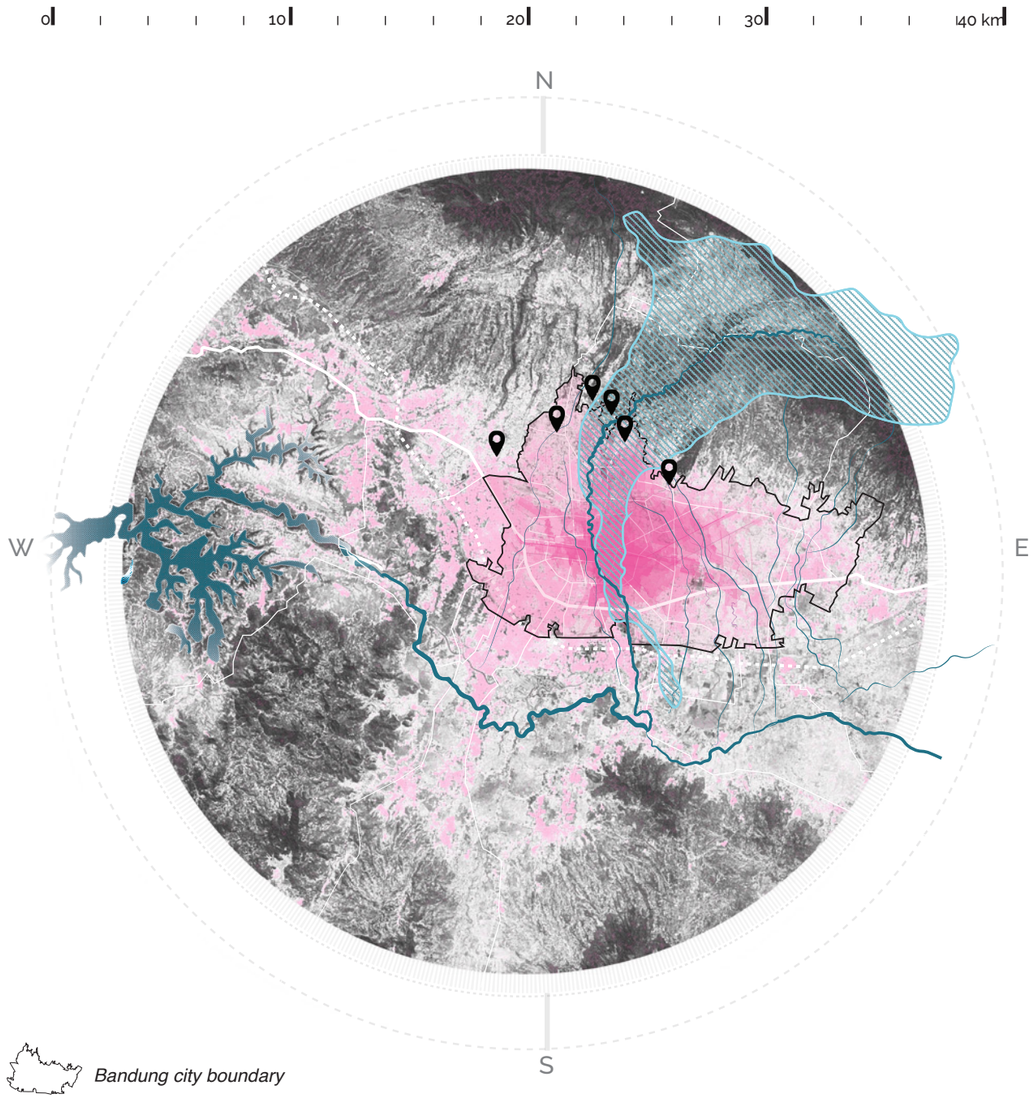
Growth of the city is fast and ithe built environment is fast, compared to the infrastructure development, which is relatively slow. This has led to extreme land degradation and over exploitation of natural resources like spring ground water, soil etc.

Although there are many factors responsible for this situation , including population increase, housing shortage, lack of policy making and implementation at rural level, etc, I believe that landscape architects can intervene in this situation and can be the agent of change by making the stakeholders aware of sustainable approaches.

The trends of urban development are inevitable, yet there are ample possibilities to envision urban development in a more sustainable way. With this project, I wish to explore the role of water in improving the living conditions and socio economic conditions in the lesser developed parts of this Indonesian city, in symbiosis with nature.

01.10 Hydrological situation of Bandung city

Topographic challenges, aggravating water issues in the city



Bandung city boundary

Density of the built environment

Cikapundung River

Citarum River

Cikapundung Catchment zone

Peri- urban locations prone to high deforestation and lowest spring groundwater levels (300m depth)

Due to the volcanic ridges, Bandung city sees 11 rivers crossing it from North to south. The main river that cuts across the city is the Cikapundung river which meets river Citarum river that flows East - west. The Cikapundung catchment zone, through the basin and the surrounding mountains covers 2100 km^2. (Shown to the left).

The Citarum river with its tributaries form the main drainage system in the catchment. The Cikapundung catchment is one of the largest catchments on the island of Java, providing water for drinking, fisheries, as well as water supply for 3 reservoirs- total of 6147 $mil.m^3$ - including local water supply organisation of Bandung city, called PDAM.

The middle catchment zone falls in North Bandung (800-1100M high). The city of Bandung is at a height of 670M above MSL. The catchment zone is 2-500M higher than the rest of the Bandung city to its south. Due to urbanisation and subsequent deforestation in the catchment, a large quantity of water from the streams in the North and all rainwater run off collects in Bandung Basin which is at 670m height, leading to flash and fluvial floods. It is likely that if such urban developments with unsustainable landuse trends continue in the catchment zone, there will be lesser green spaces and forest covers in the near future. As a result, the quanitity of storm water and its flow rate would increase considerably, worsening the flood scenario.

Additionally, the challenging hilly topography makes it nearly impossible for the centralised water supply system of the city to reach the entire city. Hence, there is a high dependence of the city on its existing ground and spring ground water reserves.

Pointed out in the map are peri-urban locations in Bandung city, which are facing extremely high deforestation rates due to rapid urban development. Additionally, these areas already have a very low spring groundwater table level - 250-300M below relative ground level.
There is great scope and necessity to improve the health of these peri- urban locations with different soil and water conservation measures, for sustainable urban development, and improve the overall health of Bandung city.

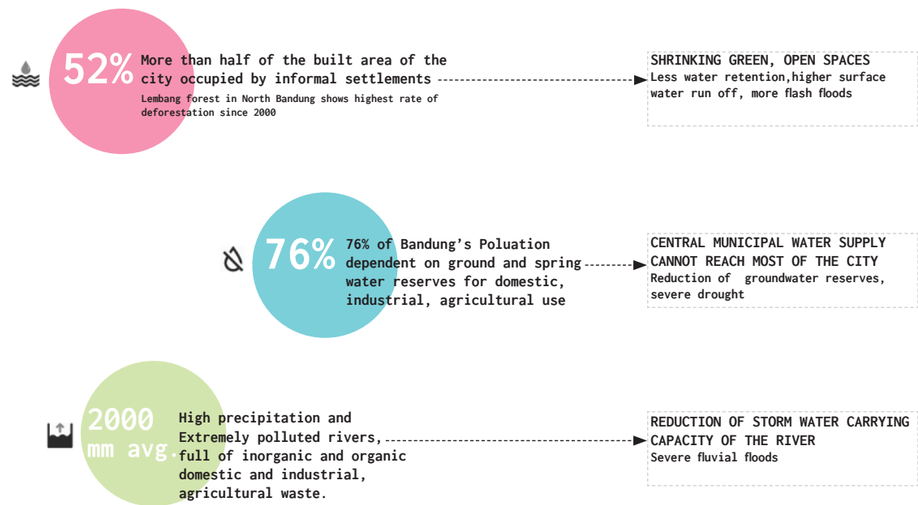
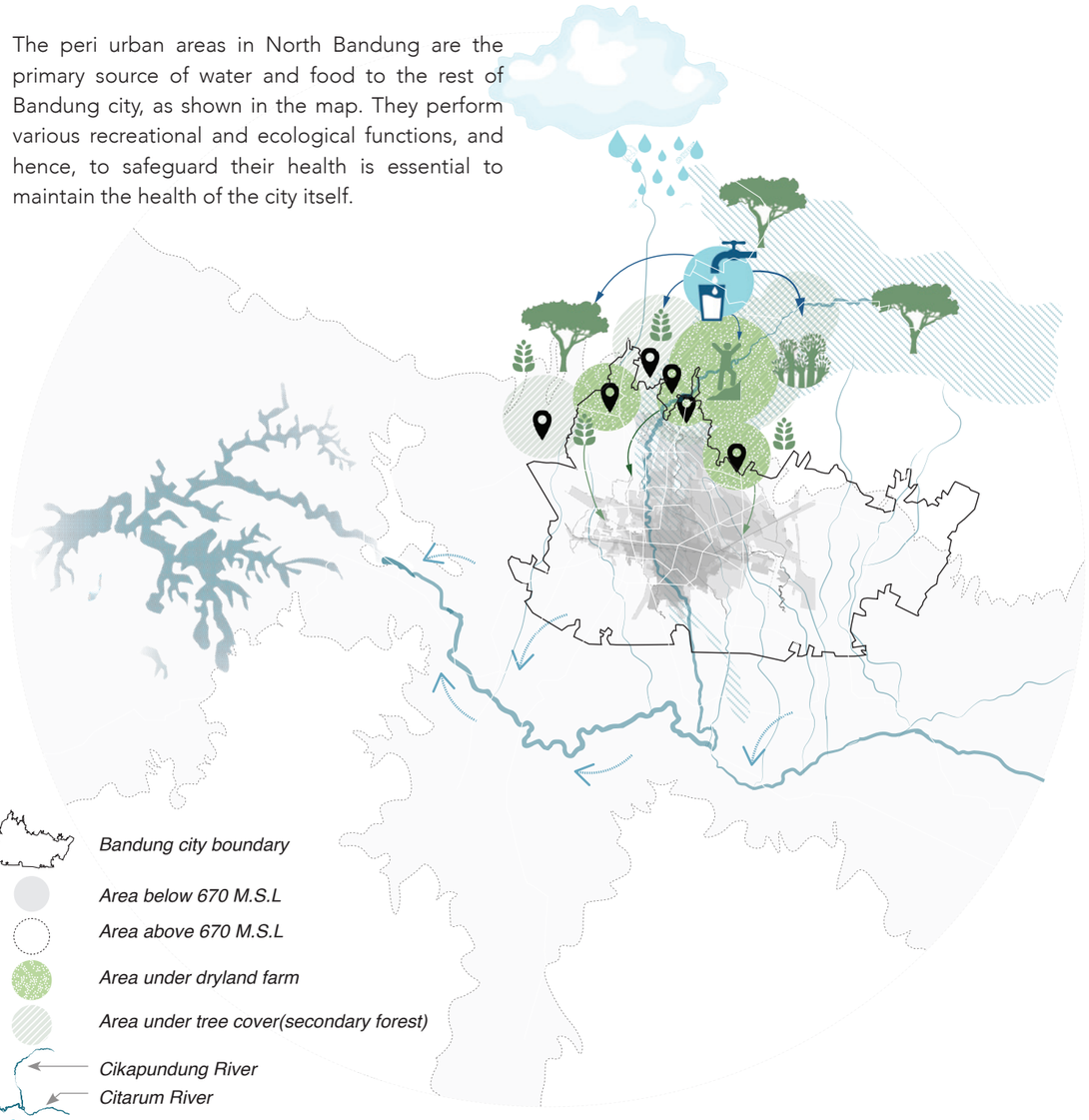


Fig 1.29 Summary of Water related challenges in Bandung city to the topographic challenges.
Source : Author

01.11 Peri-urban locations in the Cikapundung catchment and their functions for the city.

0 10 20 30 40 km

The peri urban areas in North Bandung are the primary source of water and food to the rest of Bandung city, as shown in the map. They perform various recreational and ecological functions, and hence, to safeguard their health is essential to maintain the health of the city itself.



Bandung city boundary

Area below 670 M.S.L

Area above 670 M.S.L

Area under dryland farm

Area under tree cover(secondary forest)

Cikapundung River

Citarum River

Cikapundung Catchment zone

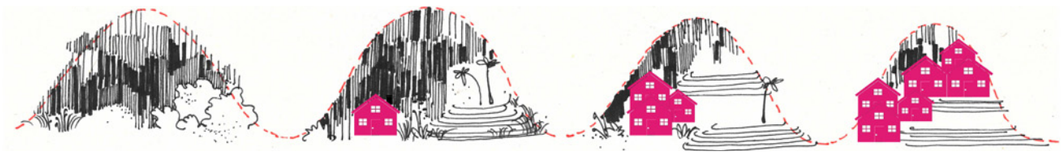
Peri- urban locations prone to high deforestation and lowest spring groundwater levels (300m depth)

Limited forest produce zone

Annual agricultural produce areas

Nature conservation areas

Details of urban developments: unsustainable agricultural, residential and commercial trends

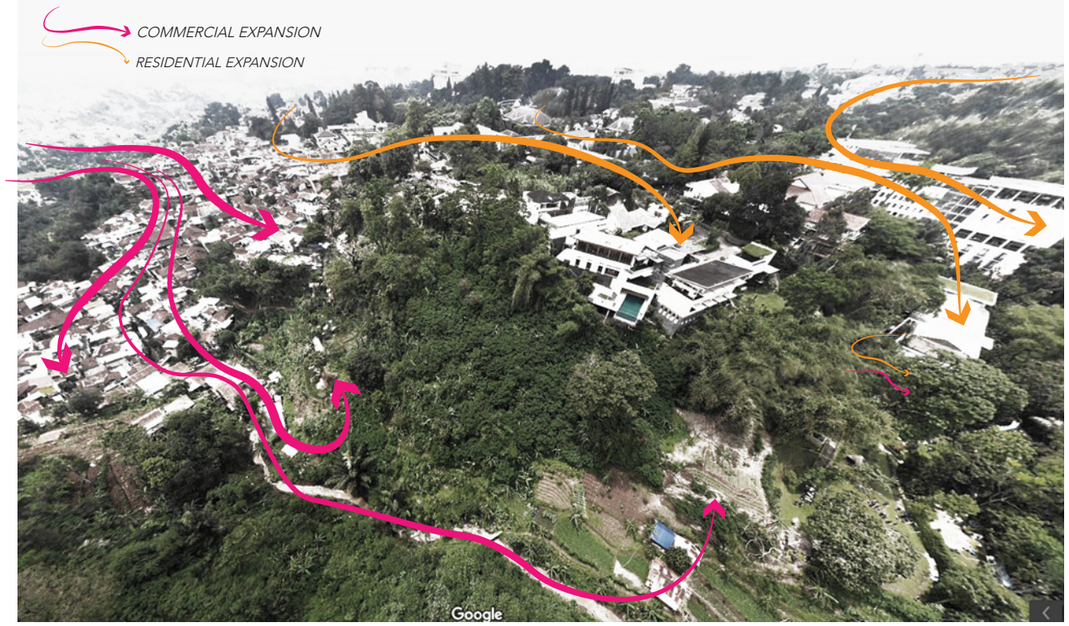


Forests covers at highlands, protect soil, maintain climate. Colonial plantations in the lowlands.

Agriculture, especially traditional dryland cultivation (known as ladang or huma), becomes the main way of life of traditional Sundanese people.

Hilly terrains converted deforested for purpose of housing, toursism. Uncontrolled expansion of dry farmlands.

LANDUSE FROM 1850-1920



01.12 Need for efficient water management in the peri-urban areas of the Cikapundung catchment

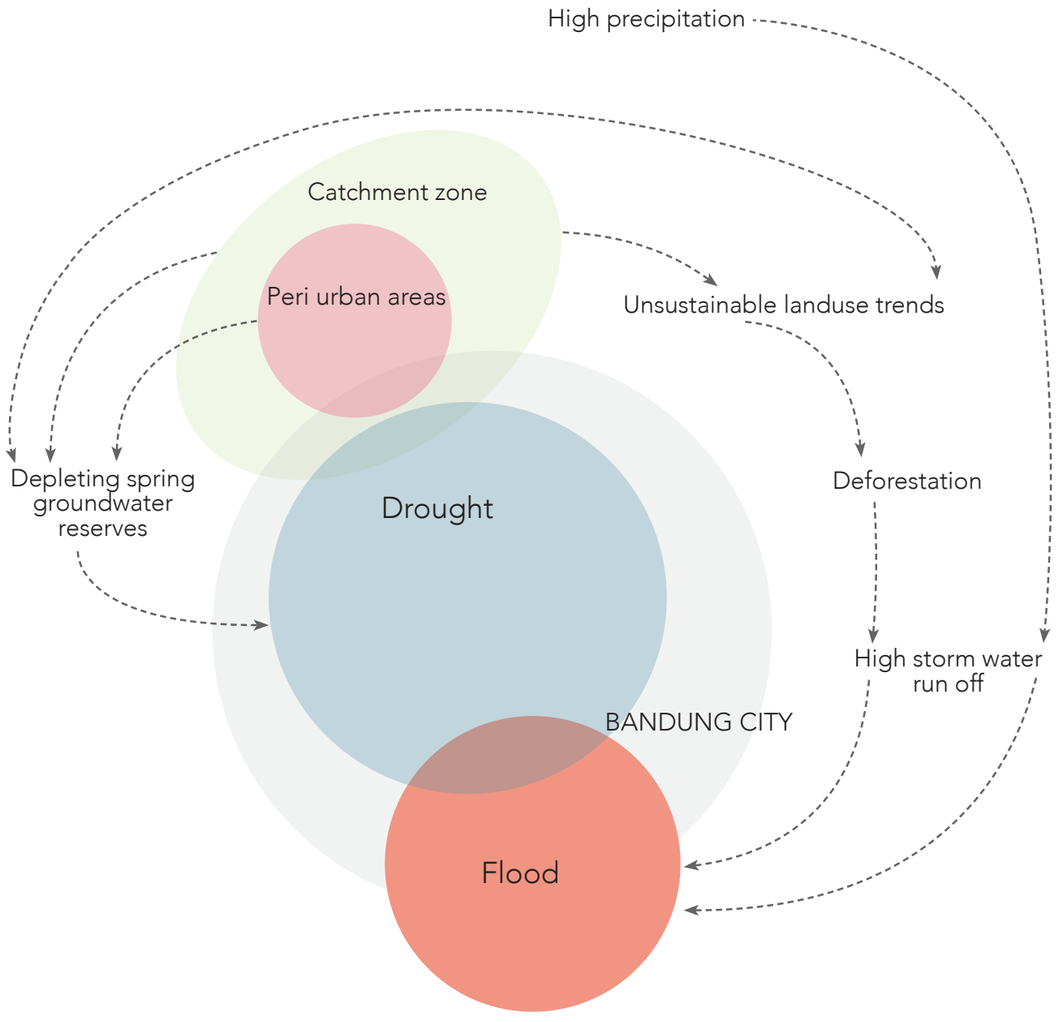
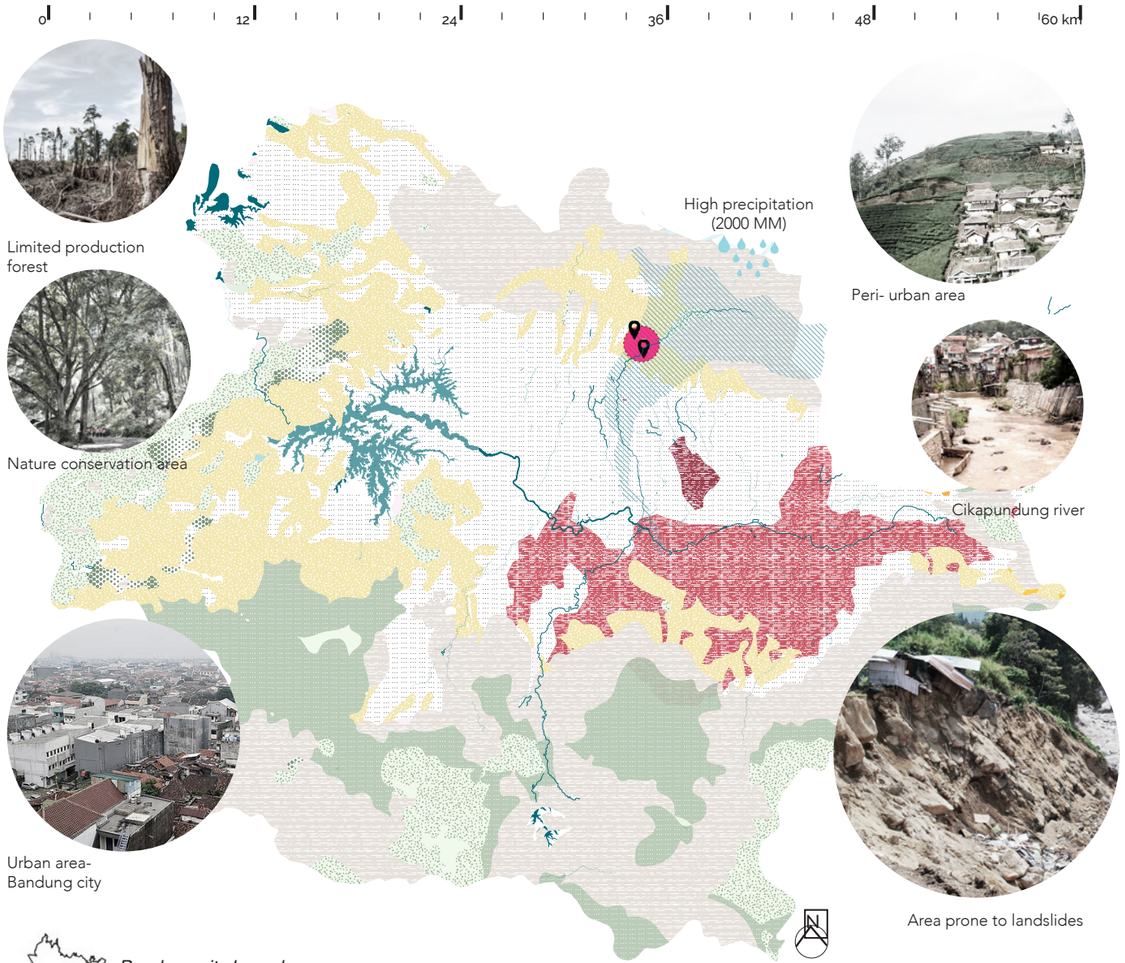


Fig 1.30 Summary Diagram of relation of flood and drought to landuse trends . Source : Author

01.13 Landuse and landscape features in Peri- urban areas



The location highlighted in pink - Dago region in North Bandung, falls in the middle Cikapundung catchment zone. The recent landuse plan shows it in the high risk zone of landslides. Dago region shows rapid reduction in spring ground water table in the last 10 years, with its level reduced from 220 M - 280M. Vast stretches of dryland farms located here, are completely dependent on spring groundwater reserves for irrigation. Dago region also shows the highest amount of informal settlements in the last 10 years, which is elaborated on in the next section. These informal settlements also depend on the existing spring ground water reserves for domestic water supply.

Additionally, Dago region also shows the highest deforestation rate in Bandung city. Because of the factors mentioned above, there is extreme land degradation in Dago region, leading to soil erosion, degradation and ultimaltely responsible for landslides. The forests being replaced by settlements and dryland farms, has resulted in reduction in sponge function in Dago region. Unustainable land-use trends are also responsible for over exploitation of natural resources like soil and water.

The features in this area include plush formal housing societies, commercial establishments like hotels and resorts, informal settlements or Kampungs, Protected forests, agricultural land, and nature conservation areas, and include mixed forests - of evergreen and deciduous nature.
green spaces- dense tree covers are remnant of the primary forests after being felled, they are referred to as secondary forests or mosaic forests which are 5-7 years old, with no specifically planted species.
Studies suggest that Soil and water conservation measures, can alleviate the issue of landslides. by immediately improving the quality of land and soil, by increasing its moisture content.
Soil conservation is carried out through strategic aforestation measures.

Water conservation by implementing rainwater harvesting infrastructure can facilitate wetland or traditional or sawah farming which is more sustainable than dryland farming. Design of a decentralised rain water based water managemement system can provide water for informal settlement for domestic use and to develop small scale private seasonal farms.
Steady soil and water conservation measures over time, make way for integrated landuse in Peri urban areas like Dago region, as elaborated in sections 3 and 4.
Integrated land-use planning is the process of regulating the use of land in an effort to promote more desirable social and environmental outcomes as well as a more efficient use of natural resources. General aims of integrated landuse are sustainable food production, improved water management, environmental conservation, ecological improvement, etc. Specific goals of the integrated landuse planning within the scope of this project are:
1. Growth of informal settlements in symbiosis with nature.
2. Promoting sawah farming instead of dryland farming.
3. Reduce dependence on agriculture as the main source of income by introducing Agroforest as a link between forests and dryland farms.
4. Improved water management system in the Cikapundung catchment zone.

—

Hence, an integrated land-use strategy needs to be envisioned in the high risk zone of Dago region in the Cikapundung catchment. It will promote the soil and water conservation in the Catchment, thereby improving sponge function of the catchment, and reduce nuisance of landslides, drought and flood.

01.14 Design Goals and Research Questions

Aims of Landscape Intervention

GOAL :

How to develop a landscape architectonical intervention, with an improved water management system, for a sustainable, integrated landuse approach in the Dago region of the Cikapundung catchment.

RESEARCH QUESTION :

Creating a vision and integrated land- use strategy to improve water and soil conservation and quality of life aspect.

SUB QUESTIONS :

1. What is the relation between the hydrological system of Bandung city and the landuse in peri-urban Bandung?

-Which kind of interventions can improve the sponge function of the catchment zone in Dago region?

-What is the rainfall and storm water dynamic in this region and its relation to aquifer recharge and how can I improve it?

-What kind of land use and water infrastructure would lead to efficiency of water management in this region?

- Is it possible to introduce a wetland (sawah-rainwater fed) agriculture system parallel to dryland farming?

-Is it possible to develop a small scale, community driven, relatively cheap, decentralised water management system for the informal settlement?

-With water harvested locally, can agroforests be encouraged?

-What kind of spatial intervention can improve the current water management scenario, its dynamics, in order to integrate land and water?

-Which are the natural phenomena that can be considered as landscape values (Rain, soil, steep land) and help generate a productive landscape?

2. What design principles could be derived from the study of the landuse technologies of the past and the present?

-Can these design principles help to propose an landuse framework for a new self sufficient, sustainable community in symbiosis with nature?

3.Can the scenarios of intergated landuse improve the quality of living and enable its citizens to value its natural resources?

-Can the integrated land-use system and the phased interventions foster a strong sense of communal pride?

-Can these interventions enable active interaction of the locals with the landscape?

-Can agro-forestry help to bridge the gap between unsustainable dryland agricultural trends and deforestation?

4.Is this framework for an integrated land use model, and its guidelines for sustainable expansion of informal settlements likely to be applied in other parts of thls city and the world with similar thematic, climatic and physical context of hilly catchments?

01.15 Stakeholder Network

Successful implementation of bottom up initiatives can be achieved with an active involvement of various stakeholders. Fig. 1.39 gives an insight into the various stakeholders related to the water resource management in Bandung city.

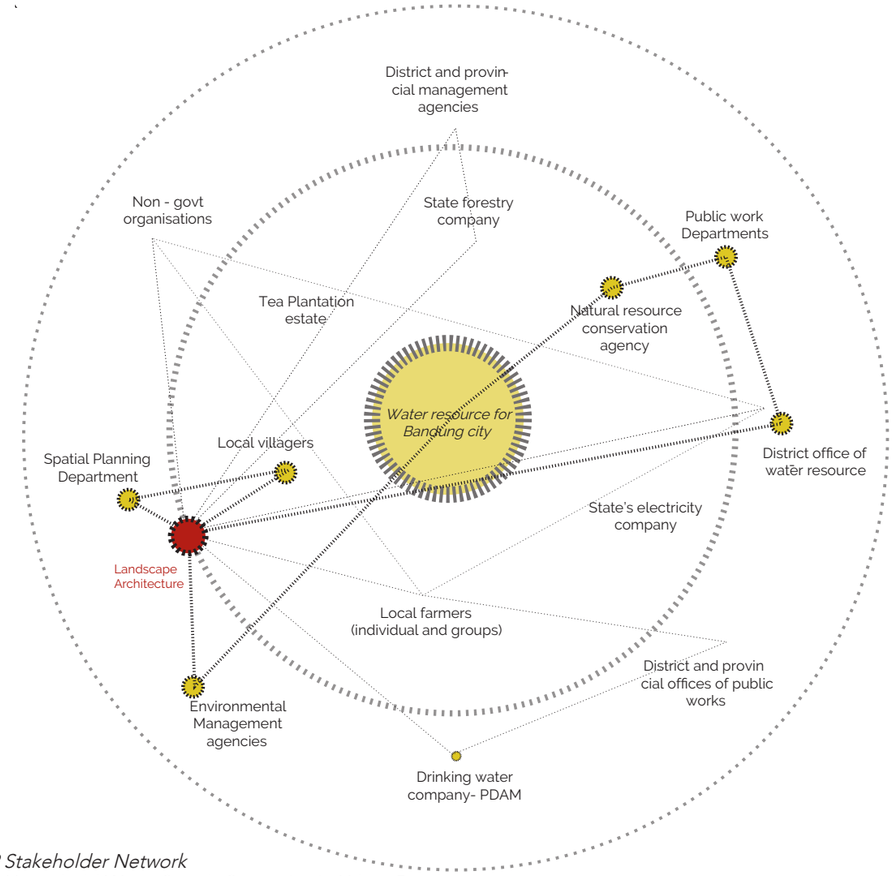
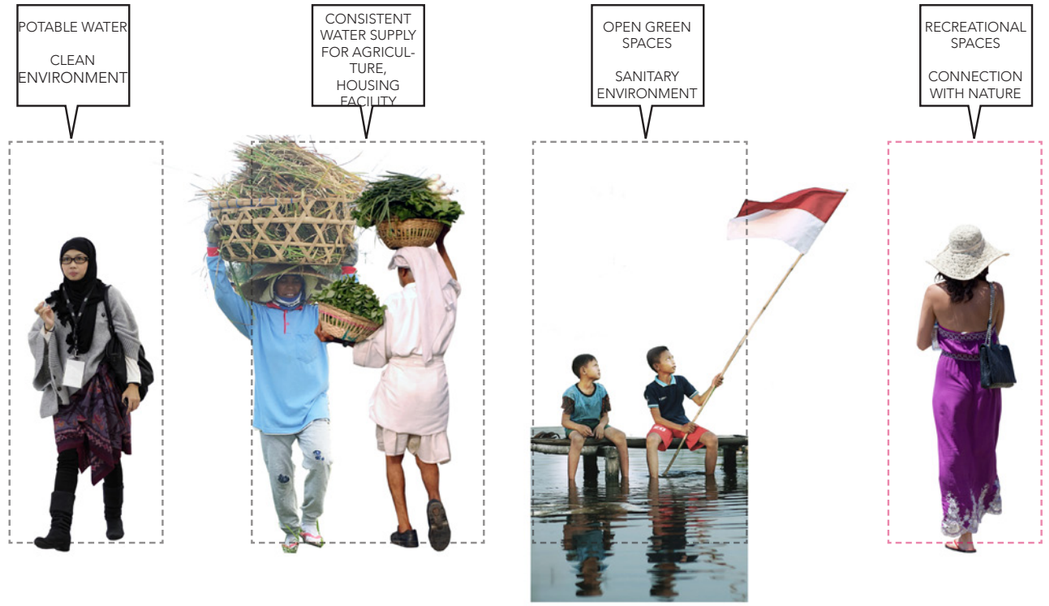


Fig 1.39 Stakeholder Network
Source : Household Water Supply Strategies in Urban Bandung,

Water resource management system of Bandung city can be categorized into 5 broad groups: Provincial and district goverrments, community, public and private enterprises, university and non governmental organisations. They can be categorised as 'holders' (controllers), users and regulators.

Level I - 'Holders' are State's Forestry Company, Tea Plantation Estate, Natural resource conservation agency. These are state owned companies and agency.
Level II - Government agencies and offices involved in Policy and regulation making. and their influence depends on district of the city and varies with every district.
Level III- District level agencies and offices, but majorly consumers in Bandung city and downstream water consumers.
This is a complex network with many stakeholders directly and indirectly involved. They are responsible for water accessibility to the residents of the city. As of today, the PDAM company is able to supply drinking water to only 36% of the city. The rest of the city shows very high dependence on ground and spring water reserves which are depleting quick.
70% of the population in the Cikapundung Catchment area subsists on income generating activities in agriculture and extractive activities which require water in high quantity.

Interest of the Locals



Locals - inhabitants as well as the floating population.

Farmers - land consolidation with communal agricultural options.

Children - given that 60% of the population of Bandung is under 40 years of age.

A socio economically beneficial spatial plan can boost eco tourism.

Urban areas of Bandung rely on the water supply from rural areas located outside their administrative boundaries, i.e. the peri-urban catchment zones. This Urban- rural interrelation can be maintained by effective management of water resource in the catchment zone. The analysis maps led to the conclusion that the health of the Cikapundung catchment zone in general is a cause of concern, with deteriorating environmental conditions, due to rapid urbanisation. This has resulted in serious land and soil degradation in the Cikapundung catchment zone, which is responsible for reduction in water reserves here.
As a result, there is severe water shortage in the peri- urban areas as well as Bandung city itself.

The vision for soil and water conservation measures requires active participation from its citizens. For them to be successful, it is necessary to review the centralised and top down planning approaches in view for bottom up solutions tailored to Dago region and are relatively cheap. The interventions of soil and water conservation in the Dago region of the Cikapundung Catchment zone, facilitate sustainable integrated landuse planning, thereby improving the sponge function of the catchment.

02 METHODOLOGY

Fig 1.35 To the left : Forests replaced by dryland farms in Dago region
Source : Author

02.01 Theoretical Framework

Mountains as sources of knowledge

"Mountains have always held a privileged relationship wtih water as the sources of the world's greatest rivers and homes of huge glacial reserves. These water towers of the world are threated by global forces like climate change, dynamics of human behavior like population growth, historically dominant activities like agriculture, industry, etc. A paradox of mountain water resources is that concern about deficits and competition for use coexist with the risks that come from their role as repositories. Mountain regions have a long history of overseeing the resource of water and thus are good sources of knowledge for examining the dilemmas of managing a public good that know no boundaries but can be diverted and traded. Unique geography, particular experience and often special institutions characterise the distinctive interactions between mountains and water. Study of this theme requires an interdisciplinary approach drawing on knowledge with theory and methods from a wide range of scientific domains focused on hydrological dynamics and human water use." (Beniston, M. 2008)

In case of developing countries like Indonesia, increase in population led to natural resource depleting activities mainly deforestation, in peri - urban areas, which are the hilly terrain of the catchments. These issues are compounded with inefficient water management. This results in not only water shortage, but also poverty and ill-health of the city like in the case of Bandung. The topography in Peri- urban Bandung is a challenge along with high volume of water. Site specific measures for water filteration, infilteration through infrastructure and aforestation measures in the Peri-urban hilly areas, can help to improve the drought and flood situation in Bandung city itself.

Design with Nature

Design with Nature approach proposes a land-suitability model, with a view to live *with* nature - which alows the community to develop a strong association with it landscape. It requires a study of land - use trends, and understanding of the site's natural features or values - which can be enhanced through the medium of landscape interventions
An understanding of a larger context is essential, because the problem scenarios in developing countries are very complex - social, ecological, technical, and to resolve them may require interventions away from the source itself.
Infrastructural solutions to be proposed require careful reading of the site - to visualise the effect of time on the landscape. It refers to designing with the knowledge of history, with a scientific and creative approach to predict and mitigate the devastating effects of climate change on natural systems.

For my project, I did a regional analysis at Bandung city scale which provided the clues and opportunities for design thinking for the city and its peri-urban Catchment zone. The landuse of peri urban areas of Bandung city can be improved greatly, to improve sponge function of the catchment by implementing rainwater harvesting measures. Investigation of landuse change in Bandung city since 1900 gave an insight into activities like wetland farming and aquaculture, which are more sustainable. Such activities can facilitate aquifer recharge in specific areas to improve the land and soil quality. I also got insights into community controlled water management systems dating back to 13th century. Such clues of ecological wisdom were a starting point to work on the design.

—

"Let us green the earth, restore the earth, heal the earth." (McHarg, I.)

Landscape as Infrastructure

Landscape infrastructure facilitates meaningful interaction of man with his environment.
Landscape typologies in Peri- urban Bandung include evergreen and deciduous tree covers or secondary forests, Seasonal farmlands, Mono-culture Agricultural lands, etc. Introduction of rainwater harvesting infrastructure facilititates water availability locally, promoting annual farming, with reduced dependence on the scarce springwater reserves in the Peri-urban areas. With Agroforest and afroestation measures, the locals are able to grow crops from a private to a commercial scale. This vision of an integrated landuse, backed by rainwater harvesting infrastructure, facilititates social, ecological and functional interactions, by which users of the space establish a sense of familiarity and identity. It also facilitates interaction of the citizens with the environment, acting like an interactive bridge between man and nature. It also provides opportunity for interdisciplinary activities generated through landscape interventions, ex. fishing, livestock farming, eco tourism opportunities.
Relatively cheap and site tailored rainwater harvesting infrastructures are laid out like bioswales, constructed wetlands, water holding farm ponds, with a gravity guided water supply system, plant based water filteration systems - which facilitate social interaction and environmental prosperity.

The community bond is very strong in the Kampungs or informal settlements in the city of Bandung. The landscape infrastructures proposed through my project provide space for activities like community orchards, homegardens, cooking workshops, small kiosks serving local Indonesian food.
The interventions can be described as *a space of flows as opposed to a space of places* (Nijhuis, S.), a vision to intergate prosperity of the people, planet and profit as well.

Operative Landscapes

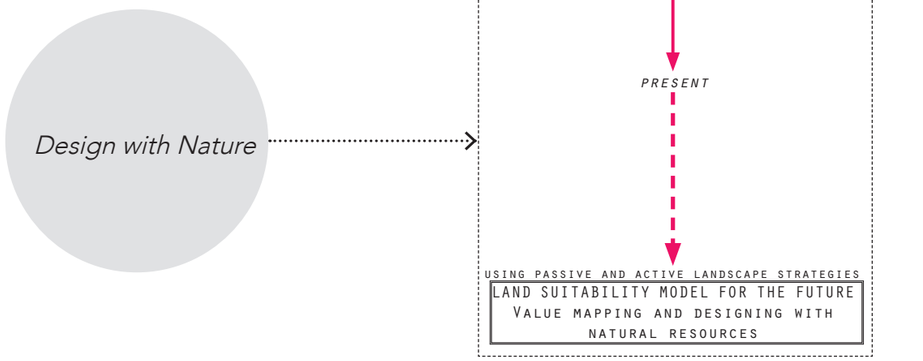
"There are infinite ways to build a community, yet the defining feature of any community is characteristically the landscape. Whether it is a park, a river corridor, community gardens, plaza or a streetscape, the public spaces where people interact provide a shared sense of ownership"
(North, A.)
In this case, rainwater harvesting infrastructures not only act as water buffers, filters and infiltrators but also add a unique spatial quality and integrate with the environment and the social fabric. The community is built along with it, grows with it, and can explore the ample benefits of harvesting water locally. Agroforest and aforestation measures carried out by the locals together create a sense of shared ownership of space as well as the natural resources like soil, land, etc. Community orchards, home gardens, private farms, livestock farms have the ability transform it into a social community. In this case, it is not possbile to lay out a top down approach or a bottom up approach, given a complex stakeholder network, and diverse interests of the many actors involved. So a mixed approach of bottom up strategies, is realised with the help of locals. As there isnt a set of defined guidelines or design tools for planning to work with already, the users (farmers, citizens) along with local governance, NGO's, contribute to the implementation of the strategies to establish a sustainable built environment, in symbiosis with nature, enhanced by its people.

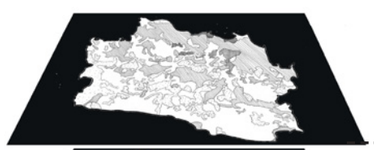
—

"The notion of the space of flows or flowscapes could serve as an impetus to develop the concept of landscape infrastructure into a more comprehensive form of urban landscape architecture which addresses the complex web of relationships consituting the urban landscape." (Nijhuis, S.)

02.02 Bandung Region - Landscape Value Mapping

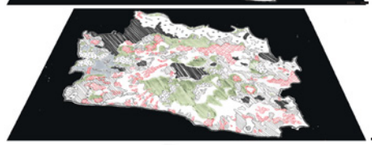
Design with nature gives an ecologically sound approach to planning and designing communities. To respond to the research question, I began analysing Bandung city over the past 100 years, with respect to its landscape values - Landuse and its trends, to understand the quality of soil, aquifers and rainfall, in order to propose conservation measures for the same. [Refer Appendix A for details.]





Land Use Map - 1960 - an insight into site specific landscape traditions.

-predominantly agrarian society: mixed type, wetland + dry
-forests - teak forests, coniferous forests
-colonial plantations, community ownership

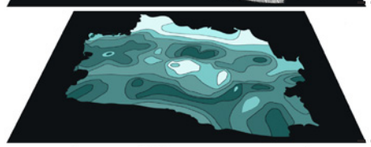


Land Use Map - 1990 - an insight into urban trends relevant to landscape processes .

-large scale deforestation resulting in landslide
-fragmented scenario of agriculture and urban expansion

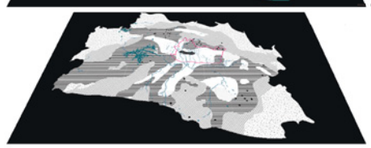
Soil Value Map - understand the qualities of soil

-planning in accordance with which soils need to be conserved, which have high and low regenration values.



Rain Value Map - rainwater management and harvesting as at asset to drought and flood ridden Bandung .

-1500-2000 mm rainfall withinin Bandung city
-above 2000 mm rainfall in the mountainour terrain of Bandung

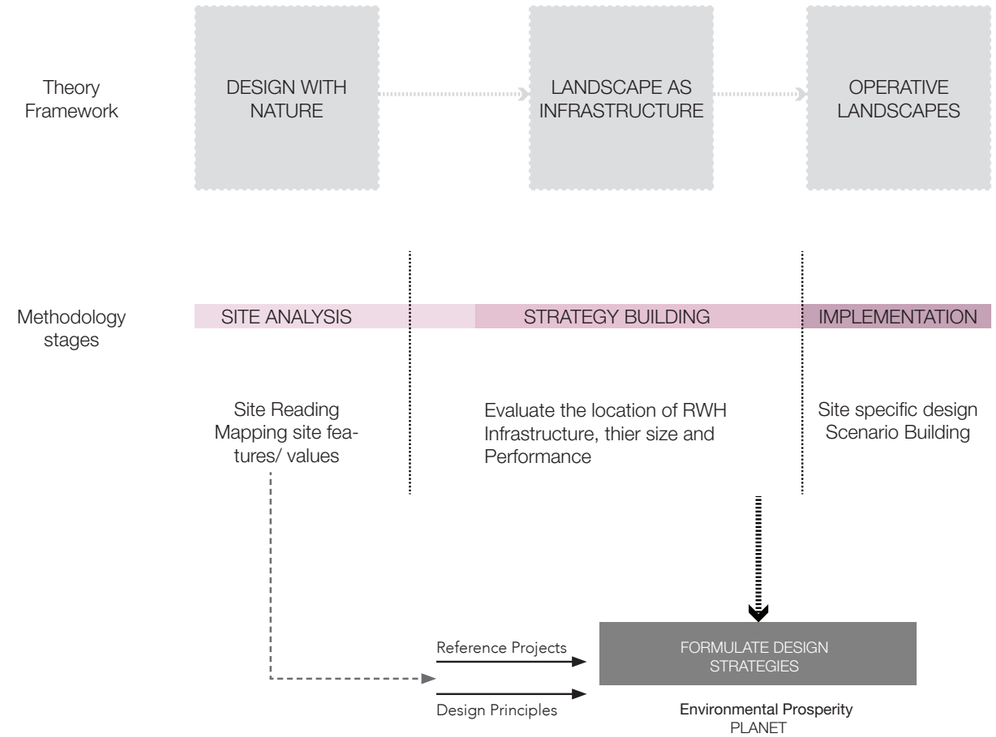


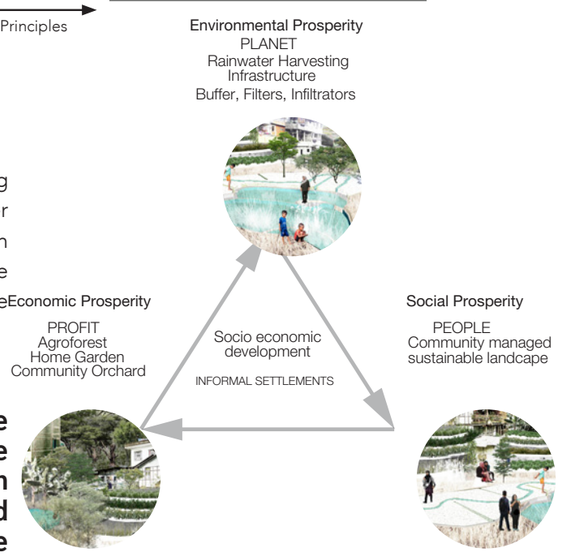
Aquifer Value Map - essential to recharge aquifer, given the current trend of water abstraction

-In the hilly terrain of North Bandung Shallow and deep aquifers are present and there is scope to recharge them.

Fig 1.37 Landscape Layers analysis, Refer Annex. A for Details.
Source : Author

02.03 Defining research framework





The theoretical base of natural value mapping of Bandung region coupled with the rainwater harvesting infrastructures and aforestation measures, are the defining ingredients to formulate design strategies for an integrated land-use approach.

Their location and size are determined such that the interventions, focusing on optimum social, economic and environmental benefit, to ensure sustainability.

Fig 1.36 Research Framework
Source : Author

02.04 Research Methodology and time planning

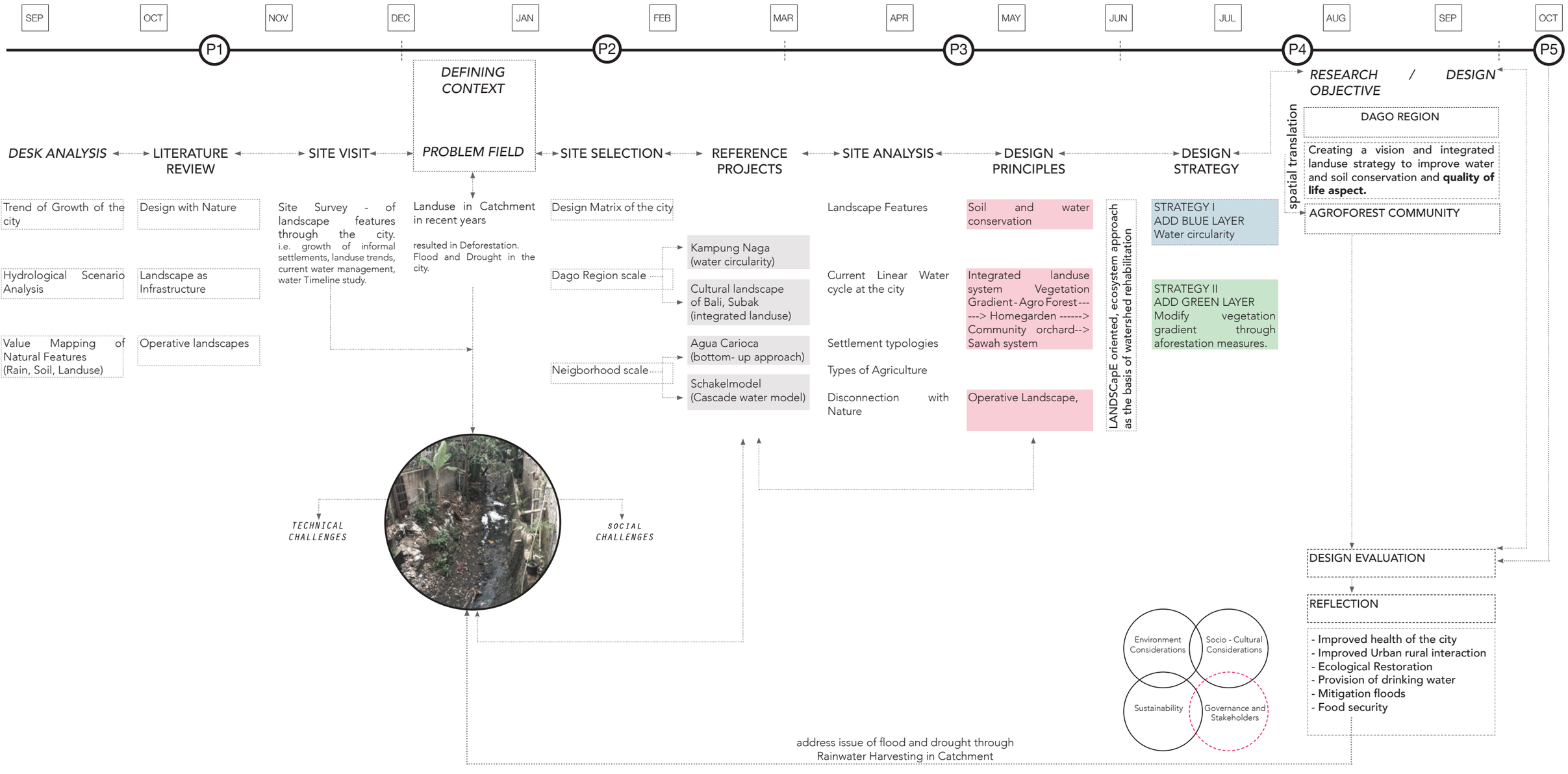


Fig 1.38 Research Methodology
Source : Author

02.05 Brief overview of all sections

In summary, Section 1 describes in detail the water related challenges in Bandung city and its relation to the current landuse trends: trend of rapid urbanisation and deforestation in the Cikapundung catchment zone, specifically in Dago region. Because of unsustainable landuse practices, the city is now facing a very grave issue of severe drought and floods over the last 20 years, This landuse change is directly rleated to the steady reduction in the sponge function of the Cikapundung catchment.

Hence, the aim of the research question is to improve the sponge function and overall health of the degraded Dago region in the Cikapundung catchment zone. This is achieved through relatively cheap water and soil conservation measures.

There are many peri-urban areas similar to Dago region with unsustainable landuse practices, which are prone to high deforestation and are now in the zone of landslides. Despite this, they see a large number of informal settlements mushrooming here and the forest is replaced slowly by settlements as well as dryland farms.

Dago region was shortlisted for landscape interventions, because this area shows the lowest level of springwater aquifer - at depth 350 M, compared to its surroundings regions like Lembaung area, which have access to springwater at 200 M depth. This is critical, since only 36% of the population in this area receives constant municipal water supply for domestic use. Hence, alternative approach is necessary to make rain water available in this area for domestic and agricultural use, alleviating the drought scenario. High precipitation in Dago region - 2200 mm for 8 months of the year. Rainwater harvesting measures would improve water circularity. Aforestation measures aim to improve the quality of soil and land, by promoting spring aquifer recharge. Since more storm water is infiltrated, lesser volume of water is released in the open, reducing the severity of floods. Additionally, aforestation measures increase the green surface area and considerably improve sponge function in the Dago region, reducing the rate of surface water run-off.

Thus, such integrated landuse measures in Dago region have a cumulative effect to mitigate drought and flood in Bandung city, Similar efforts in the other 6 areas of Peri urban Bandung for soil and water conservation can greatly benefit the city of Bandung.

Section 2 focuses on the Theory base, relevant to sustainable landuse approaches in mountainous regions. It also discusses the application of theory framework to the specific water challenges of Bandung city, which is the basis of the Research Framework.

Landscape infrastructure aimed at Rainwater harvesting and aforestation aims to not only improve the social and economic scenario in the lesser developed peri - urban fringes of the city but also improves the relationship of the citizens with their environment.
The first two sections helped to outline the research methodology, shown in Fig. 1.38 which served as a guideline for the project flow.

Section 3 elaborates on the different landscape features in Dago region, and the reason behind why seasonal dryland farming dependent on spring water reserves is unsustinable. Design experiments were carried out by different design tools like sketching, 3d model at different scales. Various land-use scenarios are developed, by trial and error, each giving a better insight into a best case scenario, which is most sustainable, with the maximum social, environmental and economic benefit.

Relevant reference projects located in peri-urban catchment zones in Indonesia and Brazil, were identified and studied in detail. Landuse is tailored to its relative height from the river, with forests located at the highest level, followed by settlements and sawah farming at the lowest level. They exemplified the design principles of a cascading water system, circular water system and improved vegetation gradient as the basis of a sustainable landuse system, with a sustainable flow of natural resources like water, soil, nutrients, etc. These design principles helped to formulate the two most important design strategies applicable at Up, mid and lowland levels:

1. Improve the water flow by incorporating RWH Infrastructure- Blue Infrastructure layer.
2. Improve the vegetation gradient by introduction of Agroforest, homegarden, community orchards, sawah farms at different scales- Green aforestation Layer.

Peri urban areas generally have the highest number of informal settlements with high dependency on spring water. Hence, informal settlements in catchment zones can be designed on the concept of Agroforest communities, with an independent rainwater based water management system, to reduce their dependency on spring aquifers.

After much deliberation, the best case scenario to be implemented in Dago region is outlined and elaborated in the end of section 3. This design is not just an outcome of the design experimentation but also a result of the contribution by different stakeholders. As mentioned earlier, it is a realisation of a mixed approach, with many bottom up initiatives, curated and implemented with the help from various government and private sectors.

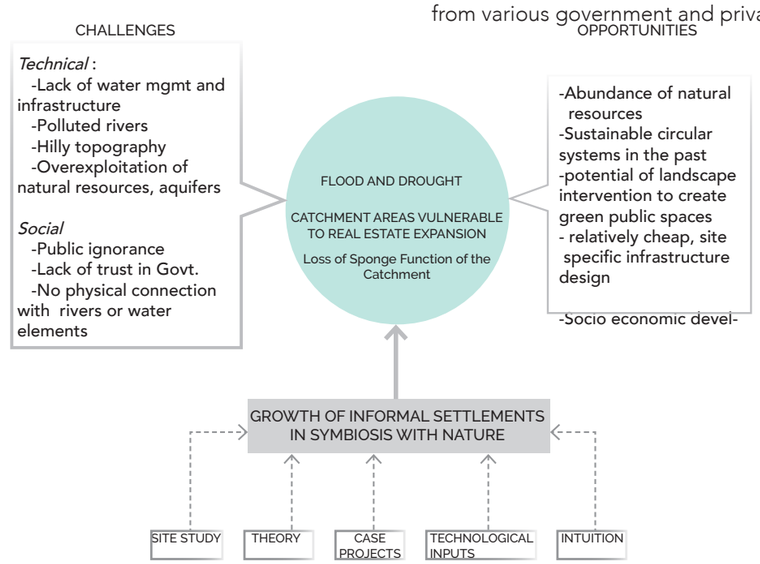
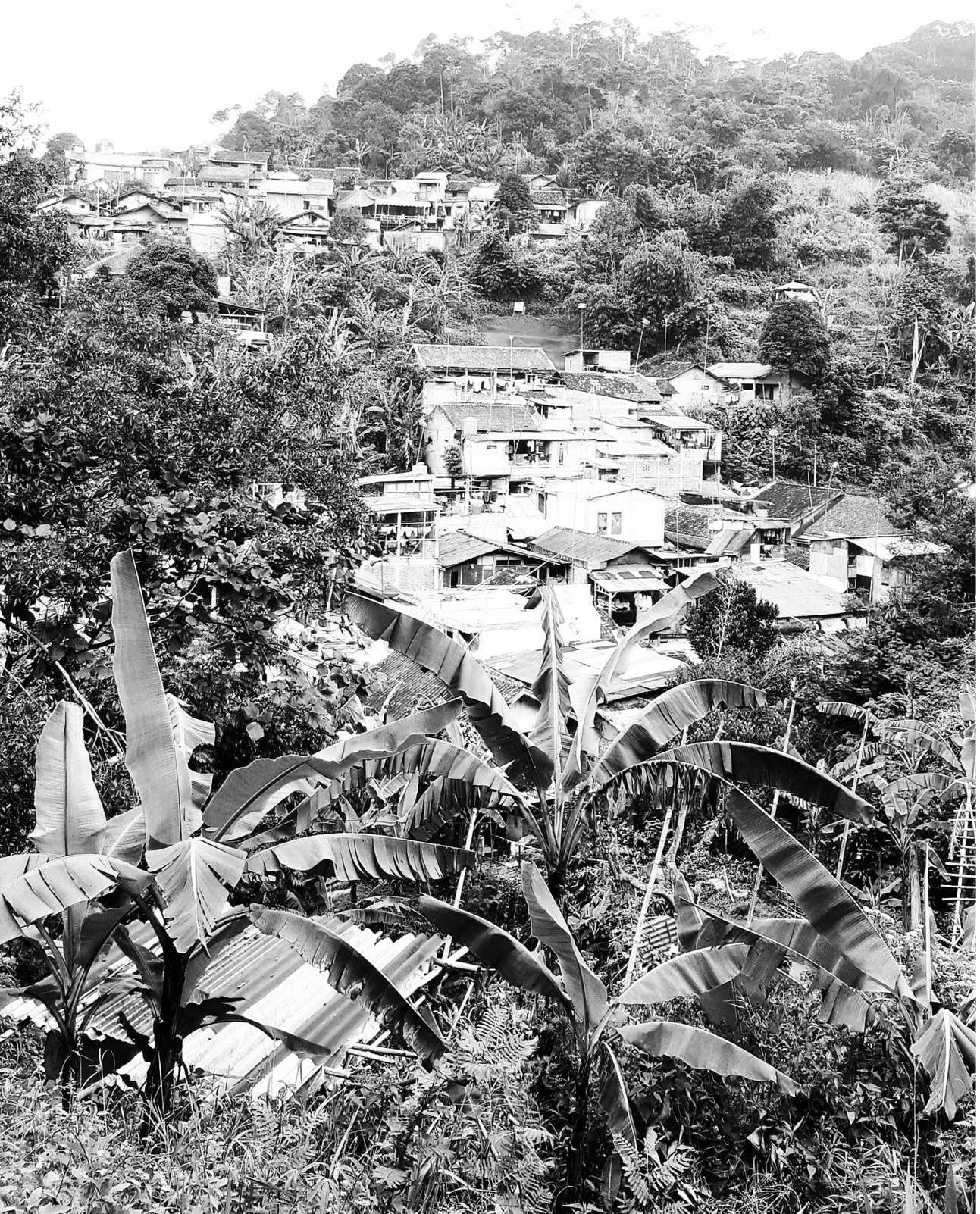


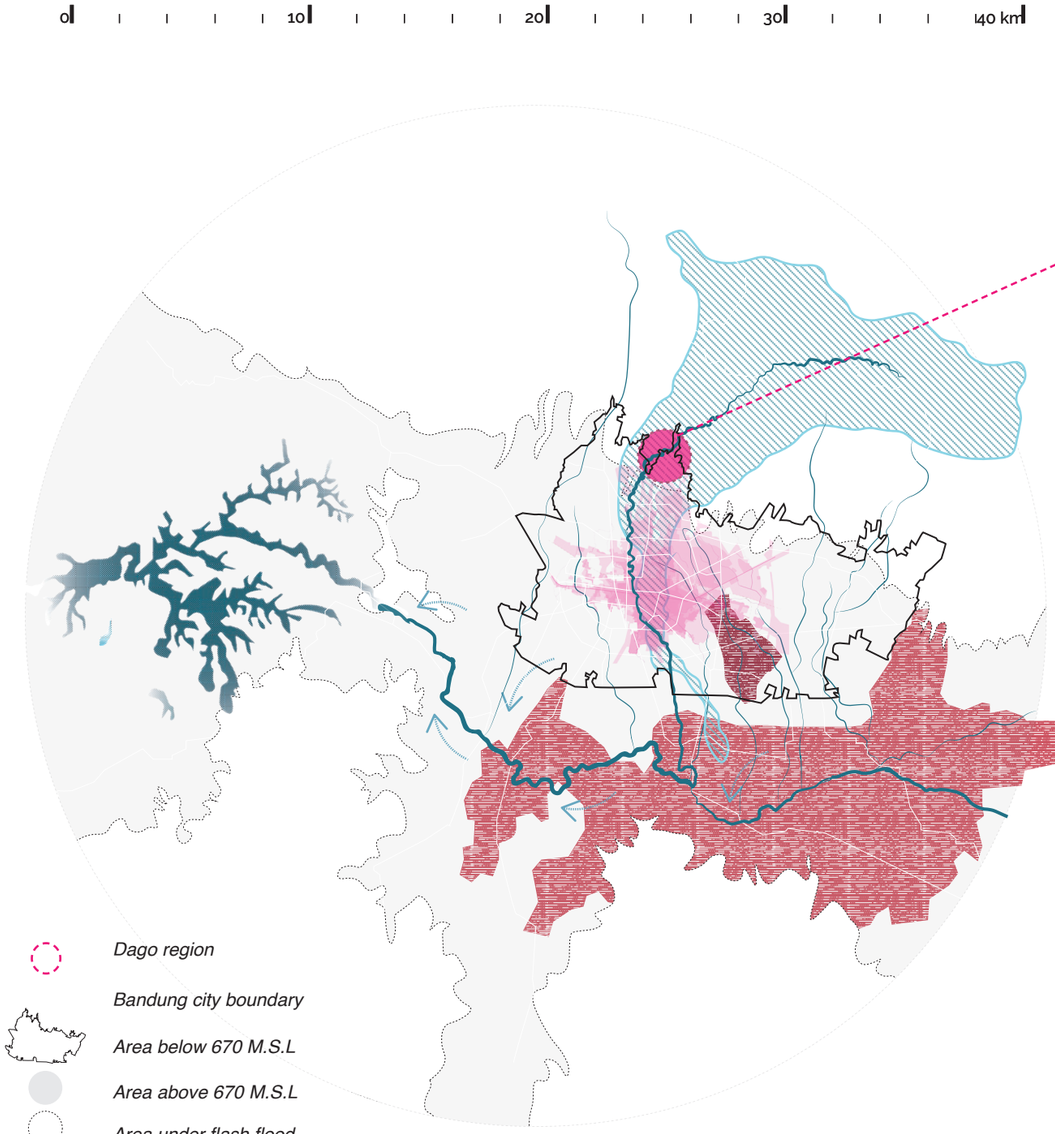
Fig. 1.33 Project Scheme summarising challenges and opportunities
Source : Author



03 REGIONAL VISION FOR SOIL AND WATER CONSERVATION : DAGO REGION

Fig 1.40 To the left : View of the landscape in peri- urban Bandung
Source : Dicko Armas

03.01 Overview and importance of Dago region



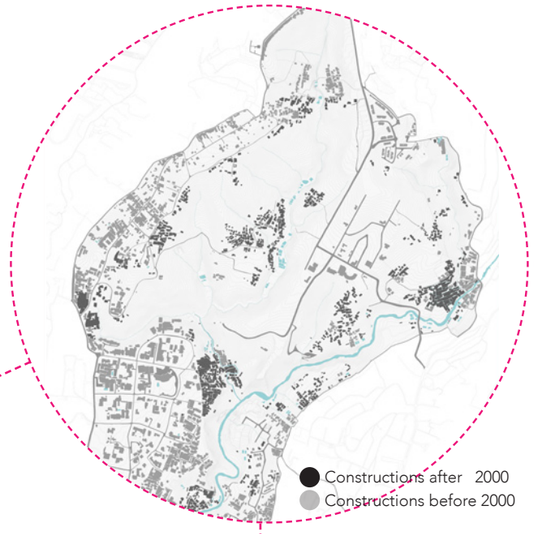


Fig 1.41 .a. Map showing recent constructions in Dago region. Source : Author

Fig 1.41 b View of informal settlements in Dago region. Source : Author

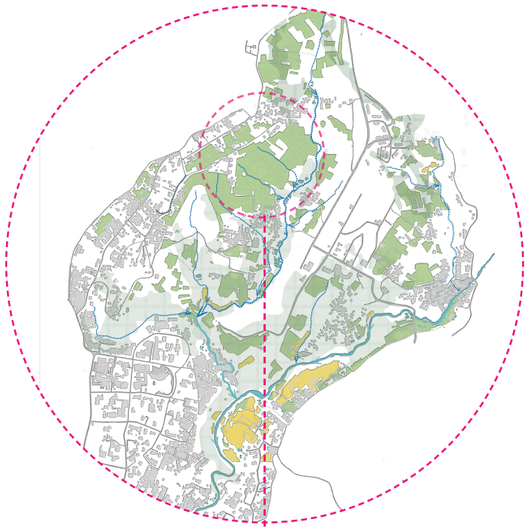


Fig 1.42a. Map showing dryland farms in Dago region

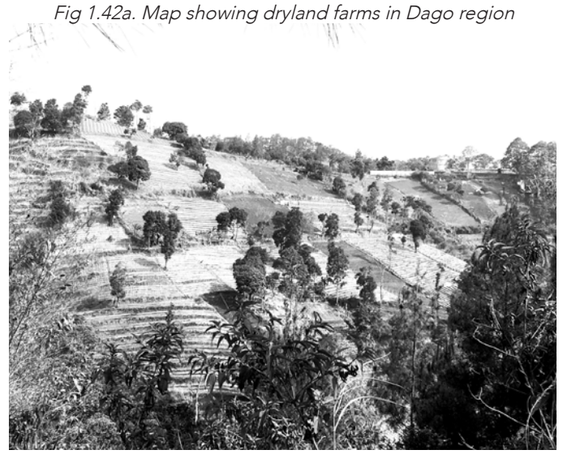


Fig 1.42.b. View of extensive dryland farms. Source : Author

Density **15000/ sq.Ha**

Access to potable water **36%**

Employment Rate **60%**

Avg. Age of Inhabitants **32 years**

Ethnic Group **Javanese, Sundanese**

Primary economic activities

Dago region is located in north Bandung, with a majority of Javanese and Sundanese population, which are dependent on farming as the main source of income.

The map shows the dense, informal settlements (marked in black) despite being in the area of landslides. As seen in the map, The structures and roads pointed out in black in Fig. 1.35. have been constructed in the past 20 years, replacing the forests there. The sustainability of these interventions cannot be fully assessed, but it is likely to not have a positive impact on the environment, given the excess demand for housing and food supplies in the city coupled with water shortage issues.

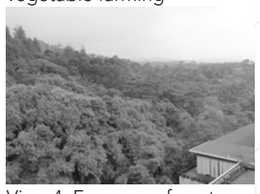
03.02 Landscape features


View 1. Upland vegetable farm

Primary Landscape features at the site largely include dryland farming and dense tree covers - primary, secondary, dense evergreen and mixed deciduous and everygreen forests as shown in Fig 1.43. Highlighted in brown are fragments of abandoned farmlands, which are a cause of concern, as they are severely degraded.


View 2. Public Garden


View 3. Rubber tree and vegetable farming


View 4. Evergreen forest


View 5. Secondary forest vegetation


View 6. Wetland Rice farming

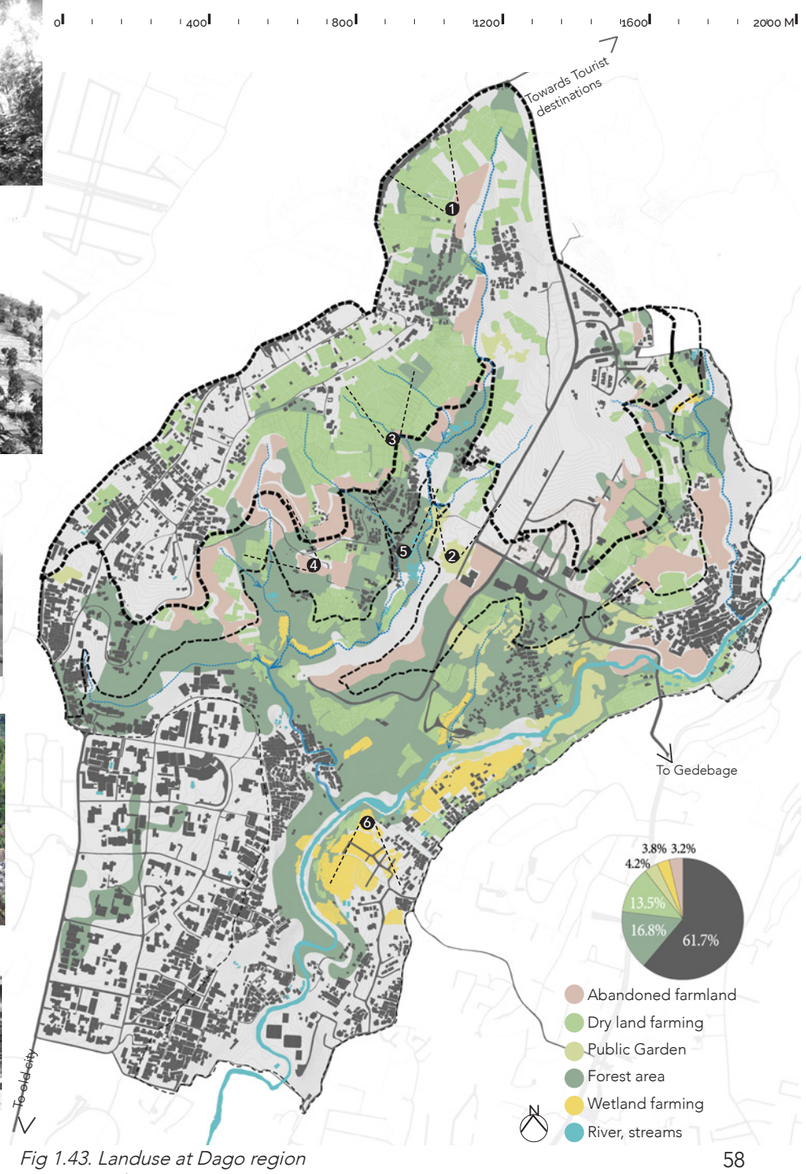


Fig 1.43. Landuse at Dago region
Source : Author

03.03 Flora and fauna relevant from soil water conservation viewpoint

Upland zone - 900mm above M.S.L
[areas with slope less than 22%]

Mid and lowland zone - 850-900mm M.S.L
[areas with slope above 22%]

Upland zone - 900mm above M.S.L
[areas with slope less than 22%]

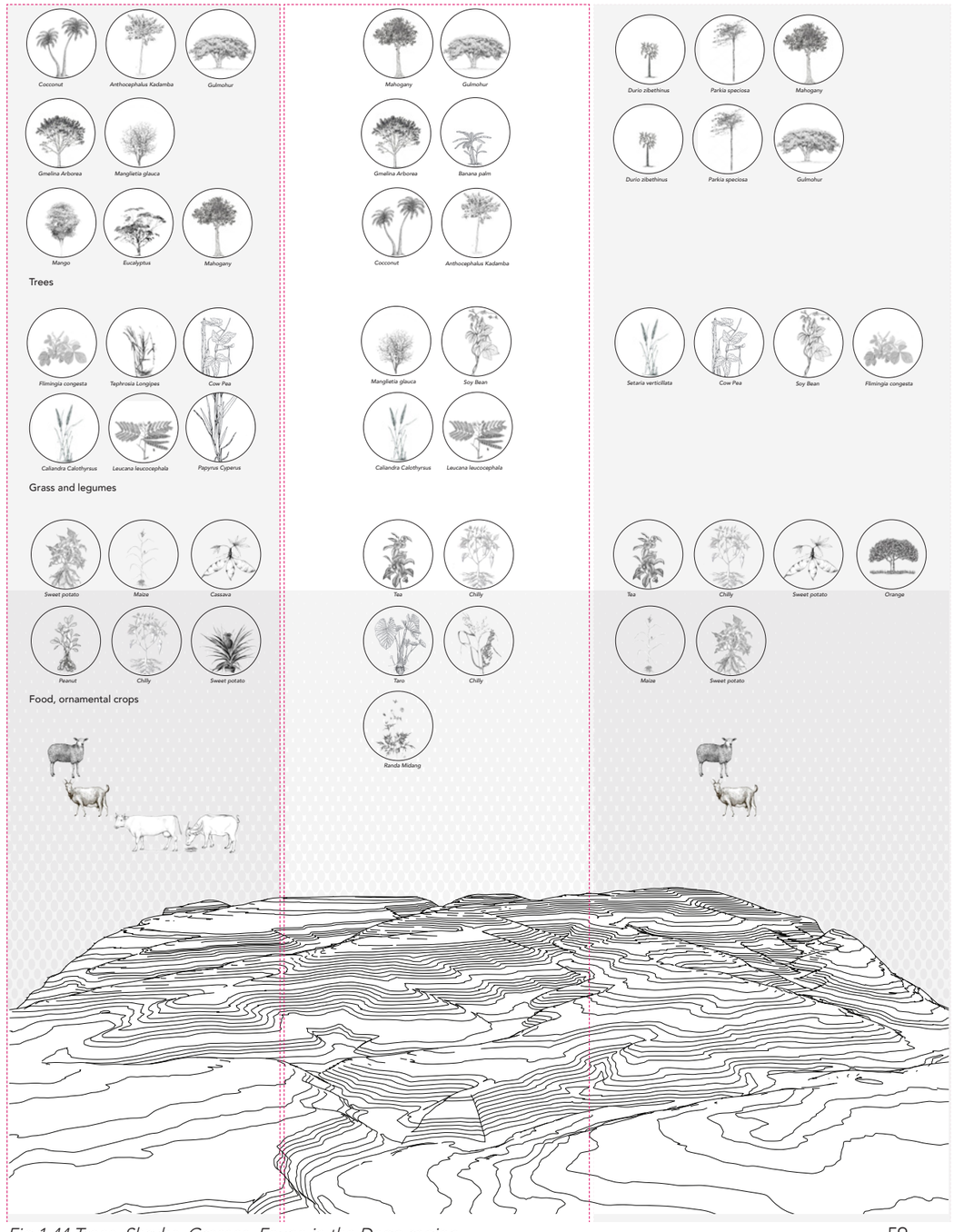


Fig 1.44 Trees, Shrubs, Grasses, Fauna in the Dago region
Source : Author

03.04 Farming types analysis

Out of all the farming types, the most sustainable one is Sawah farming, practiced in the lower section of the valley adjacent to the river. Also sustainable but observed at a small scale is clusters of agroforest - Pine,rubber and coffee agroforest - where a cash tree grows together with vegetable or fruit trees like banana, chilli beans and tomatoes, etc. annually.

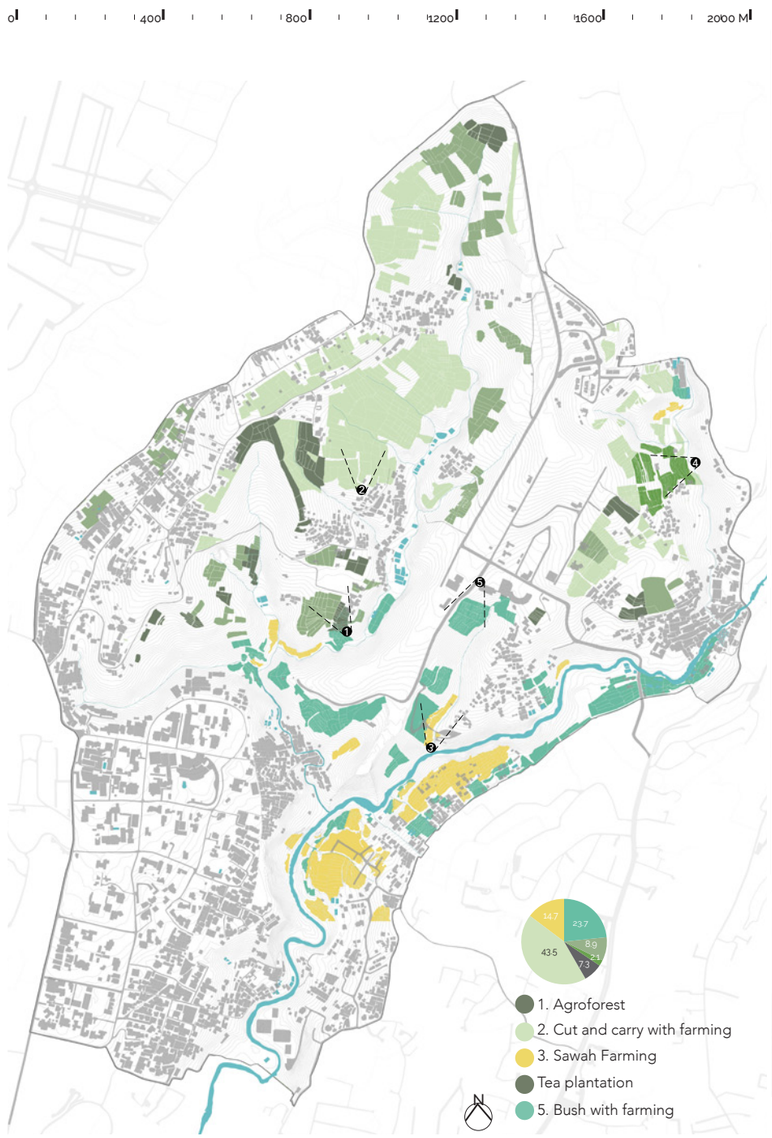


Fig 1.45. Farming types in Dago region
Source : Author


1. Agroforest


2. Cut and carry with farming


3. Sawah Farming


4.Tea plantation


5. Bush with farming

03.05 Agroforest as a sustainable link between forest and dryland farming

AGROFORESTRY - is a collective term for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence.

"In Indonesia's tropical environment, where precipitation ranges from 1500 to more than 3000 mm/year, often falling within a few months of the year, traditional techniques are generally poor in conserving soil and water. As a result, productivity falls in the uplands themselves, while material washing down into the lowlands causes sedimentation and disruption of water regimes. This disruption of the ecosystem threatens investment into infrastructure, especially irrigation systems, water reservoirs and hydroelectric facilities and roads, as well as industrial and domestic water supplies and coastal estuaries important as fishing grounds. The problem is of such dimensions that unless corrective measures are taken, the productivity of agricultural areas in both uplands and lowlands is likely to be seriously impaired within a few decades." (Adiningsih J., and Karama A.,98)

Soil and water conservation efforts can make more surface water available to cultivate Agroforest, Home gardens, Community orchards and Sawah farms. These aforestation efforts together improve the vegetation gradient in the upland areas of Dago region. Different scales of farming - annually and seasonally, help to achieve food sufficiency. The efficient use of natural resources and its ecological benefits of such an integrated landuse system are discussed in detail in chapter 4.

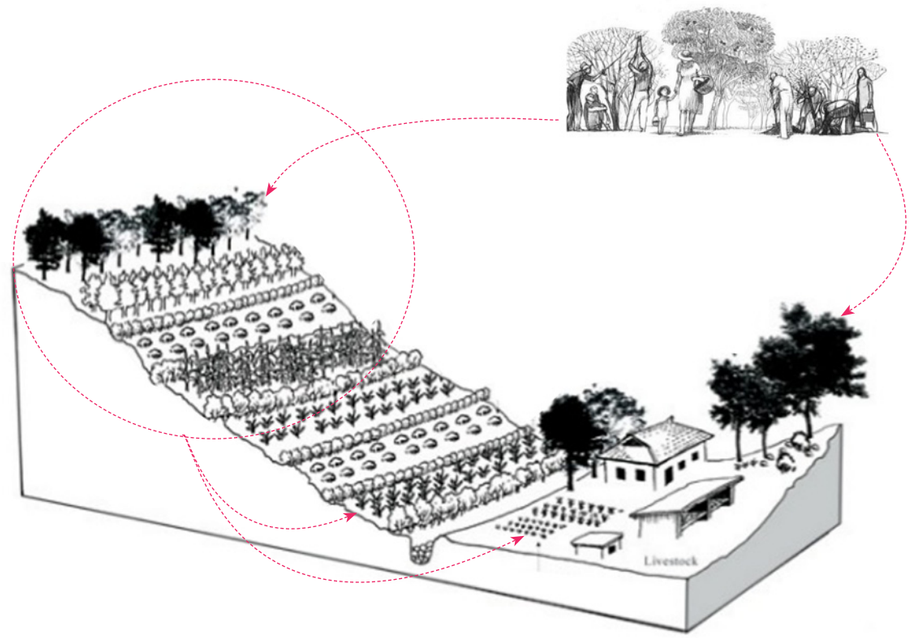


Fig 1.46., Agroforest supporting the cultivation of smaller scale private farms Home Garden, Community orchard, sawah farming - integrated sustainable landuse system. Source : FAO (Food and agricultural organisation of the UN)

03.06 Amenities and services

Fig 1.43. Small kiosks and eateries in informal settlements. Source : Author

Fig 1.49 Map of amenities and facilities in Dago region
Source : Author

03.07 Water supply analysis

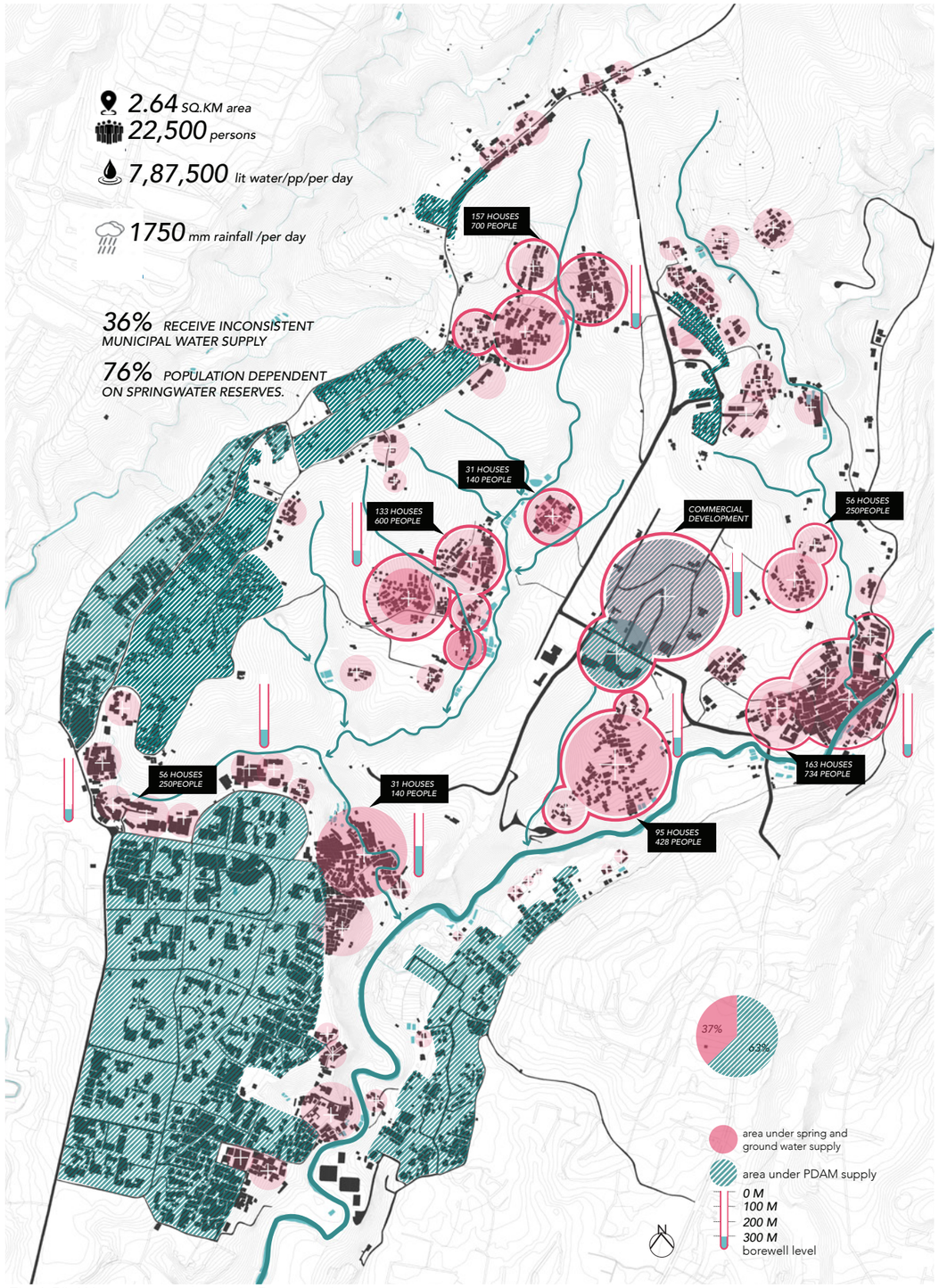
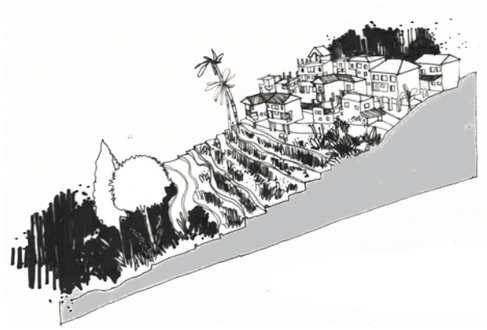
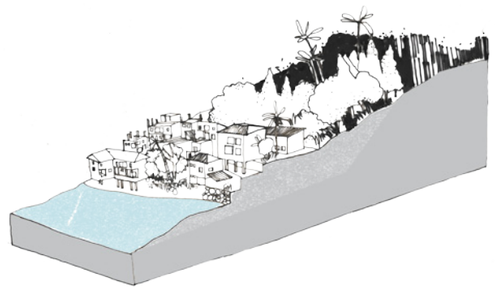


Fig 1.50 Water supply details in Dago region
Source : Author

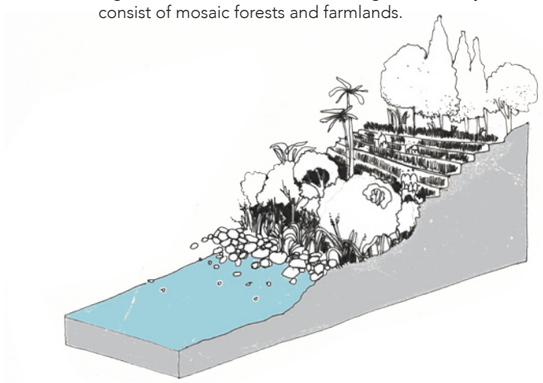
03.08 Informal settlements and their relation to landscape



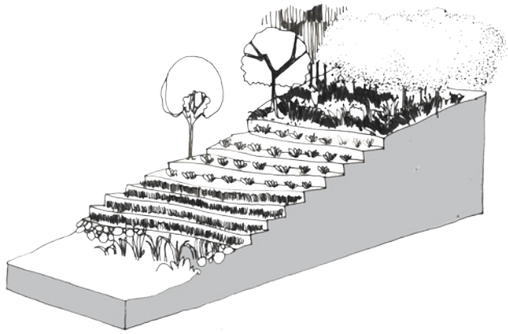
1. Fig 1. Hillside Informal Settlements, grow from higher access roads down through the valley, consist of mosaic forests and farmlands.



2. Fig 2. Riverside Informal Settlements, grow from the river upwards to the valley, erasing forests as they take over.



3. Fig 3. Isolated settlements surrounded by shifting agricultural land and remnants of primary forests.



4. Fig 4. Monoculture farms between mixed evergreen and deciduous forests.

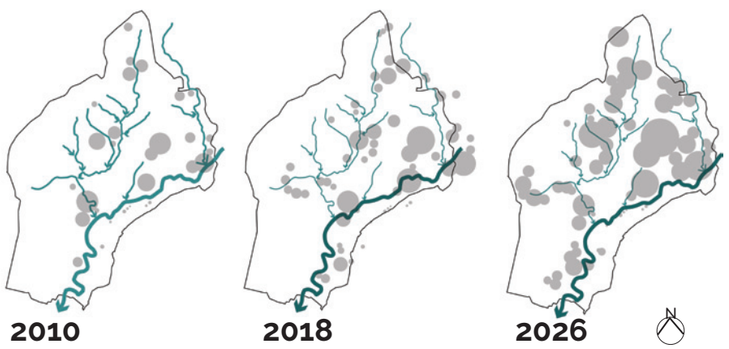


Fig. 1.51 Predicated growth of informal settlement with time.
Drawing Credits: Author

It is interesting how informal settlements in peri-urban Bandung grow around a source of spring ground water, as shown in figure 1.52 The Centralised water supply system of Bandung city does not extend to most of Dago region.There is complete dependence of the informal settlements on spring ground water reserves for domestic use and irrigation use. So, it is necessary to explore the potential of localised, decentralised water supply and sanitation systems to support the growing settlements, and make water available for them.

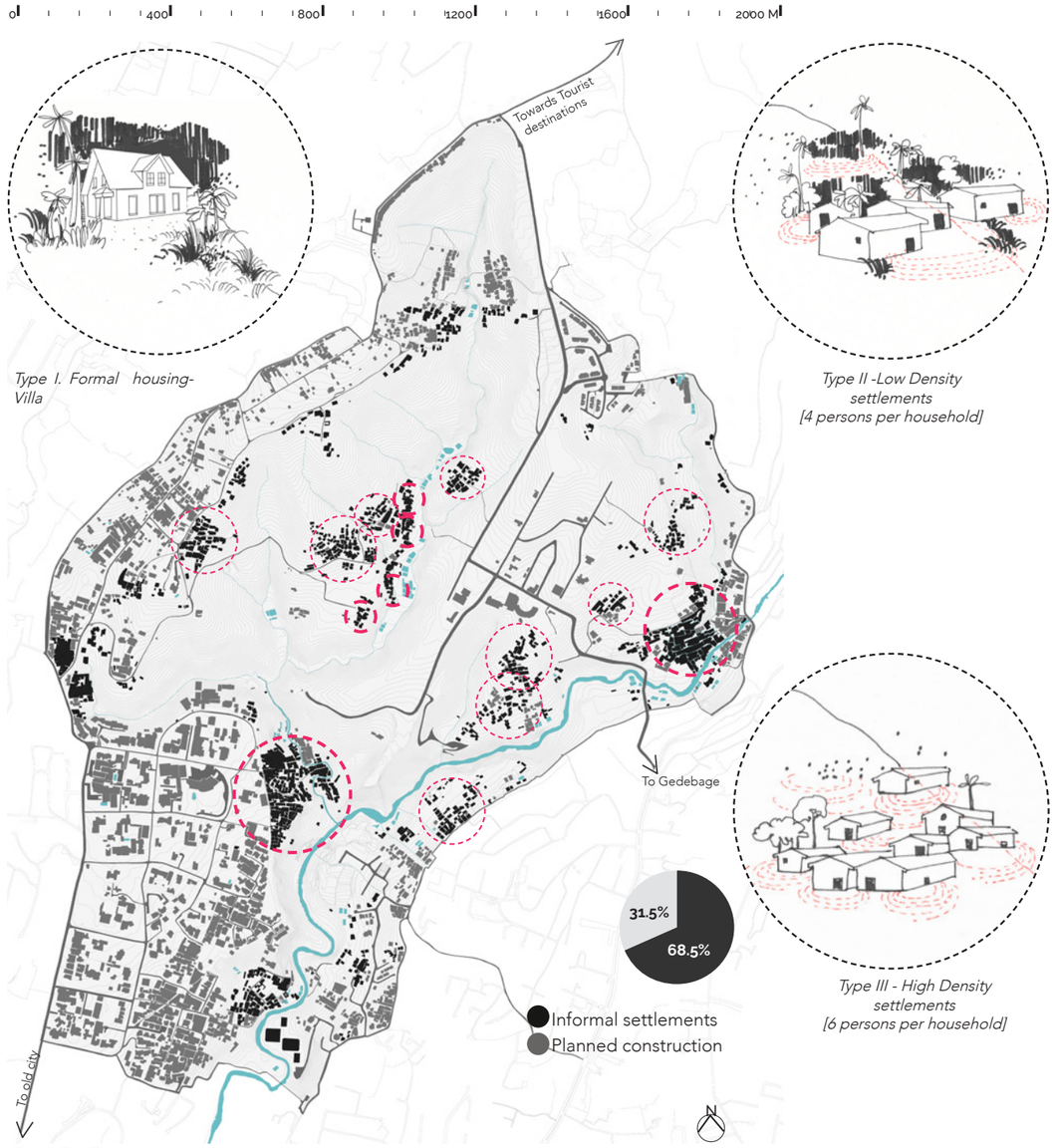


Fig 1.52 Formal and Informal structures
Source : Author

03.09 Slope Analysis of Dago Region

Study of landuse at different levels

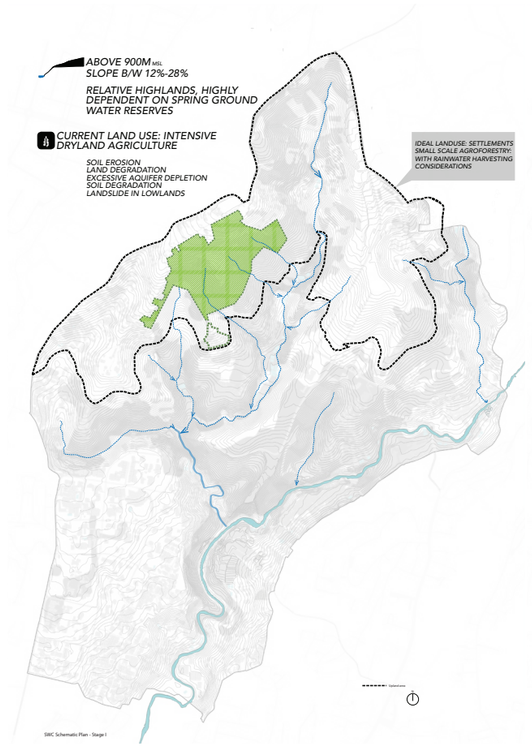


Fig. 1.53. Upland Zone.
Drawing Credits: Author

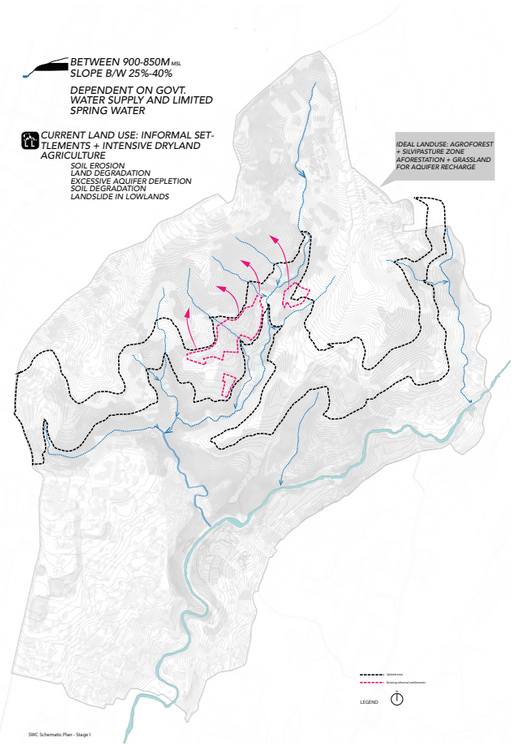


Fig. 1.54. Midland Zone.

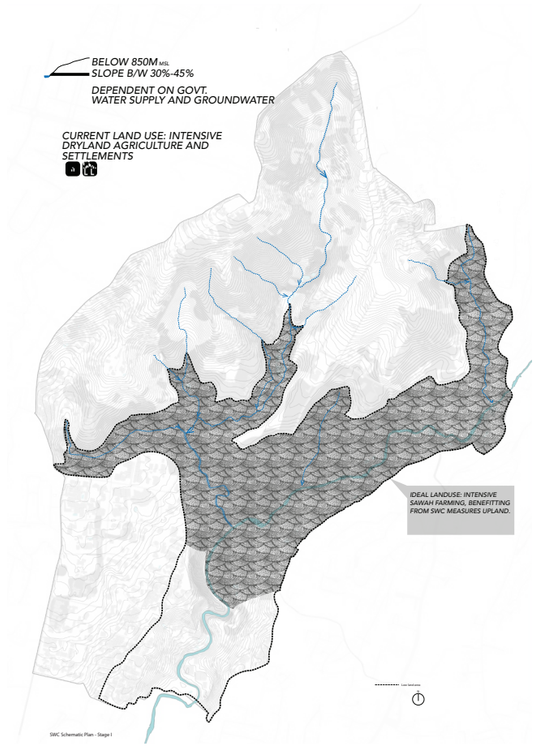


Fig. 1.55. Lowland Zone.

The urban development in Dago region, specially the informal settlements and the dryland agricultural practices have led to excessive deforestation, soil erosion, land degradation, soil degradation, ultimately leading to landslides here.

The site study with respect to slopes and soil types suggested that for planning purposes, the Catchment areas can be grouped into Upland Midland and Lowland levels - relative to the main Cikapundung river- as shown in Fig 1.53-55.
The upland area from Soil and Water Conservation view is the core zone[slope below 20%] - ideal for real estate development, the middle or buffer zone is ideal for agroforestry/ mixed vegetation[slope above 20%, prone to landslides] and the lowland area adjacent to rivers and streams is ideal for sawah farming.

The reason behind severe land degradation in Dago region is that the existing landuse situation is opposite of an ideal landuse, which is outlined in detail in the section of Reference projects.
The upland/ highlands should consist of forest and nature areas, and midland zone should have the settlements/ living areas and lowland zones should have sawah farms.

However, a large amount of land upland has been converted from forests to farmlands, and is dependent on springwater supply which is inconsistent. Nor does this area have a constant source of Municipal water supply, due to the elevation difference of 200m from Bandung city. The problem which such shifting agricultural cultivation of replacing the forests by farmlands is that the spring aquifer is likely to dry up over time, and such farm plots are rend ered useless and are eventually abandoned.
Settlements are in the fertile mid and lowland zone, which coupled with leads to extreme depletion of spring aquifers and land degradation.The soil here is Regosol, which is extremely prone to erosion, causing landslides. Hence, ideal for this region, would be forest or agroforests and trees with good water holding capacity. The lowland zone has a cover of andosol soil, which relies on surrounding evergreen trees to maintain its fertlity, hence the existing tree cover or secondary forest needs to be retained.

In summary, incorrect landuse over the years in peri urban areas Dago region has led to severe pressure on natural resources and unsustainable water flow situation, as shown in Fig.1.56 and 1.57. Hence soil and water conservation enables improved water management and also introduces natural resources like fertiliser (bio- gas, mulch), good quaility soil, fodder, etc in the environmental cycle of the peri-urban areas, to improve its health. It helps to gradually change the landuse from the unsustainable trends to an ideal landuse.
.

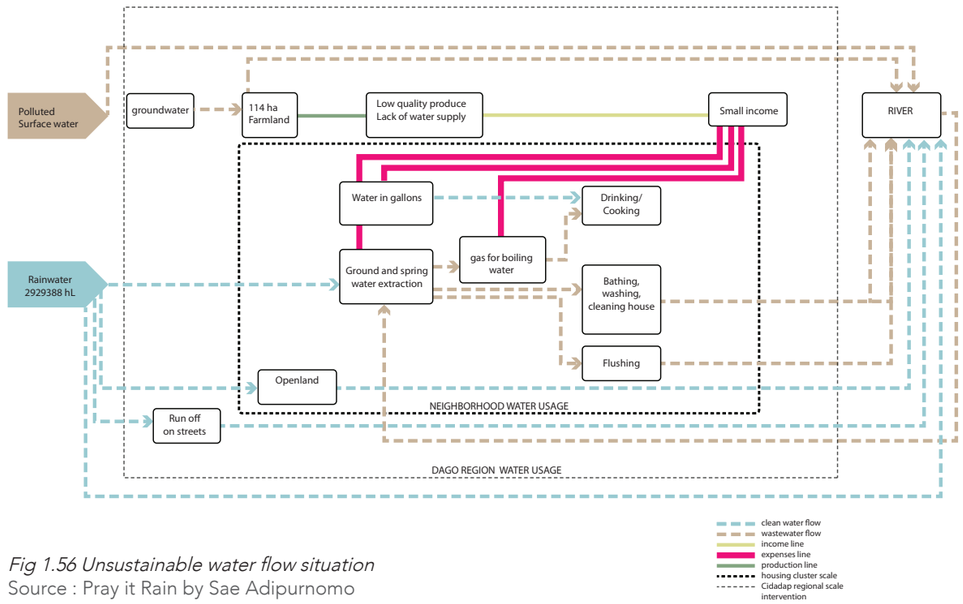


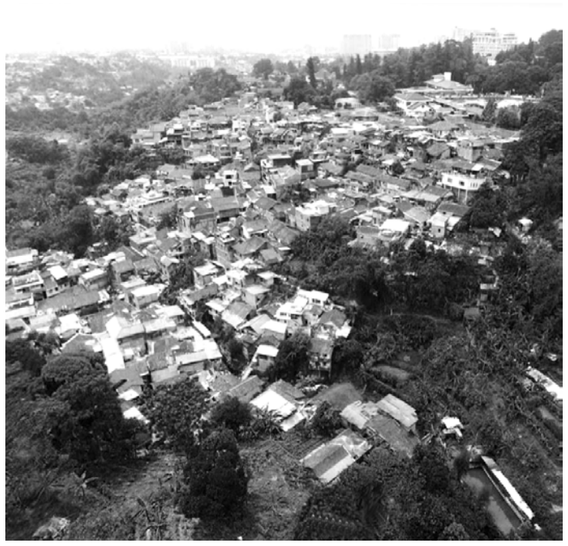
Fig 1.56 Unsustainable water flow situation
Source : Pray it Rain by Sae Adipurnomo

03.10 Current hydrological scenario at Dago Region

Issues due to unsustainable landuse practices

Intensive agriculture in upland, dependent on limited springwater reserves, hence unsustainable.

Lowland Zone - Informal settlements sprawl, erasing forests as they expand.



Upland Commercial Zone - PUBLIC Facilities and Amenities

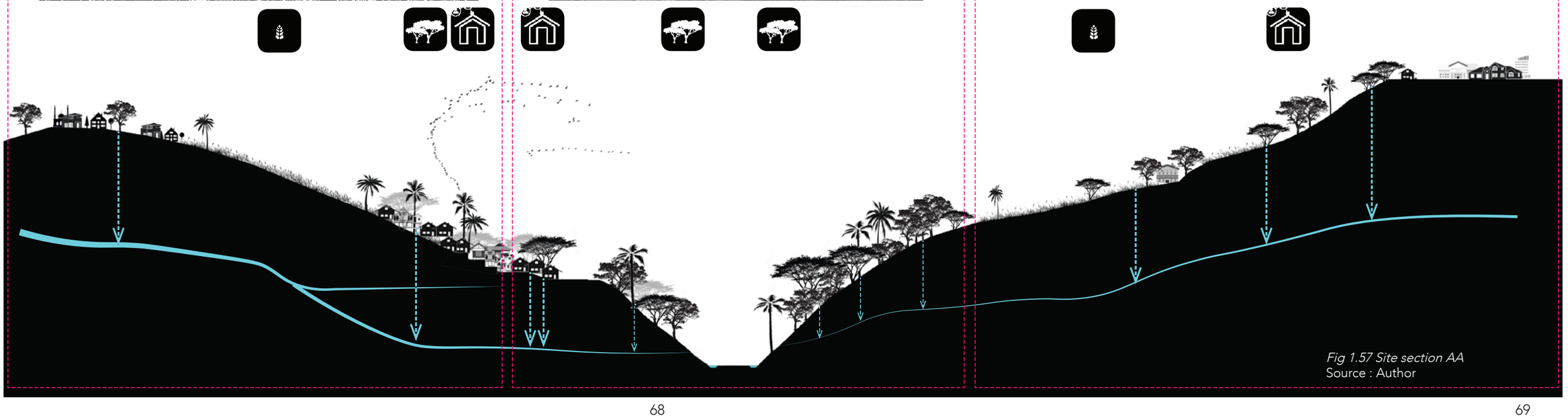


Fig 1.57 Site section AA
Source : Author

03.11 Reference Projects and Design Principles

Kampung Naga, Indonesia

It is a traditional village situated in a peri-urban area, in the vicinity of Bandung city. The aim of this village is to live sustainably with nature and be self sufficient. The residents are aware of the limited capacity of nature, and they do not depend on the resources outside of the village boundaries.Which is why, they only allow a limited number of residents to live in the village. This way, the environmental system is kept in balance.

It is a circular ecological system as shown in Fig. 1.58. It is maintained by the residents and a cooperative community is responsible for the water management within this village. Kampung Naga's circular water and natural resource system interconnects different flows together. Such a system is highly beneficial for soil and water coservation.

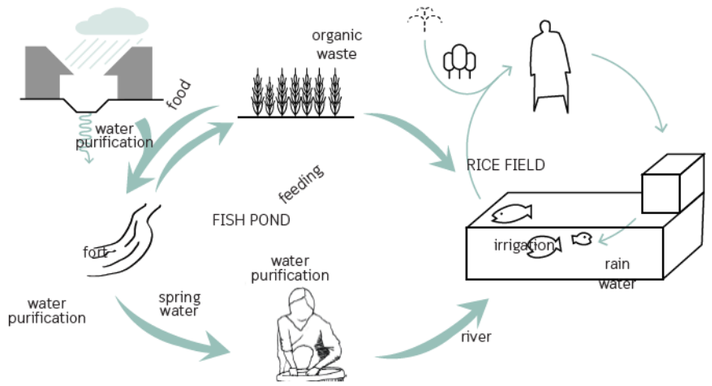


Fig 1.58 Circular ecological sytem in Kampung Naga
Source : Boomi Kim

Fig 1.59 View of Kampung Naga village at Midland zone
Source : Author

Fig 1.60 View of fish ponds at Kampung naga
Source : Author

Design concept

- Circular water management in in a closed neighborhood
-treating and recycling wastewater directly where it is produced
-Residents of this village live with nature, aware of its limitations.

Environmental relevance

-Wet rice fields - with a longer growth cycle (6-7 months
-Fish ponds to treat local organic sewage

Social relevance

- Community managed water supply and sanitation system
- Active relationship between the community and nature.
- Awareness of use of natural resources

Landuse at Kampung Naga exemplifies the integrated land use system, with forest at upland zone, houses in midland zone and sawah farms in lowland zone, as indicated in Fig. 1.61. The location of Kampung Naga is strategically placed near the clean water source. Clean water sources - i.e. water from the upstream of the river is at the highest contour, amongst the forest cover so that water is free from pollution coming from residential waste. Rain water is not used for daily life. Instead of using it, rain water is guided to the small channels, made of permeable gravel from the river, by orientation of the roofs. Its infiltration contributes to recharge the groundwater. Lastly, fish ponds purify the water after using for daily activities and discharge purified water into the downstream of the river. Fish ponds are the key component of the water system of Kampung Naga. They reinforce the ecological relationship between people and nature.

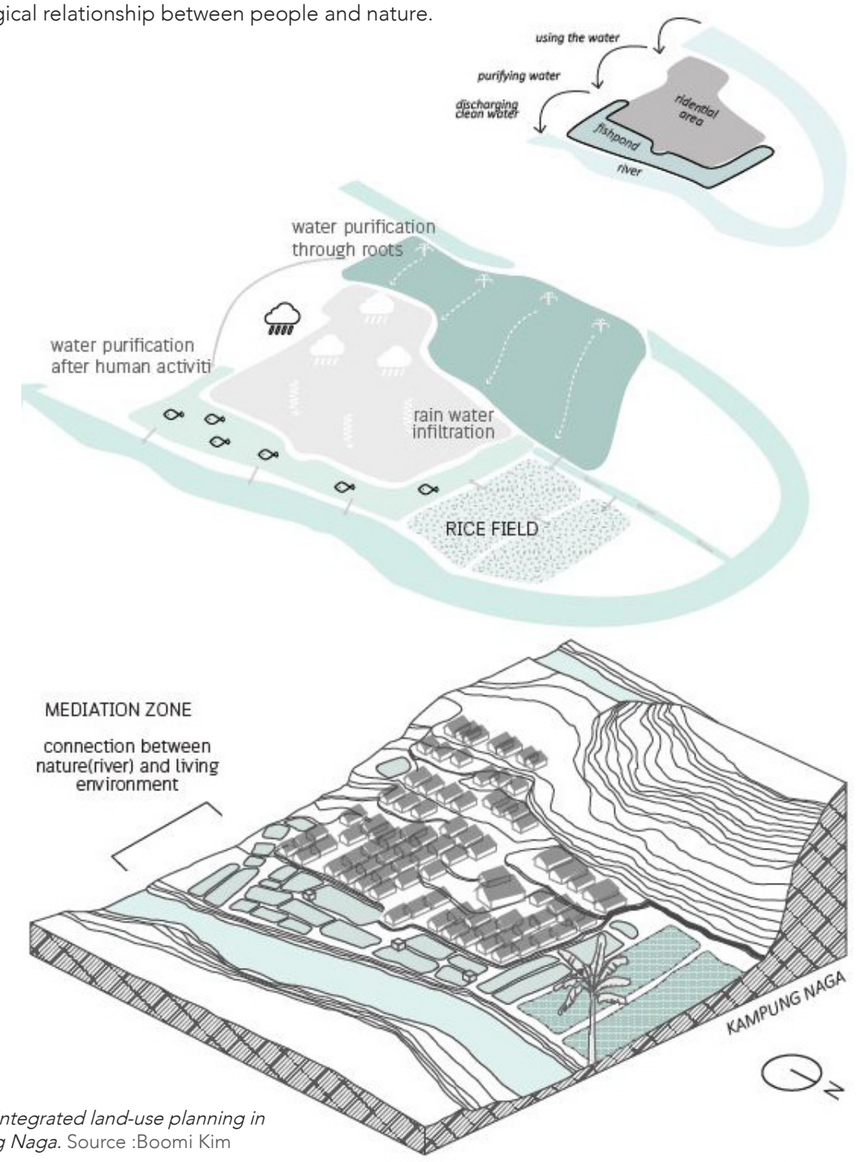


Fig 1.61 Integrated land-use planning in Kampung Naga. Source :Boomi Kim

Reference Projects and Design Principles

Agua Carioca, Brazil

This is an landscape infrastructural project in an informal settlement in Rio. It proposes a decentralised water supply and sanitation for informal settlements in Rio, Brazil, to address issues of water scarcity and pollution in natural water bodies. This water management system is designed in close vicinity of the neighborhood, shown in Fig. 1.62. The water chain is designed through scales from XS(building) to XL(region). It aims to create closed loop water system and it is holistic at the same time. The chain links from a building scale to regional scale, as shown in Fig. 1.63. Different scale and location have the same principle – using constructed wetland – but is adapted to different condition with a transformation in size..

Fig 1.62 View of informal settlement with its independent, decentralised water management system. Source : Ooze

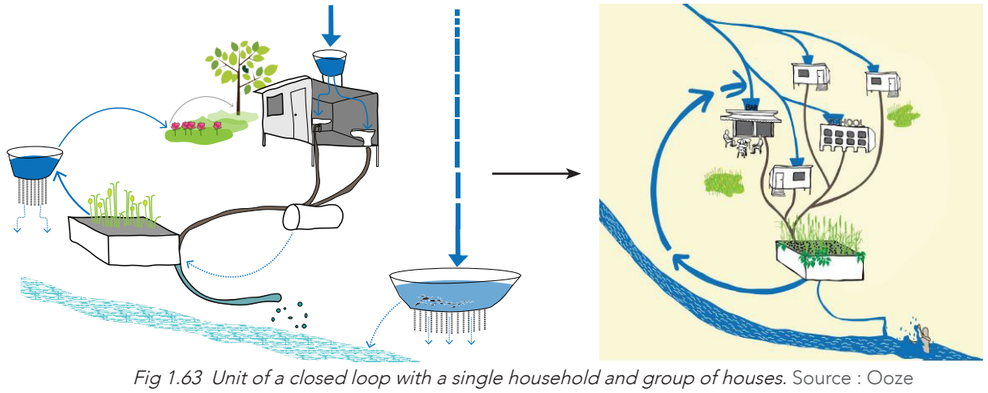


Fig 1.63 Unit of a closed loop with a single household and group of houses. Source : Ooze

Design concept

- Decentralised water management in informal settlement.
-Rainwater harvesting as source of potable water
-treating and recycling wastewater directly where it is produced

Environmental relevance

- Different scales of constructed wetlands and their contribution to enhance ecology.

Social relevance

-Community managed constructed-wetlands
- Involvement of different actors in Rio de Janeiro - activists, municipality, researchers and community leaders.

About the landuse, On the hilly landscape in the upland zone, terraced landscapes are created and function as a buffer zone against landslide. In the lowland zone, electricity generated from solar panels helps to pump up to recycle water. Existing informal settlements are located in the midland zone, as shown in Fig. 1.65
What is interesting is that the planning of this project is carried out with inputs and active involvement of the locals. The projected is implemented with participation of all stakeholders. Various actors from bottom-up to top-down, such as researchers, activists, local residents etc.) are interviewed to underpin the project.
Change from secluded linear water management to visible water management structure draws people's attention and encourages their participation.

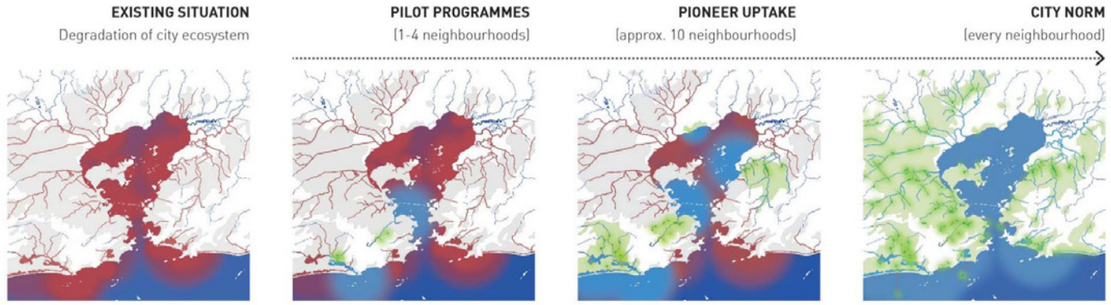


Fig 1.64 Impact of water management strategies over time, to purify the wastewater, allowing sewage water to be cleaned before it enters the rivers. Source : Ooze

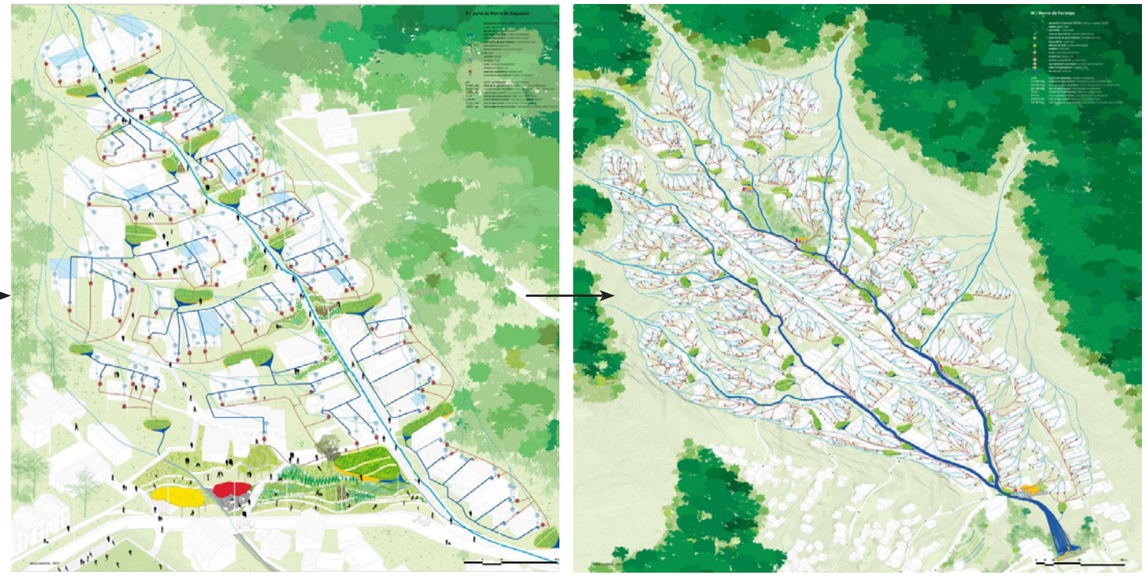


Fig 1.65 Planning through different scales of the informal settlement. Source : Ooze

Reference Projects and Design Principles

Subak System, Indonesia
Schakelmodel system

Subak is the water management (irrigation) system for paddy fields on Bali island, Indonesia which was developed in the 9th century. For the Balinese, irrigation is not simply providing water for the plant's roots, but water is used to construct a complex, pulsed artificial ecosystem. The system consists of five terraced rice fields and water temples. The temples are the main focus of this cooperative water management, known as subak.

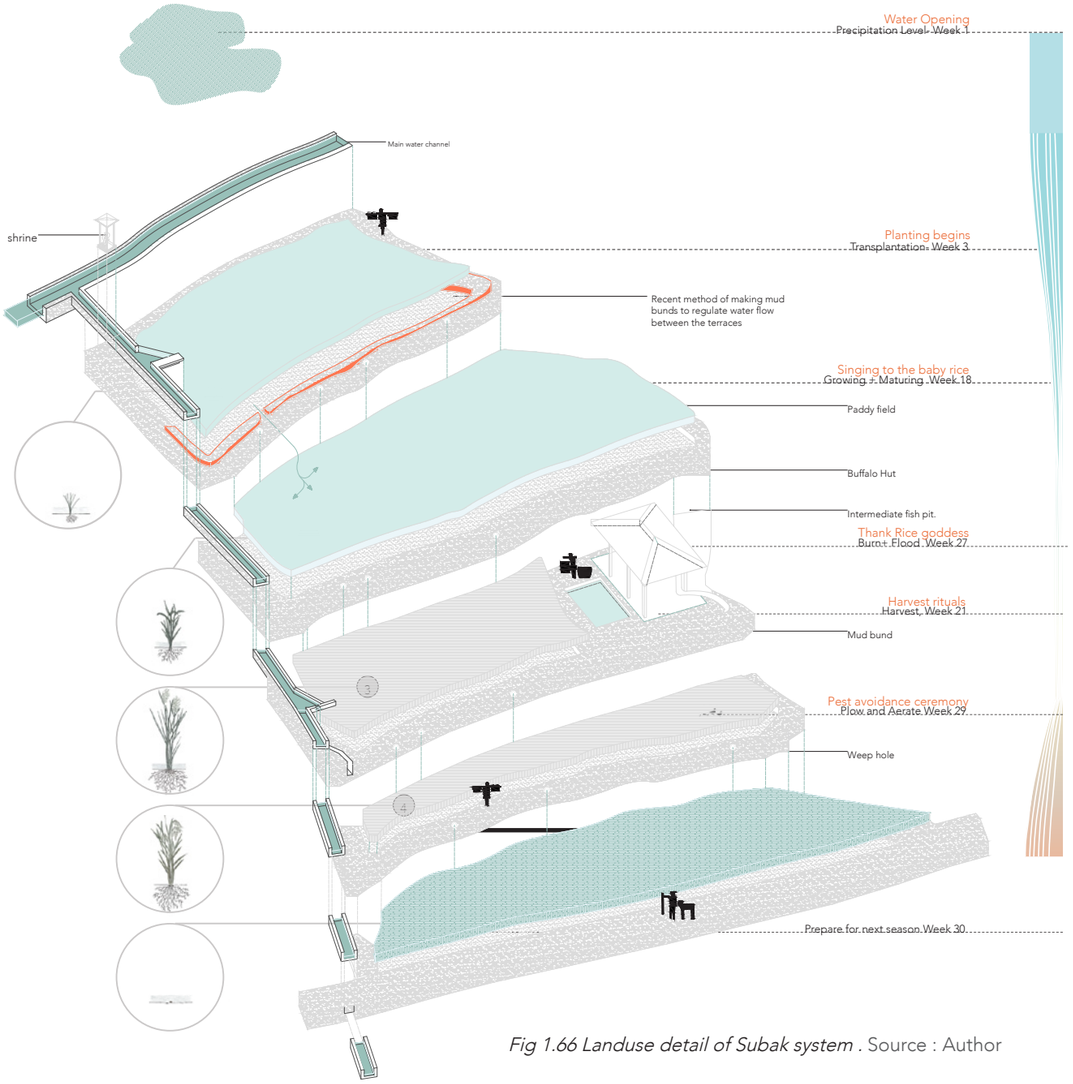


Fig 1.66 Landuse detail of Subak system . Source : Author

Design concept

- Integrated landuse in hilly areas
-Rainwater fed, rice growing system coordinated with monsoon season

Environmental relevance

-Rainwater leaches nutrients like nitrogen and potassium from the andosolic the forest soil as it flows, allows rice to be grown organically

Social relevance

- Community designed managed water supply and sanitation system
- Distribution of farming and livestock activities within the community.

The local cycles of nutrient dispersal and seasonal precipitation are cleverly adapted into the subak system. The water and nutrient flow in these sawah farms , making it ecologically rich. It is referred as the 'CHANS' -Coupled human and Natural system. Traditional rice paddies like Bali's subaks are the most biodiverse and productive agrarian systems in the world, requiring no pesticides or fertilizers.

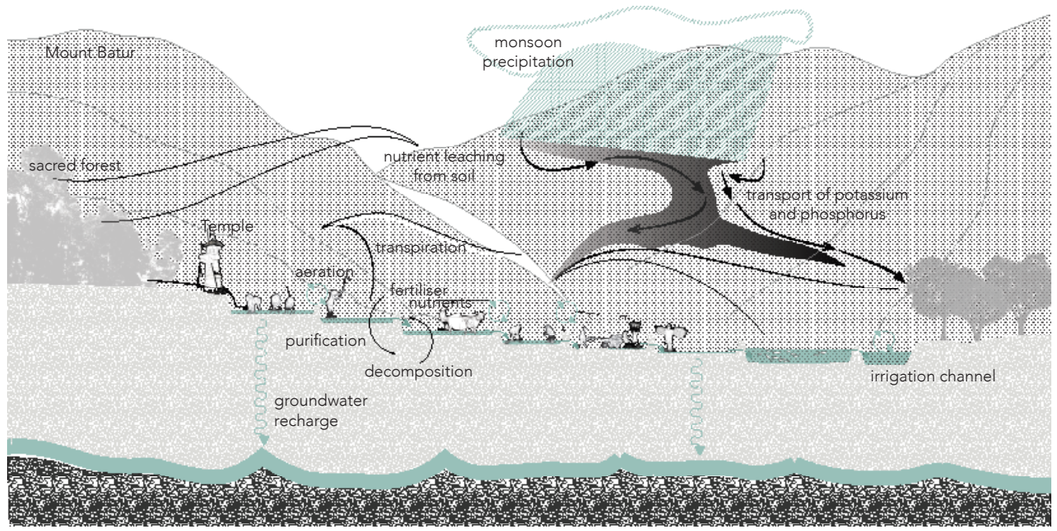


Fig 1.67 Section showing nutrient and water flow
Source : Author

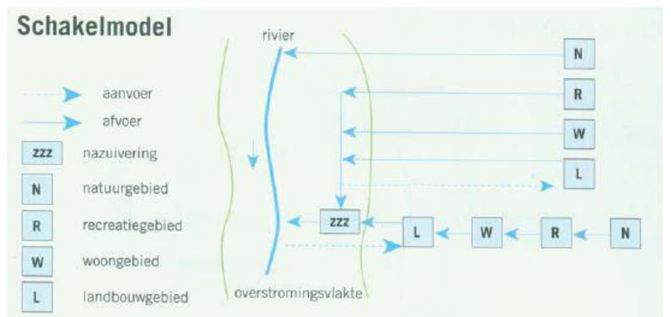


Fig 1.68 Design Principles to Modify Vegetation Gradient
Source : Author

Schakelmodel is a type of landuse system, Coordinating the water system(sewage water flow) and land use is an important aspect. For example, nature and recreational areas demand the best water quality (Tjallingii, 2004). These areas will therefore have to be included within the water system of agriculture and industry. As seen in Fig 1.68, the proposed water flow are from clean to dirty, cleanest at the highest contour. The landuse functions included are Nature(at highest elevation), recreation, living and agriculture(at lowest elevation). It also recommends sewage and storm water to be different flows.
In case of Sawah farming practices in this project, they are located at the lowland zone, for nutrient benefit, as shown in section 1.67. The agricultural run off in these Sawah fields, connected to fish ponds and purified. Hence, farming although at lowland, has one of the cleanest water flows.

03.12 Conclusion from Reference Projects
and Application of design principles to Dago Region.

LAND-USE AS PER GRADIENT :

The case study of Kampung Naga and Bali Subak system, show a landuse categorised with a vegetation gradient from forest, to different scales of farmlands. The highest altitude(upland zone) consists of forest covers, through which rainwater flows through streams and rivers to lower altitudes(mid and lowland zones), before entering the sawah fields fields. This particular landuse strategy- similar to the Schakelmodel/ Cascade system is very beneficial in the catchment, as every element in this system - trees, soil, water, play a specific role in the system and contribute collectively to produce high, organic yield in the lowland. It initiates a circular chain of natural resources, beneficial for the environment.

MODIFICATION OF WATER FLOW :

Water flow in high slopes of the catchment is vital to the health of its land and the environment. From all the 3 reference projects of the past and the present, it is evident that rainwater harvesting infrastructure has potential to initiate a sustainable water flow. Rainwater harvesting elements like fish ponds, constructed wetlands, act as water buffers but also purify the waste water, before it is let into the river. Introducing water retentive trees like mahogany, jabon, can help in spring ground water recharge, and improve the biodiversity through growth of 'valley forests.' Fig. 1.69 shows the water buffer potential at Dago region.

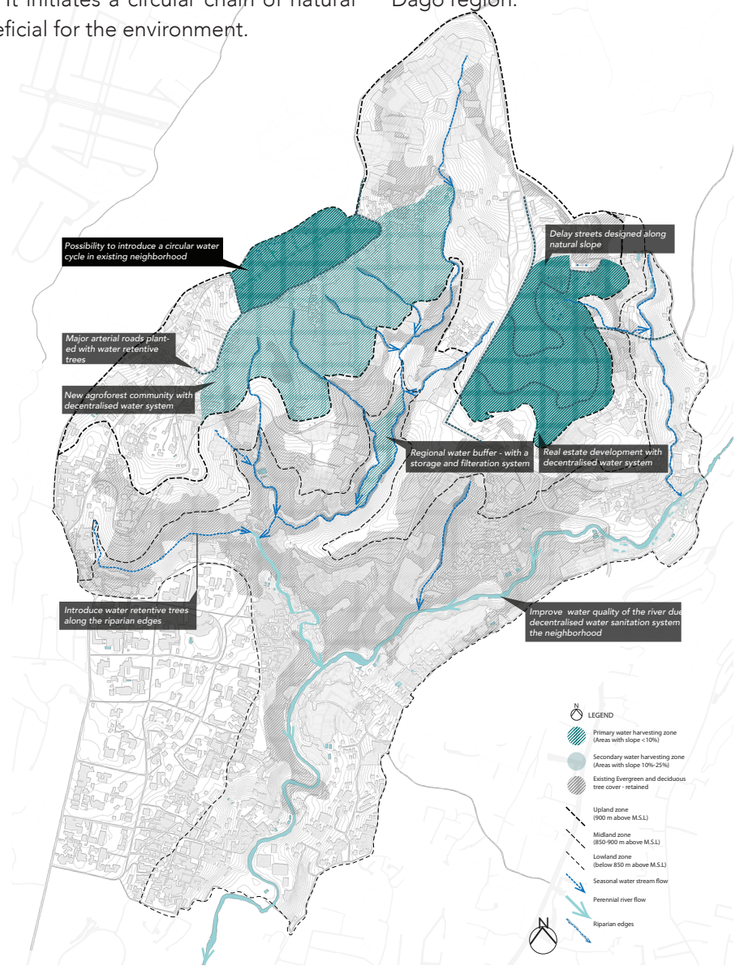


Fig 1.69 Principles to Improve Water Circularity
Source : Author

DEPENDENCE ON AGRICULTURE AS MAIN SOURCE OF INCOME :

The case study of Agua Carioca shows the benefits of harvesting water locally. It enables its citizens to grow food in their vicinity- by growing Agroforest, Home gardens and community orchards- Private farms at different scales. With time and implementation of rainwater harvesting measures, grasslands can be grown as well, promoting spring aquifer recharge and feed livestock farming. Such an integrated land-use helps achieve food security by sustainable farming methods. Additional profit is generated, through rearing animals, production of commerically viable trees in agroforest, while offering mutual benefits of added natural resources like biogas. As a result, new functions also enable other sources of income.

CITIZEN'S PARTICIPATION:

Availability of water locally through relatively cheap measures would lead to improved quality of land. The practical aspect lies in envisioning an integrated expansion of the farmlands and informal settlements,through the primary forest and agro forest, that would encourage citizen's participation. with view of stakeholders like PNPM Mandiri, PMD, the Kecamatan Development Programme and the Urban Poverty Project. They aim to improve living conditions by providing social and economic infrastructure, monetary support, etc. with a CDD - community development approach.

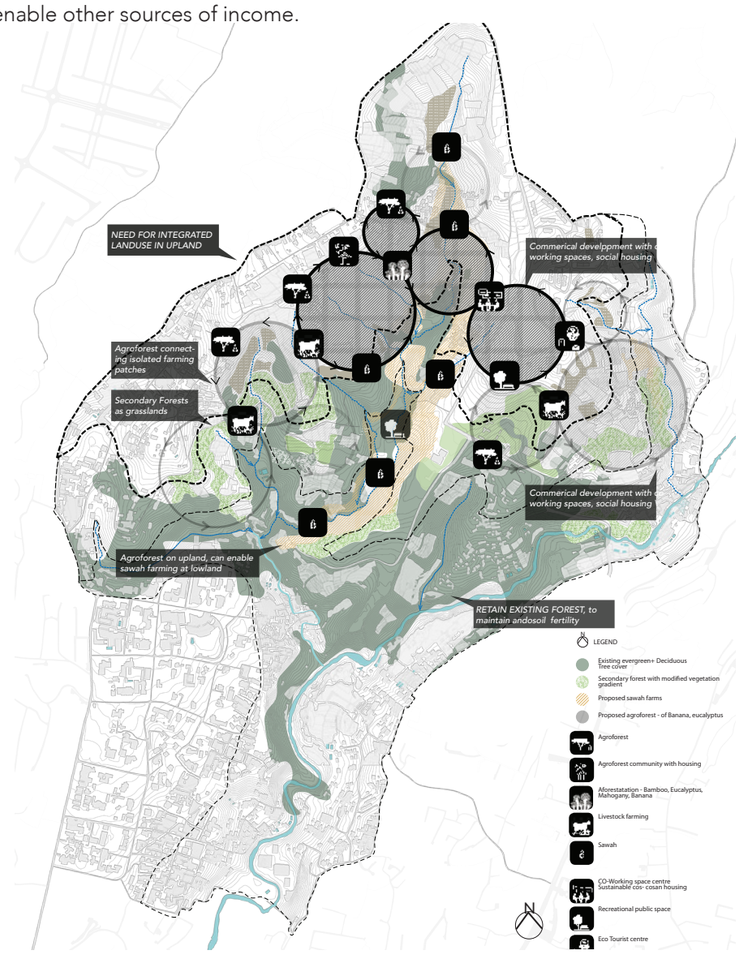


Fig 1.70 Design Principles to Modify Vegetation Gradient
Source : Author

STARTEGY I: IMPROVE RAINWATER BUFFER, FILTERATION AND INFILTERATION

BLUE LAYER

	ELEMENTS
BUFFER	Raingarden Farm Ponds Constructed Wetlands Seasonal Storage Overhead Tanks
INFILTRATION	Biophore Programme Water Retentive Trees Porous paving Agroforestry
FILTRATION	Constructed wetland- Plant Filters Septic Tanks Farm Ponds

STRATEGY II : IMPROVE VEGETATION GRADIENT BY AFORESTATION

GREEN LAYER

Aforestation measures at riparian edges
Different scales of farmlands:
Agroforest- Annual farming
Home garden - Annual farming
Community Orchards- Annual farming
Sawah - seasonal farming
Pastureland Cultivation

Fig 1.71 Strategies implemented
Source : Author

In the upland zone rain water harvesting infrastructure is introduced. It purifiies storm water run off, with halophytes like reed and cyperus. This purified water is made available for surrounding existing farmlands, to reduce their total dependency on spring ground water reserves. Aforestation along roadsides and seasonal streams with deep rooted trees like Mahogany, Eucalpytus.

In the midland zone, informal settlements are provided with rainwater harvesting infrastrucutre for a decentralised water supply and sanitation system. Once this is implemented, water is available locally. In the following monsoon season, Agroforest is planted with pioneer trees of Coconut, Jabon, Banana. As more rainwater is harvested in the midland, small home gardens and community orchards can be cultivated. Thus, different scales of private farms are grown, which helps in general aforestation in the midland zone.

Finally, farm ponds/ fish ponds are constructed in the lowland zone that can aid sawah cultivation in the lowland zone.

All these measures collectively help in soil and water conservation in Dago region, elaborated in detail in the next section.

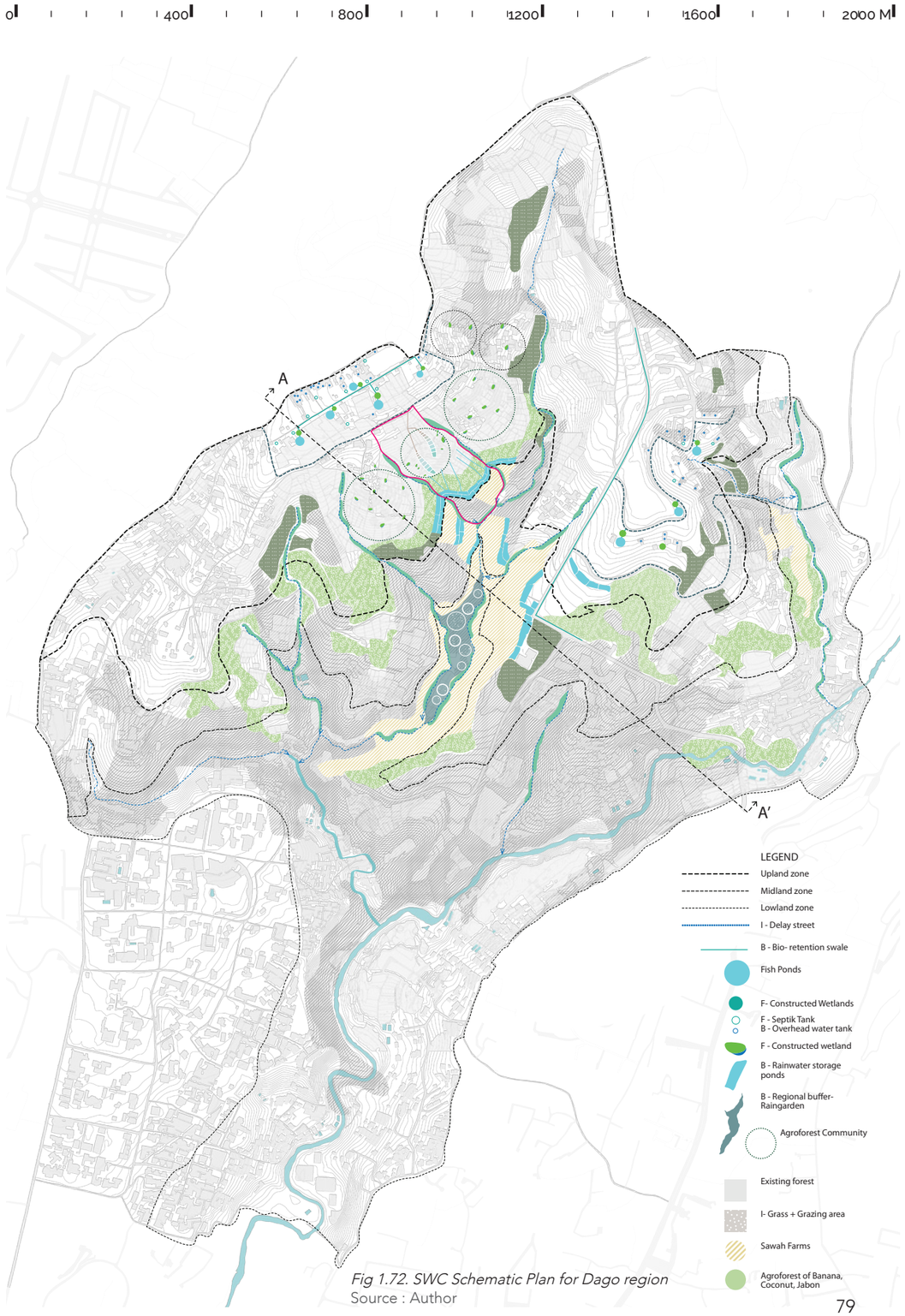


Fig 1.72. SWC Schematic Plan for Dago region
Source : Author

03.14 Schematic drawing of rainwater harvesting infrastructures and agroforestry measures at Upland, Midland and Lowland zones.

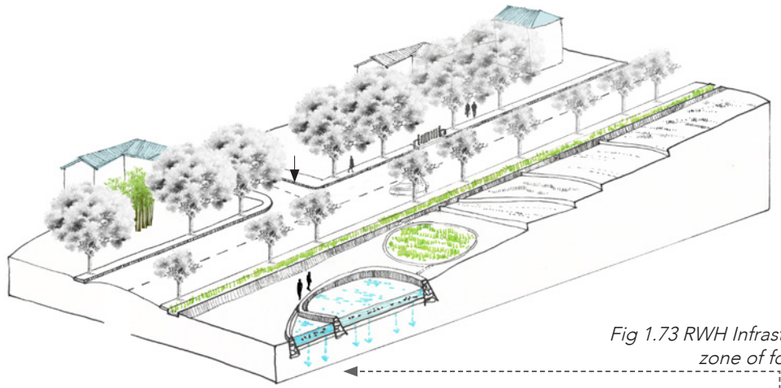
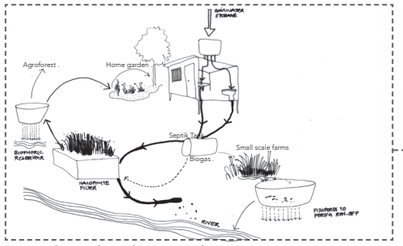


Fig 1.73 RWH Infrastructure in Upland zone of formal settlements.



Based on the diagram by, Ooze, Agua Carioca.

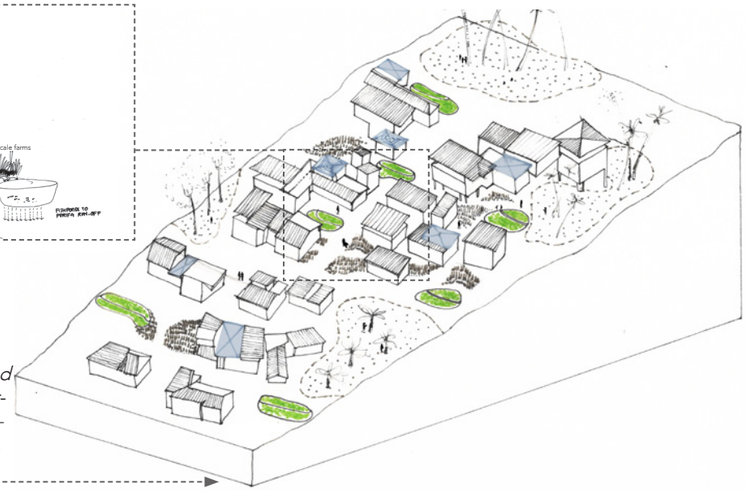
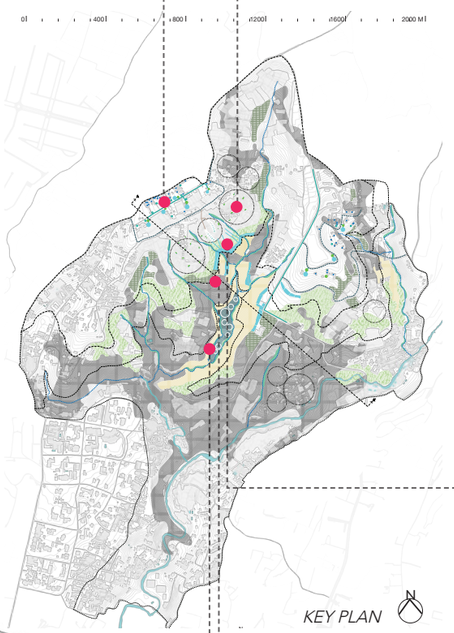


Fig 1.74 Introduction of Constructed Wetlands Septik Tanks and Agroforests in Upland zone of Informal Settlements to make a new Agroforest Community.

Fig 1.73 -1.77 show the spatial quality of the Rainwater harvesting infrastructure, water flows and the vegetation details.

Fig 1.73 shows the Road network with Bioswale channel and Water retentive and shade giving trees like Eucalyptus. Bioswale is connected to constructed wetland which is connected to fish ponds that act as water buffers and infiltrators. The idea is to retain rainwater, and encourage aquifer recharge. Fig. 1.74-76show system of water purification in informal settlement zone, which provides fresh water locally, that can be used for various activities like domestic use, home gardens, small scale farms, grasslands, recreation, etc.

Fig. 1.77 shows the various water infiltration elements and their spatial quality. The zone betwen the Midland to the lowland is designed for high water and soil retention, as it is an area prone to landslides. The agroforest, grassland, sawah farms, trees at riparian edges, farm ponds, all collectively channel water into the regional water buffer, the rain garden.



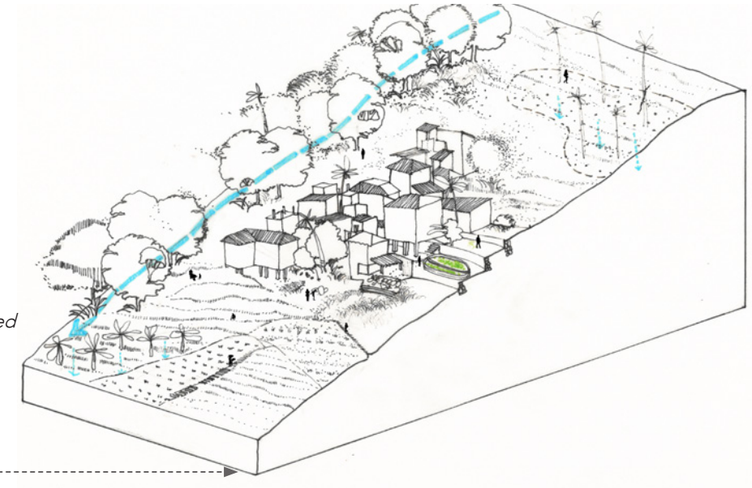


Fig 1.75 Introduction of Constructed Wetlands, Septik Tanks and Valley Forests at Riparian edges. Agroforest and Local farming in the Midland zone to make a new Agroforest Community. Source : Author

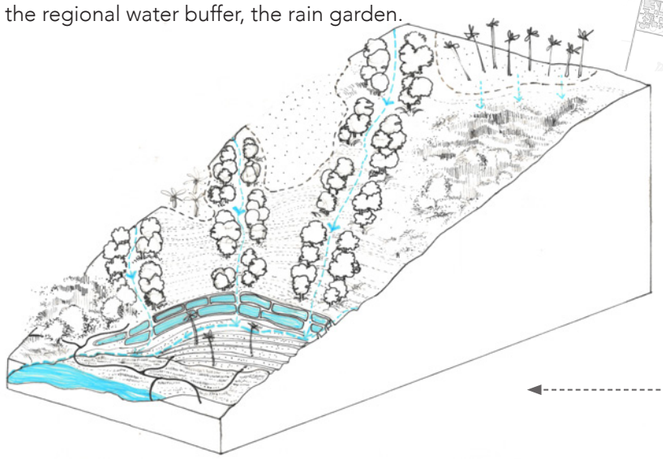


Fig 1.77 Agroforest, Valley forests at Riparian edges, farm ponds and sawah farms contribute water to the rain garden. Source : Author

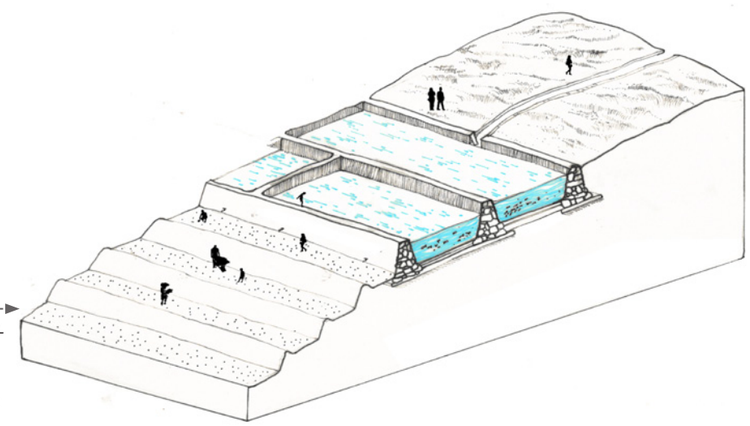


Fig 1.76 Large Farm ponds at Midland fed by stormwater gathered within the site itself, that enables Sawah farming in lowland. Source : Author

Details of pahsewise Implementation:

Phase 1

In the upland zone of formal settlement with slope less than 20%, it is the highest area in the entire region, The primary arterial roads are modified by adding bio-swale channels. They are planted with grasses like cyprus palmera, which purify the storm water by filtering organic impurities, as water flows through the gently sloping terrain.
This acts as a water buffer and takes water to the bio retention pond. This process produces clean water which can be used for the current seasonal farms in the upland area. In case of excess water in the bio retention pond, it is stored in fish ponds. The fish ponds help in water storage and aerate the water, so that it does not stagnate.
Additionally, existing roads could be modified to accommodate native, rwh trees like ficus, eucalyptus, that are water retentive trees - and functions as delay street.
These strategies help the recharge of spring water aquifer and the ponds help to buffer and circulate the water. In this way, storm water is made available for the existing farms in the Monsoon season. This reduces dependency on spring aquifer.

This would require a time frame of about 1.5 - 2 years.

Phase 2

Midland areas with higher slope – 20—40% are identified. After this, the seasonal streams are identified. No considerations are given to the riparian edges right now. The riparian zones are planted with specific trees of economic and water harvesting function like Mahogany and Eucalyptus. Their roots absorb water and they improve moisture content of the soil. The riparian zones can continue to grow to become valley forests.

After this, Agroforest plantation in informal settlement midland zone with trees like Banana, Coconut, etc. Around these trees, grasses like Soy bean, cow pea, are planted. Agroforest plantation improves moisture content of the soil and help in aquifer recharge and slope stabilisation.

These afforestation efforts take 6 months.

Phase 3

Overhead Rainwater harvesting tanks are provided for the informal settlement cluster. These provide potable water for domestic use. Parallely, constructed wetlands are built as small water dams. A constructed wetland of about 30 sq. m can purify sewage water of 10 households, approximately 35-40 people. The sewage of the Agroforest settlement is connected to constructed wetlands which it. To make this water usable for agricultural purposes, it is connected to a septik tank, which filter out organic matter into a sludge, to make water available for farming,

With these interventions, rainwater is harvested locally for domestic use. water filtered by the constructed wetland and septic tanks, make extra water available for agricultural use . This locally purified water is used to help growth agro forest, community orchards and home gardens in the immediate vicinity of the settlements. The modified vegetation gradient improves the moisture content and quality of the soil land.

Implementation of soil water comservation in informal settlement zone woud take 6 months - 1 year. I

Phase 4

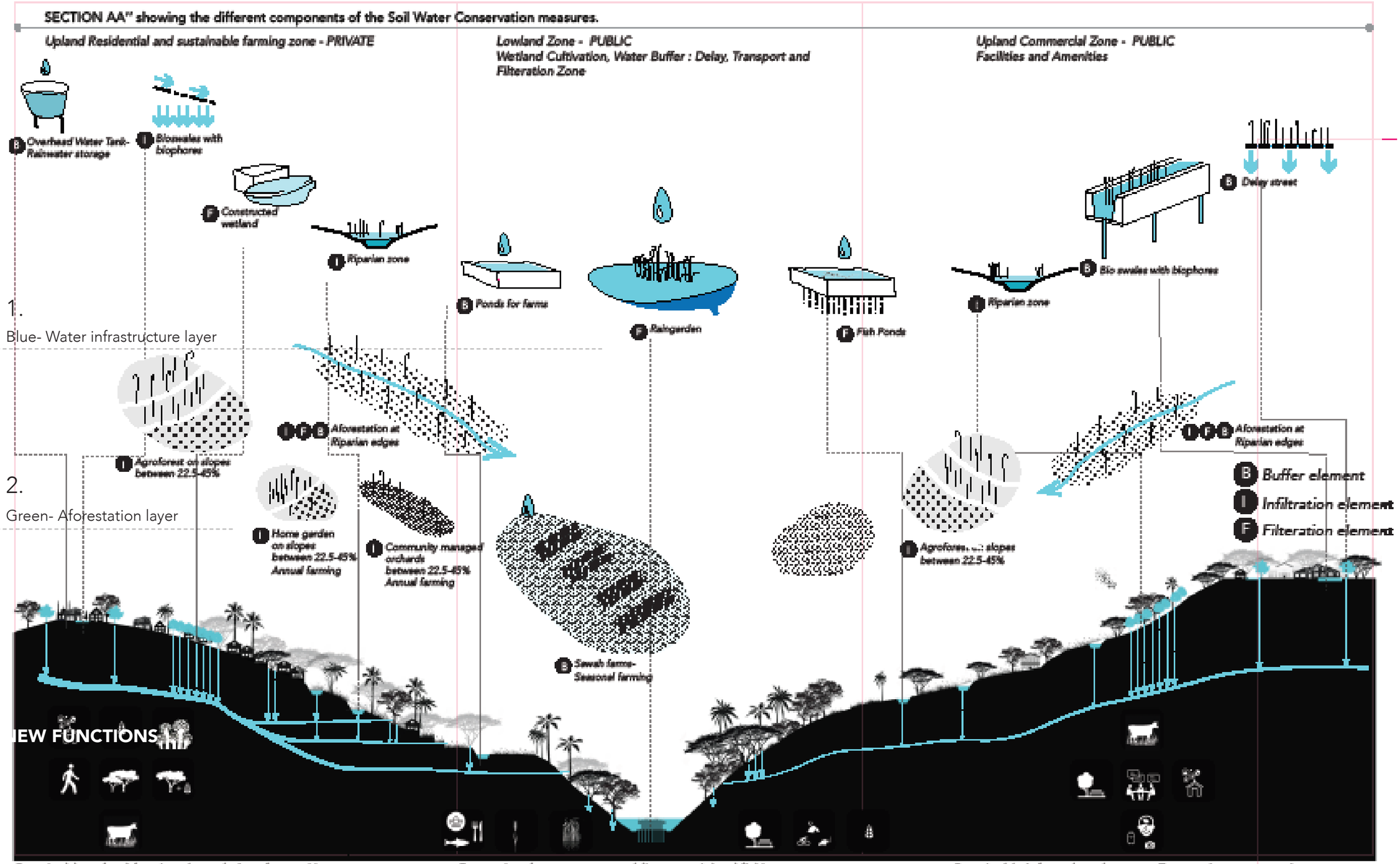
n the lowland zone, farm ponds are constructed for seasonal sawah farming. They contain fish, to keep the water aerated before it is supplied to the sawah farms. Sawah farming is known as wetland farming, where rice, maize is grown.

This requires a time span of 6 months.

The implementation of the soil water conservation stratgies require about 4.5- 5 years in total. The water infiltration efforts in upland and midland zones make water available to the lowlands and the raingarden. The raingarden is a source of high yield seasonal farming, Cultivation of legume plants in this zone help in slope stabilization and prevent landslides, It acts as a buffer but also provides ample opportunities for recreation, and additional income due to new activities like fishing. hiking, camping etc.

03.15 Blue -Green layers introduced at Dago region

and their function regarding water buffer, filteration or infilteration



03.16 Elaboration about the new Blue - Green layers and the outcome.

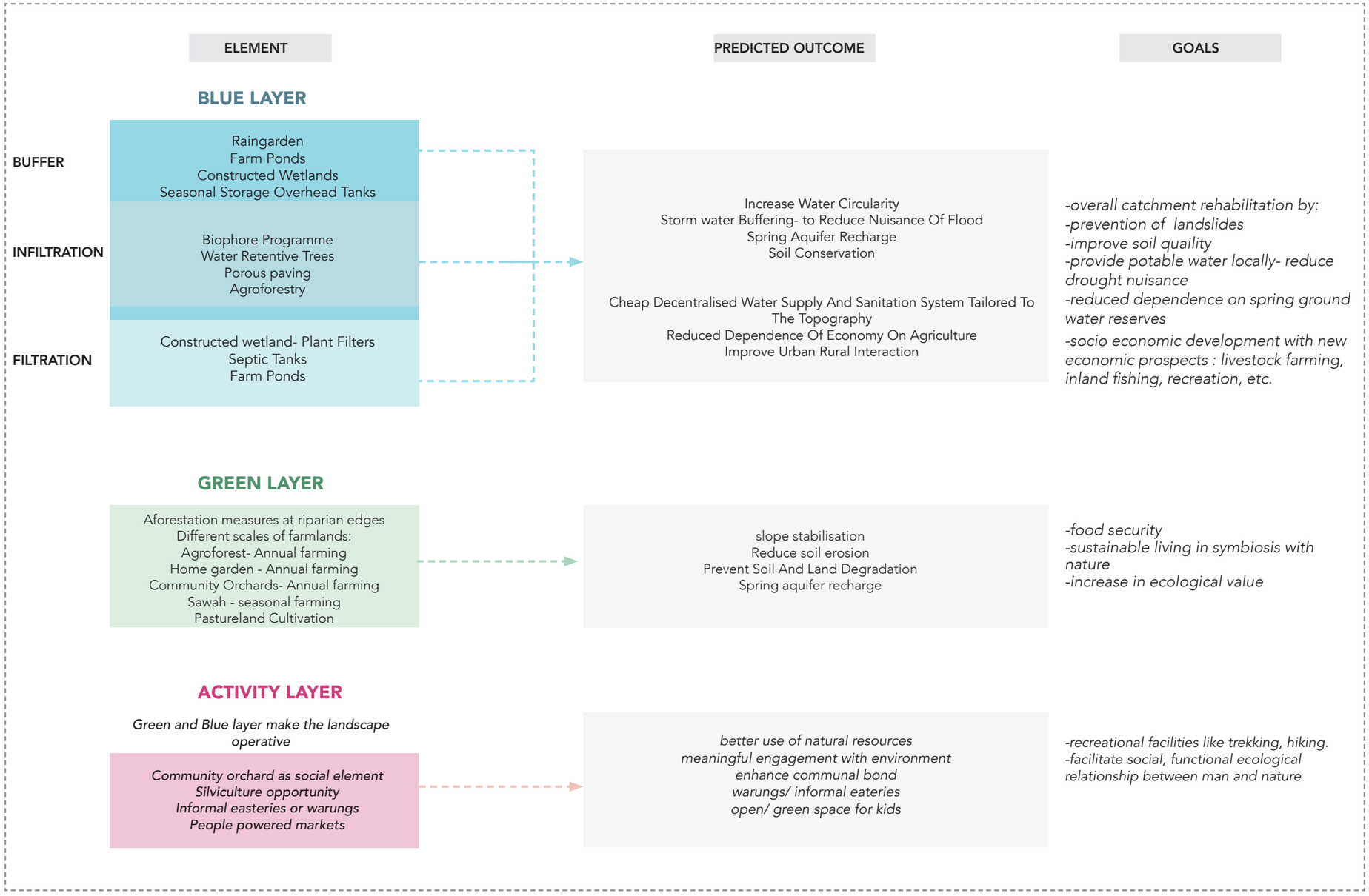
Flowchart listing the outcomes and goals of the Blue-Green infrastructure layer.
Source : Author

BLUE LAYER -

It is the vital component of the Soil and water conservation Programme.
Rainwater harvesting infrastructure of various scales is introduced at Upland Midland and lowland zones. Their size is determined by the water requirement for domestic or irrigation purpose.
The Dago region in North Bandung is also explored for its potential as a water reservoir at a meso scale, by implementing the Rain garden- the regional water buffer. This leads to improvement in sponge function of Dago region because of the water buffer, filteration and infilteration techniques.

GREEN LAYER -

Presence of water available locally allows various aforestation and sustainable farming systems to be incorporated at various levels. Integral components of this Green layer are the agroforest, home garden, community orchards and Sawah farms. These have a direct impact on reduction in landslides in Dago region. It ensures an efficient use of natural resources, as shown in the next section.
The inetgrated land-use facilitates sustainable food production through the different scales of private and commerical farms.



03.17 Impressions of the Raingarden- Dago region water buffer.

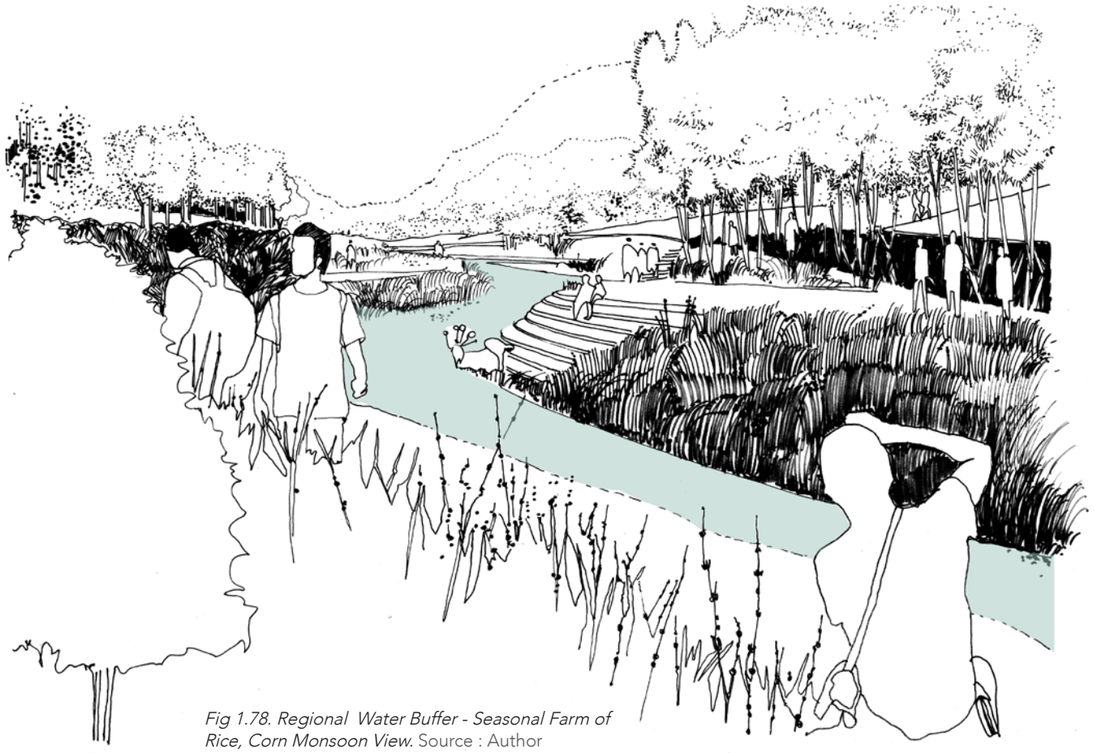
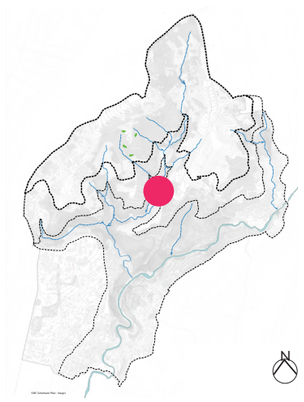


Fig 1.78. Regional Water Buffer - Seasonal Farm of Rice, Corn Monsoon View. Source : Author



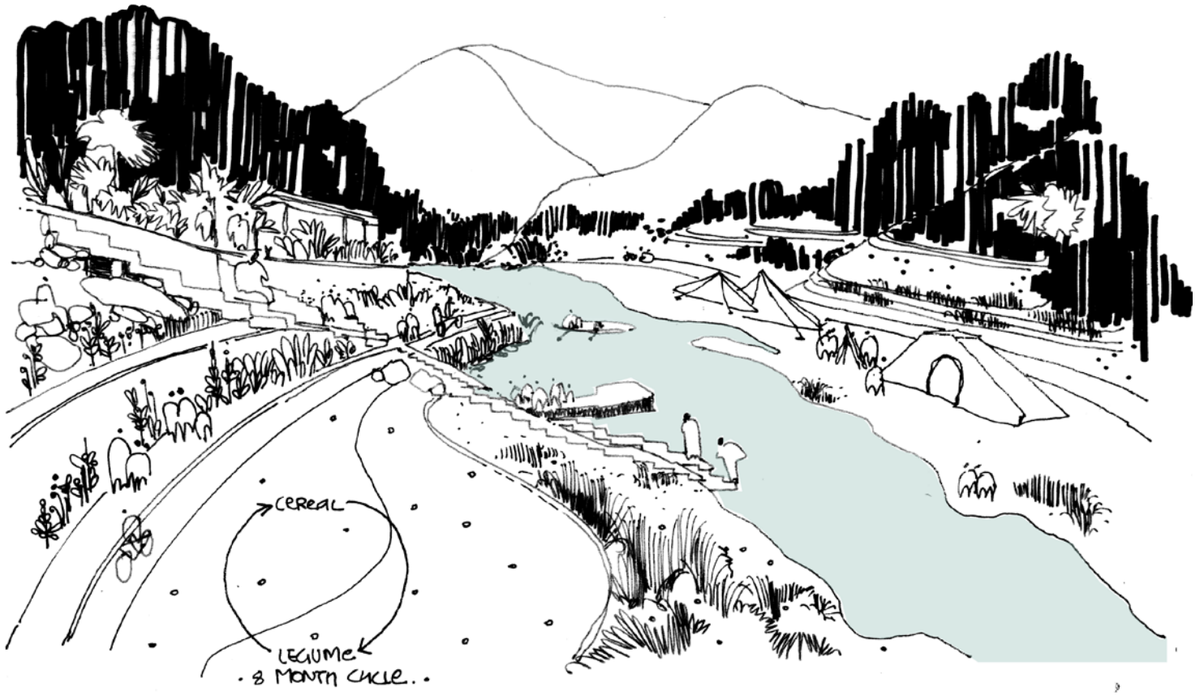


Fig 1.71. Regional Water Buffer - Summer View. Source : Author

Fig 1.70 and 1.80 show the atmosphere of the rain garden. In the monsoon season, it can be used for seasonal farming.
In the summer season, it can be used for recreational activities like hiking, camping, fishing.

03.18 Aforestation by introducing different scales of farmlands in midland zone

Fig 1.81. Agroforest and Homegardening within the informal settlements in Midland zone. Source : Author

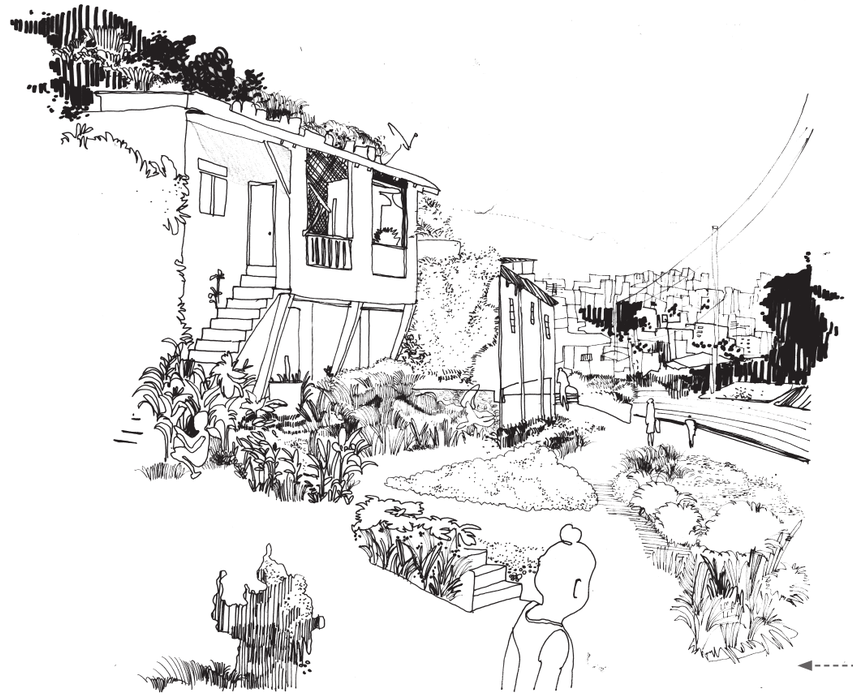


Fig 1.82. View of agroforest neighborhood in lower midland zone .Source : Author

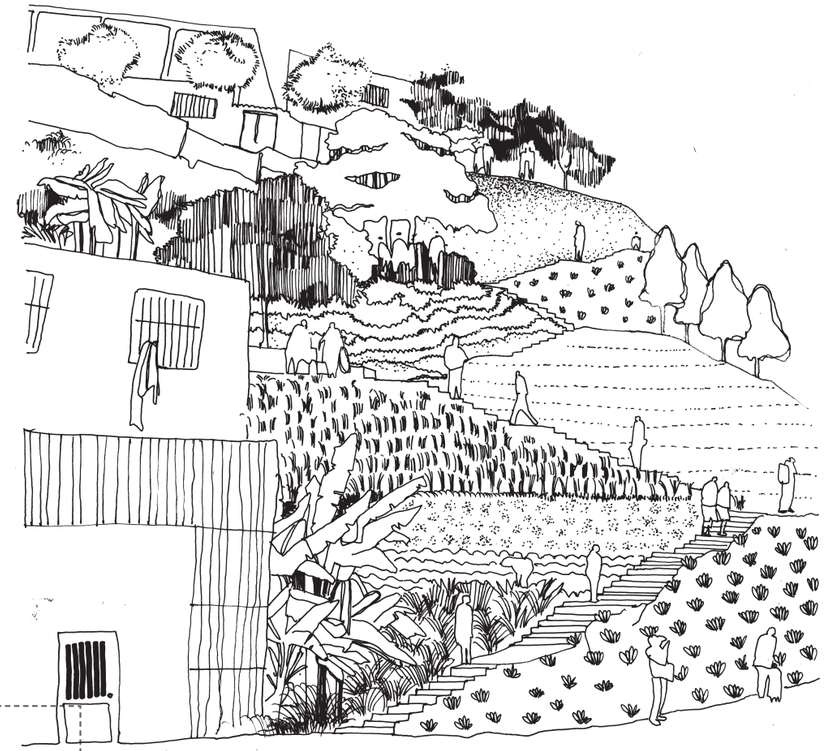


Fig 1.83. Unstable slopes stabilised by Vegetation Gradient in Midland zone

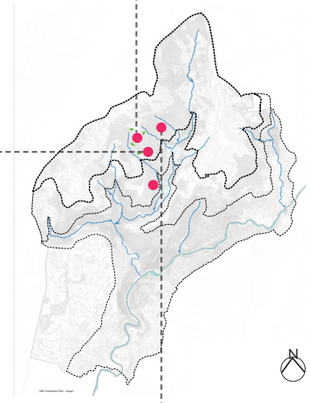


Fig 1.84. Community orchard of Orange connecting houses of the Agroforest settlement. Source : Author

03.18 Sawah farming in lowland zone

Fig 1.85 View of rice farms in lowland zone
Source : Author

03.19 Modified Water Flow of Dago Region

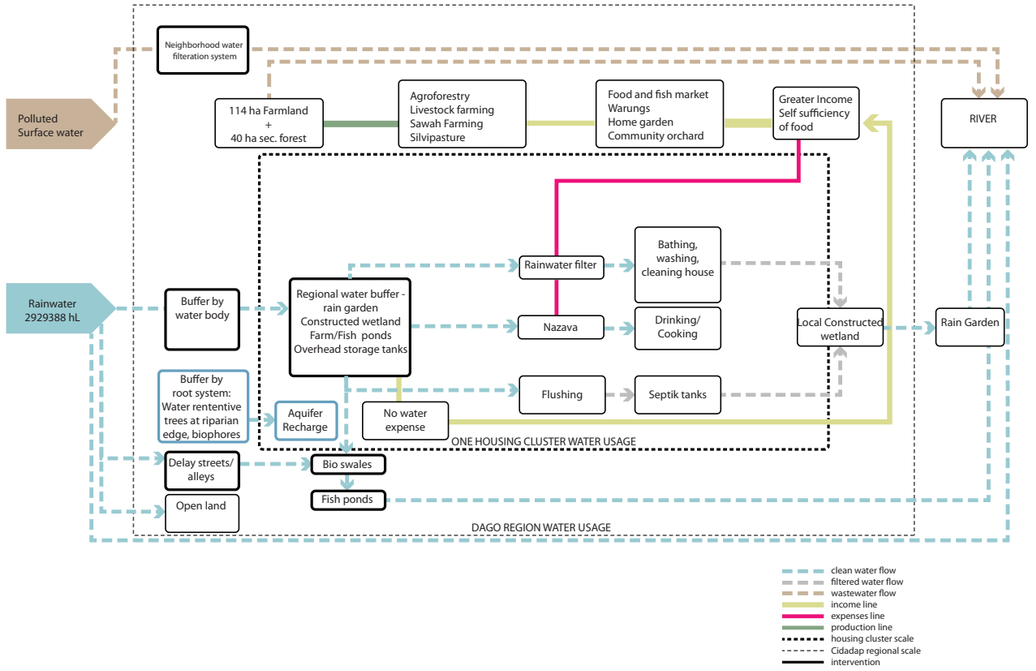


Fig 1.86 New sustainable water flow situation
Source : Author, based on the diagram by Sae Adipurnomo

MODIFIED CIRCULAR WATER FLOW OF DAGO REGION: 2029

Fig 1.86 show the modified sustianable water flow situation after implementation of the Soil Water Conservation vision in the Dago region.

In the Upland zone with slope less than 20%, measures to store and filter storm water ensure clean water is let out for usage of the surrounding farmlands. This reduces the depedency on spring water reserve and also helps aquifer recharge through the water retention avenue trees. Additionally, biophores are installed in areas with soft soil. They are steel tubes that promote water infiltration and thereby spring aquifer recharge.

In the **Midland zone** with slope higher than 20%, Riparian edges are planted with water retentive trees like Mahogany, and Eucalyptus. They are effective in reducing top soil erosion and improve the quality of the water. These help in spring aquifer recharge in the Midland zone.

In the agro-forest community, installation of Overhead Rainwater harvesting tanks saves the excess money spent on purchasing water to drink and for domestic use. The soil water from the houses goes in the vicinity to small Septik tank(to filter sludge and solid impurities) and then constructed wetland to let out clean water which can be used to water home garden and orchards. Availability of water locally, within the agroforest community through these small constructed wetlands make them an integral part of the landscape that its people can identify themselves with, and take care of.

At the lower midland level, farm/fish ponds act as buffer and infiltrators and provide water for the sawah farming at lowland level. Rice, Corn, Cassava can grow annually, giving a high yield. Water in these ponds is nutrient rich, having flown through the agroforest area in the upland.

All these water retention measures collectively contribute to development of the Raingarden of Dago region.

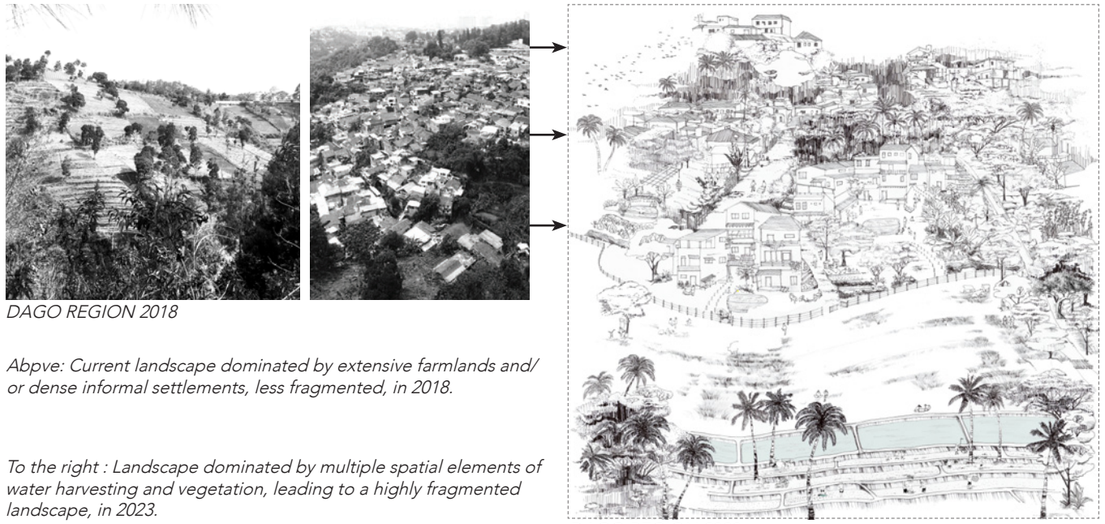
03.20 Fragmentation in Dago Region

As seen below, there is limited water management infrastructure in Dago region currently. The landscape is visually dominated by extensive farmlands and dense settements, clustered among dense tree covers. The current scenario is visually fragmented.

With the introduction of the Blue and green infrastructures of soil and water conservation measures, the landscape is fragmented further. However, as seen in the impressions, the water infrastructure and aforestation measures act as an integral functional and visual link. The resulting integrated land use makes it an active and operative landscape, seen in image 1.87.

The area under commercial farms is reduced in the 2023 vision. This is because these seasonal unsustainable/ abandoned farms are replaced in favor of sustainable farming practice which accomodates the agroforest, home garden, community orchards for annual farming. Within the agroforest community, vertical growth of informal settlement is recommended to retain existing tree cover and enhance it with agroforests. Seasonal grassland cultivation and seasonal Sawah farms are implemented. Area under sustainable sawah farming is higher in 2023. The aforested riparian zones, eventually form valley forests. The valley forests blend with the existing forest cover.

In conclusion, the new blue-green layers leads to addition and separation of the integrated landuse activities. The resulting landscape of Dago region is spatially highly fragmented.



DAGO REGION 2018

Abpve: Current landscape dominated by extensive farmlands and/ or dense informal settlements, less fragmented, in 2018.

To the right : Landscape dominated by multiple spatial elements of water harvesting and vegetation, leading to a highly fragmented landscape, in 2023.

DAGO REGION 2023

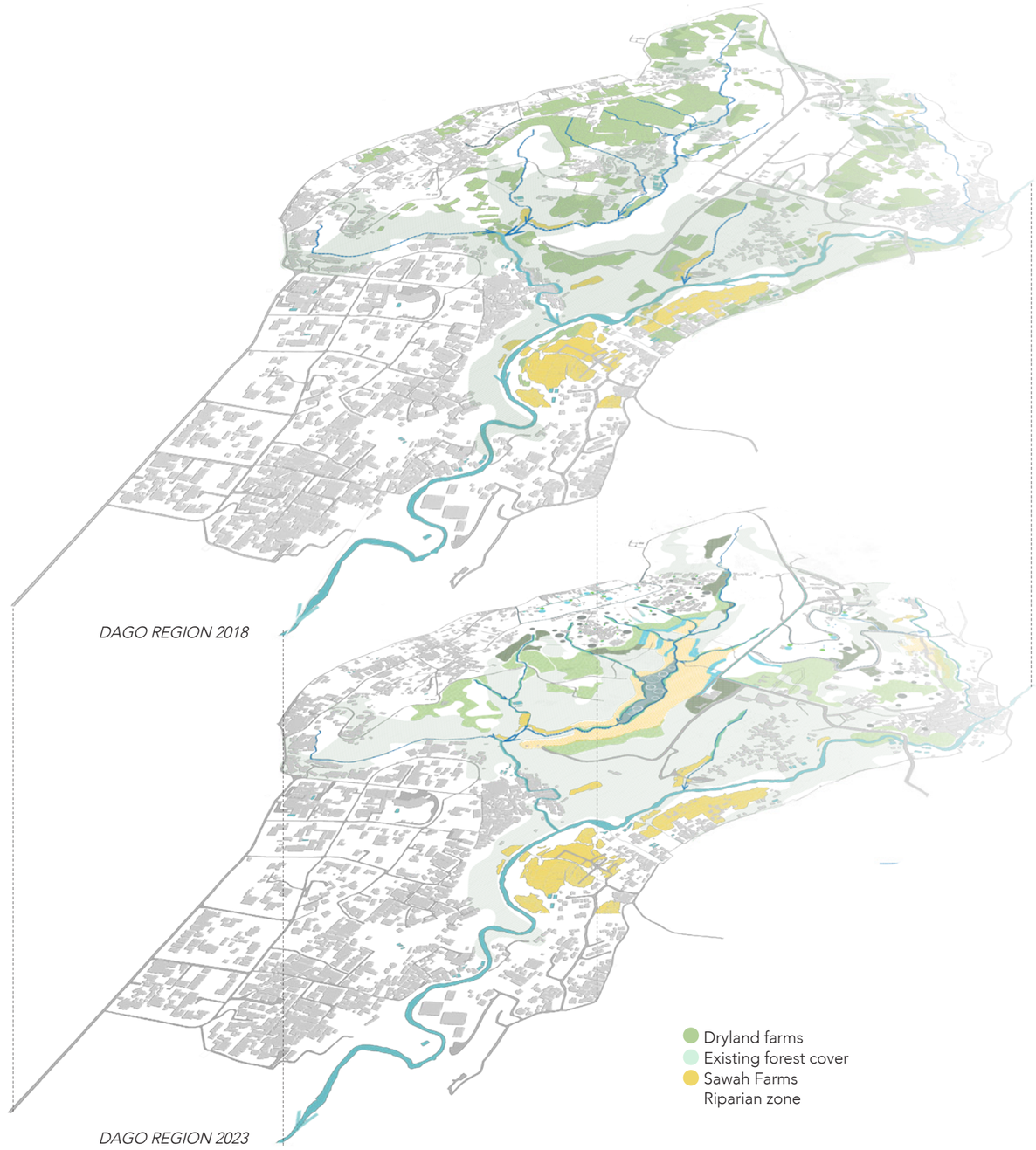


Fig 1.87. Before and after scenario in Dago region.

04 *DETAILS OF INTEGRATED LANDUSE IN MIDLAND ZONE*
Development of Agroforest Community

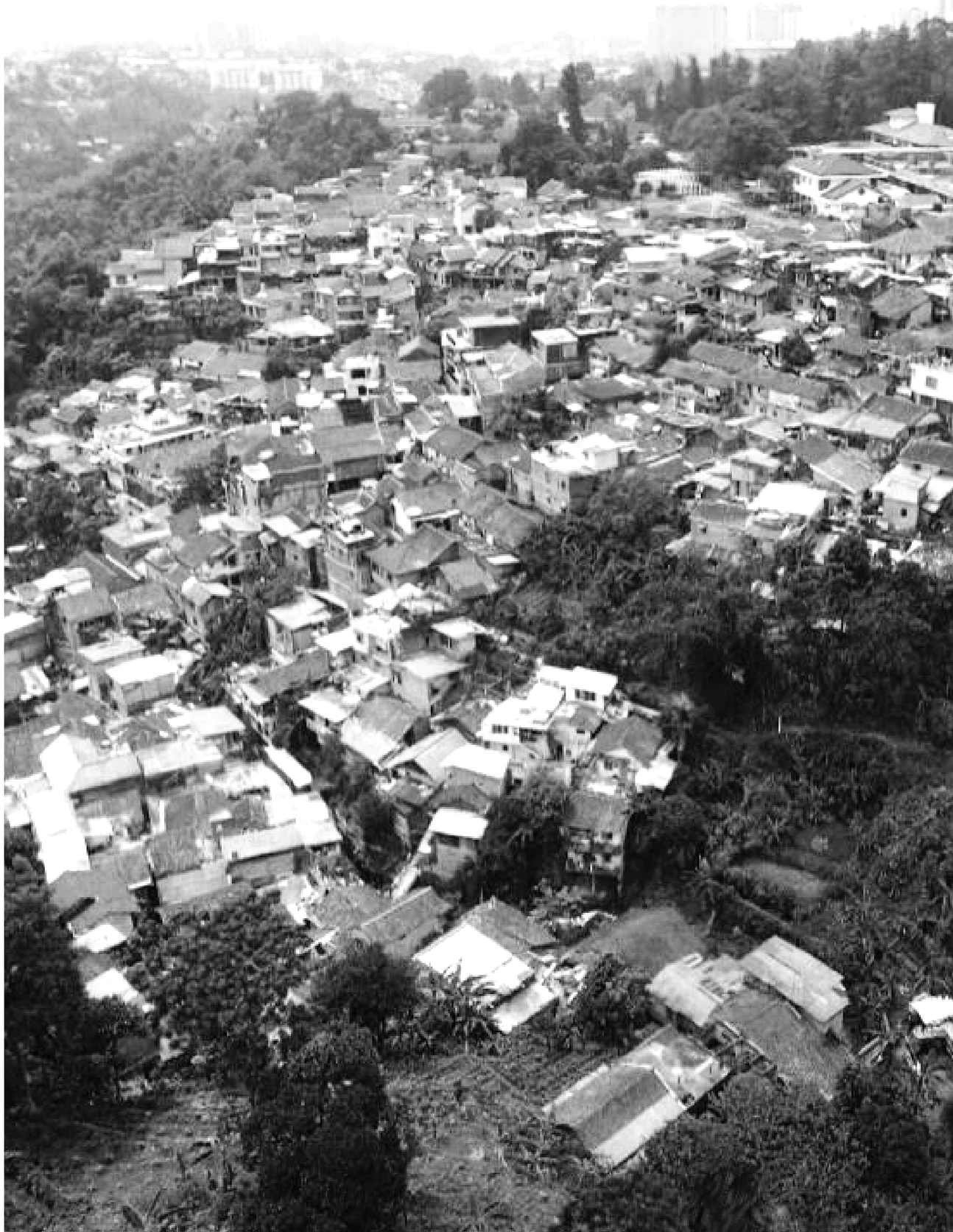
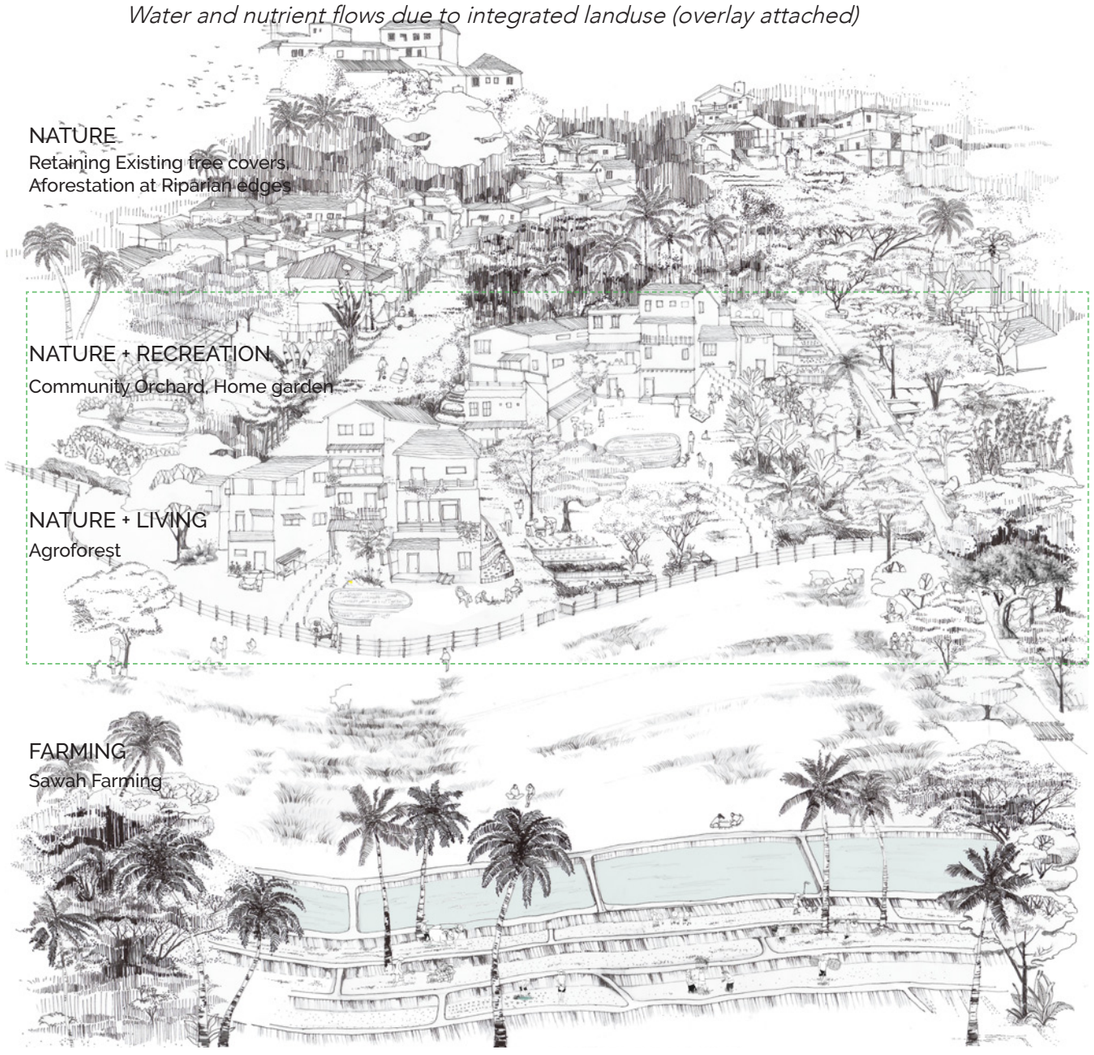


Fig 1.88.To the right: Existing, dense, informal settlements in Dago region
Source : Dicko Armas

04.01 Detailed view of the Agroforest Community

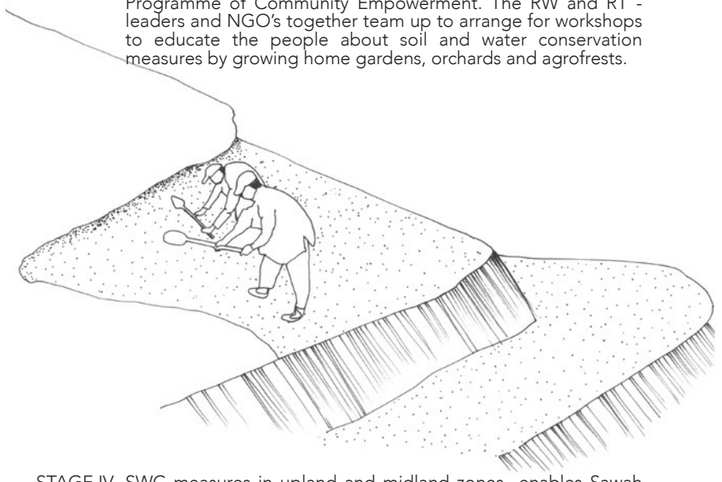
Water and nutrient flows due to integrated landuse (overlay attached)



STAGE I Septic tanks and constructed wetlands are constructed with local stone. Overhead Rainwater harvesting tanks are installed. This initiative is managed by the Kecamatan Devpt. Programme and PDAM - the Municipal water board.

STAGE II Riparian zones of seasonal streams are aforested with trees like Eucalyptus and Mahogany to facilitate water infiltration. Participation of citizens with help from NGO's and Bandung Environmental Management agency.

STAGE III Agroforests are grown around the informal settlement, driven by the citizens, backed by the PNPM Mandiri Scheme - National Programme of Community Empowerment. The RW and RT - leaders and NGO's together team up to arrange for workshops to educate the people about soil and water conservation measures by growing home gardens, orchards and agrofrests.



STAGE IV SWC measures in upland and midland zones enables Sawah farming in the lowland. The citizens can contribute to making terrraces for the farms. This allows annual farming of Rice, maize, Cassava, etc.The farming activities are backed by Farmers Organisations.

Implementing soil and water conservation measures in stages, with active participation of citizens, as shown in the above images. It is a mixed approach, invoving the citizens and various public and private organisations. that facilitates an integrated landuse to include various scales of farming. This promotes a meaningful interaction of its citizens with nature. Adressing the water and soil conservation issue in informal settlements, enables water buffering, to help with the flood and drought scenario of Bandung city..

Fig. 03 Detail of water management system in Agroforest community.

RWH Tanks

water for
home gardens

use of natural slope to
aerate water

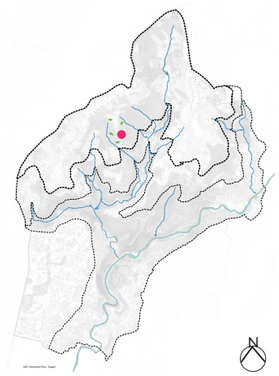
Constructed wetland with plants like
Bracharia, Papyrus Cyperus

cleanwater supplied
downstream

Septik Tank

Organic waste settled as
sludge- BIOGAS produced

fertiliser for
plants



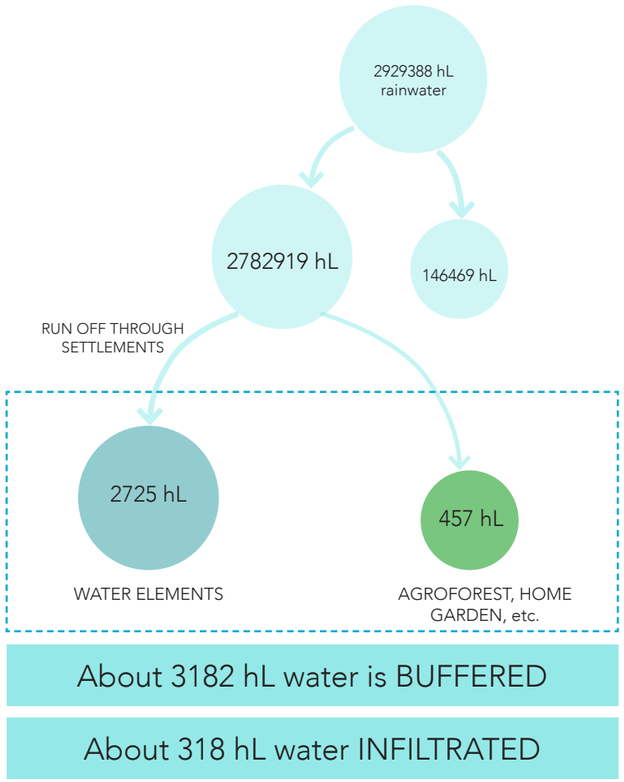
05 DESIGN EVALUATION

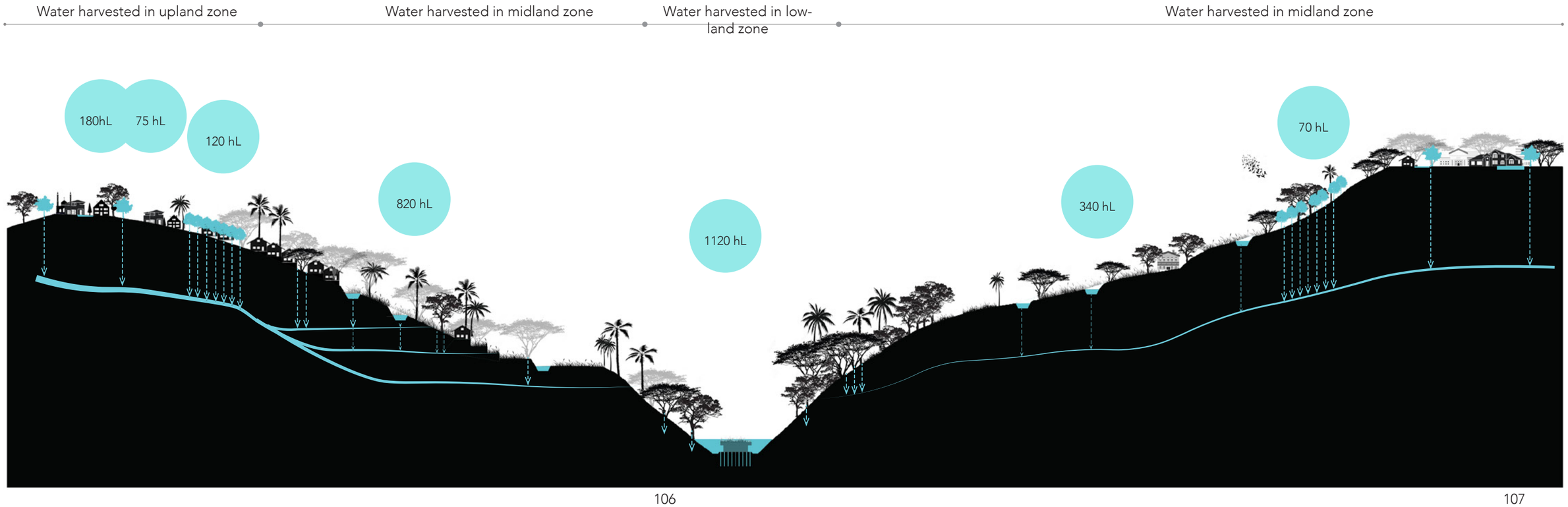
05. 01 Rain water harvesting details of Dago region

WATER BUFFER : The different water elements, help in water retention and buffer. All in all, 10% of the total volume of precipitation, is buffered in Dago region.

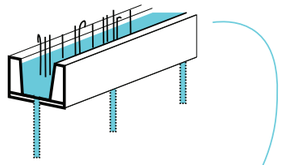
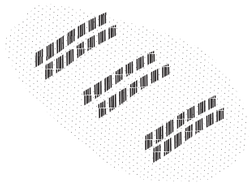
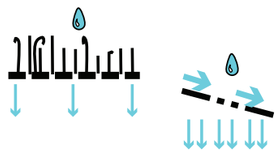
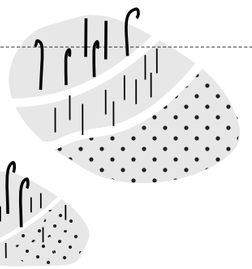
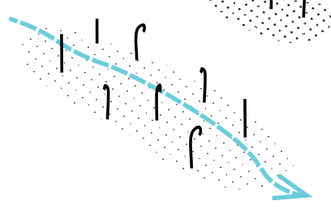
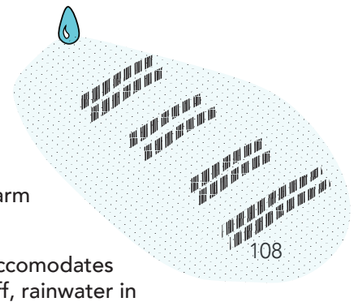
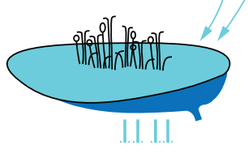
WATER INFILTRATED : With water infrastrucutre and aforestation methods combined, 7% of the total volume of precipitation in Dago region is directed to spring aquifer. Trees like Mahogany, eucalyptus filter the water from organic impurities. Hence, the quality of water in spring ground water reserves is higher.

WATER FILTERATION : the system of constructed wetlands, septic tanks and fish ponds aerate and purify the domestic and storm water from organic impurities. Trees like mahogany, eucalyptus also purify storm water from organic waste. Inorganic impurities of industrial waste, need additional measures, which are beyond the scope of this project. The aerobic water filteration methods outlined in this project ensure clean water to be let into the Cikapundung river. In Dago region, the water flow in formal and informal settlements is similar to the recomendations of sustainable water flow in the Schakelmodel system.





05. 02 Components of the the Blue- Green layer.

	ELEMENT TYPE	RECOMMENDED SIZE OF WATER INFRASTRUCTURE	SIZE OF THE FARMLAND IRRIGATED	EFFECT ON QUALITY OF LAND AND SOIL
UPLAND ZONE of Formal settlements	Bioswale Channel along Primary roads, slope less than 10% 	600mm width, with a 7% slope.	COMMERICAL, SEASONAL FARMING: Existing dryland farms irrigated by water collected and purified in the constructed wetland the vicinity.	Land and soil quality improved as moisture content of both is increased. Rainwater harvesting measures prevent farmlands from being abandoned to lack of irrigation opportunity over time.
	Delay street, trees with deep roots planted along primary roads to promote water infiltration 	8-10 M length 		
	Constructed wetland to provide water for existing farms in upland zone 	Trees spaced at 4.5 m c/c		
MIDLAND ZONE of Agroforest Community	Rainwater harvesting tanks for domestic use 	2000 L tank for every 20 people, for domestic and private farming. 	PRIVATE, ANNUAL FARMING **Agroforest:** Coconut, Banana, Jabon 70-80M length, 15-20 M width, tiered system of small trees, medium sized trees, shrubs. **Home Garden**: Coconut, Papaya, Chikoo 8-10 M length, 3-4.5 M wide. Mix of cash crop, legume crop, perennial florals, ornamental and medicinal plants. Legume crops can be changed seasonally. **Community managed Orchards:** Mango, Chikoo, Sitaphal 6-7.5 M wide, 18-20 M length. **Aforestation at Riparian edges :** Mahogany, Ecualyptus trees, spaced at 4.5 m c/c, on both sides of the seasonal stream. 15 m width aforested along the entire length	Land and soil quality improved as moisture content of both is increased. Valley forest improve ecology and promote indigenous reed species like Phragmites karka, which purify the storm water. Different scales of farms enable food sufficiency.
	Constructed wetlands and septic tanks to purify domestic grey water 	5-7.5 M length, 3-4.5 M width, tailored to existing contours. 1.2 sq.m. per person 		
	Valley forest: Trees with deep roots planted along seasonal streams 	7.5M width on both sides of riaprian edge aforested. 		
LOWLAND ZONE of Sawah Farms, Raingarden	Farm, Fish ponds 	12-15 M length, 3-4.5 M width, approx 56 lit of water irrigates 1 sq.m of Sawah farm per day 	COMMERICAL, SEASONAL FARMING **Sawah (Rainwater fed) farm** of width 2.7-3 M width,along the existing contours with slopes higher than 22.5%.	Sawah farming is a sustainable farming practice. Rain garden offers benefit of seasonal farming and recreational opportunities and improves ecological condition.
	Raingarden 	200 M length. Accomodates the Sawah run off, rainwater in monsoon season	300 M length, 20-30 M width, storage capacity of agricultural run off, and precipitation.	

05. 03 Effect of the Blue- green landscape strategies in Dago region on flood and drought in Bandung city.

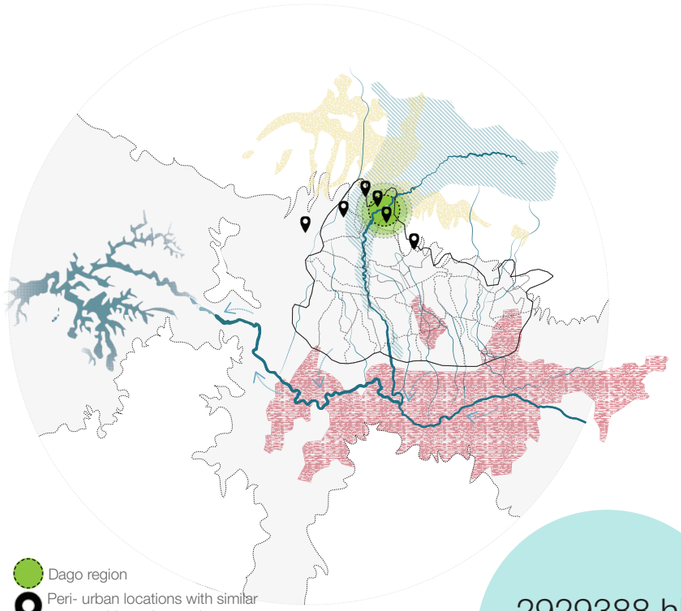
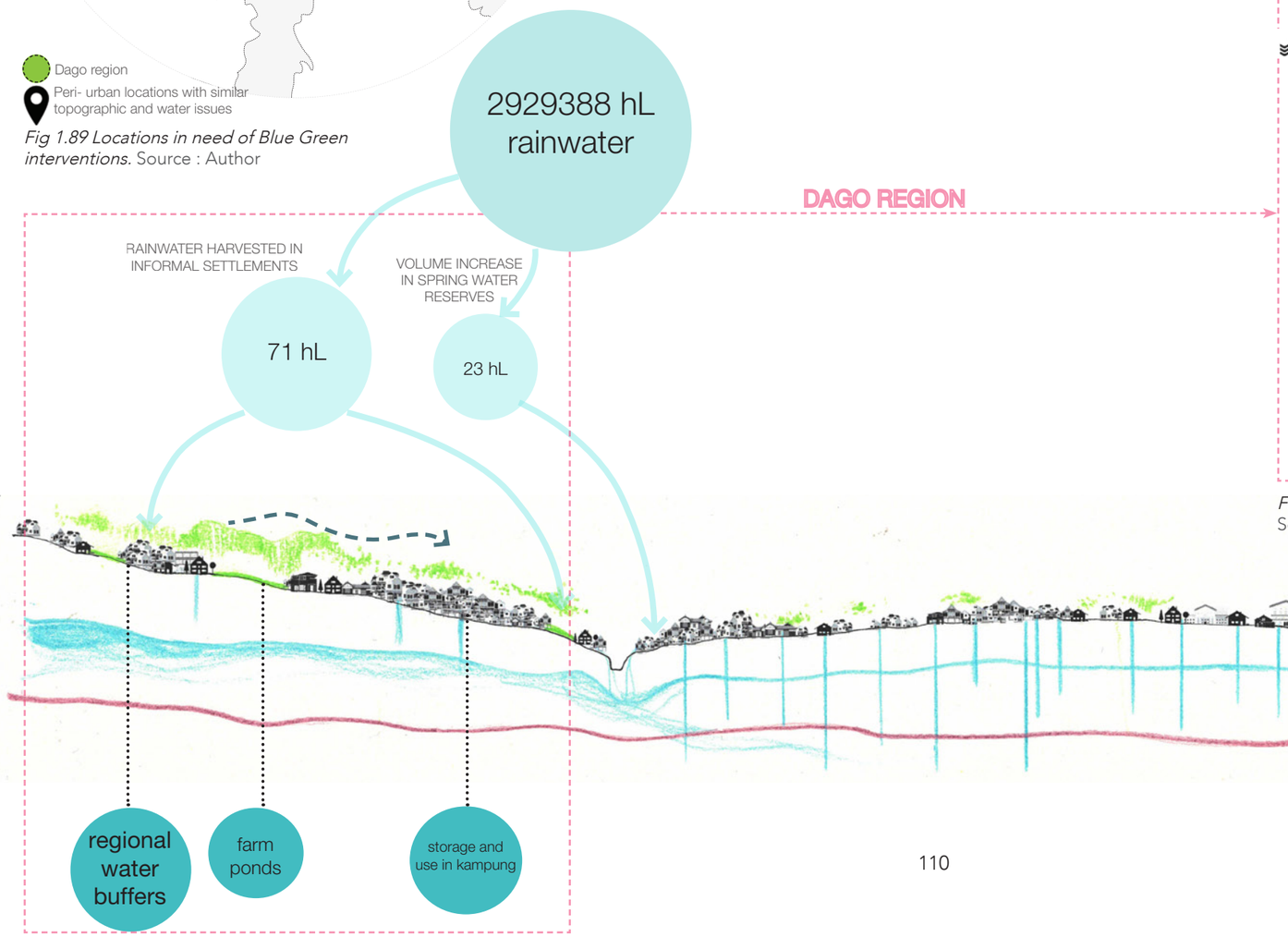


Fig 1.89 Locations in need of Blue Green interventions. Source : Author



The effect of the stratgies in Dago region will slowly alleviate the flood and the drought situation in Bandung city. Flood level would be reduced as the strategies are implemented. All the vulnerable peri urban locations- as pointed in Fig 1.89 need to make soil and water conservation efforts urgently for significant improvement in Bandung's flood and drought scenario over the next 5 years.

The soil and water conservation programme has benefits for Dago region and Bandung city, besides reduction of drought and flood. They improve the ecological value of the city by reintroducing the vegetation at riparian zones. As the raingarden and other water elements provide enough water for domestic and agricultural use, there is surplus available for recreational purposes and new functions like fishing. Food security is achieved in Dago region. Hence, the quality of living is highly improved, especially in peri- urban areas. Studies suggest that living in harmony with nature offers several health benefits, outlined in Fig. 1.90.

However, it is not sufficient to implement soil and water conservation strategies in just the peri- urban regions. There is great scope to improve the quality of land and soil in the Cikapundung catchment to improve its sponge function with integrated landuse planning. Afforestation and rainwater harvesting measures need to be carried out at different scales in Bandung city, to strengthen its blue- green network. Only then can the flood and drought scenario can be reversed totally.

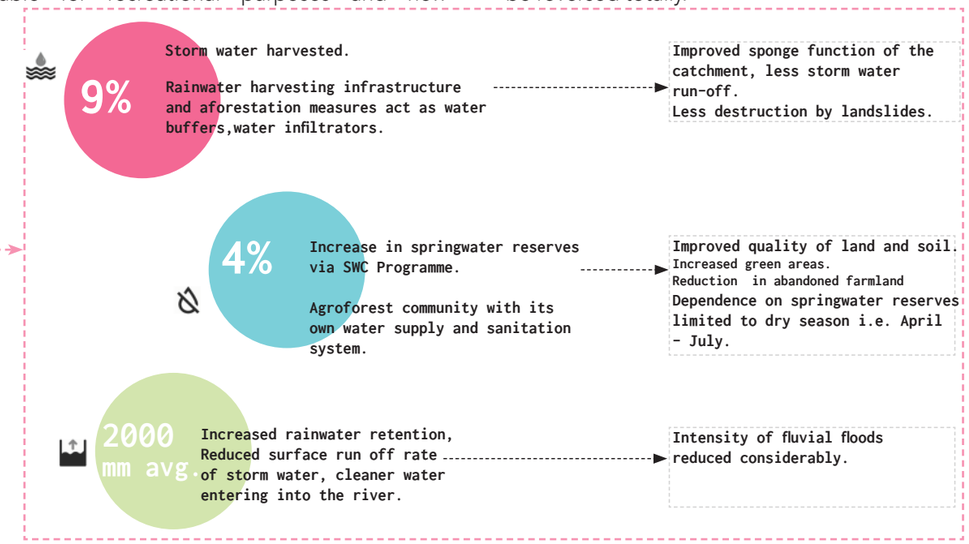


Fig 1.90 Water harvesting details and their effect in Dago region
Source : Author

Fig 1.90 New water flow situation
Source : Author, based on the diagram by Sae Adipurnomo

05. 04 Stakeholders involved in implementation of Blue Green infrastructures

Fig 1.91 outlines the stakeholders involved of the Soil- Water Conservation measures in the Dago region.

Regarding the water infrastructure elements, their implementation is under the Bandung Municipality. Different institutions are responsible for infrastructure works in formal and informal settlements, highlighted in blue and pink respectively. Informal settlement zones have the involvement of government inititatives for rural empowerment and NGO's that act a link between the citizens and municipal organisations.

The aforestry initiatives are curated and sometimes even funded by International organisations like the United nations. There is a better research database regarding aforestation and farming practices, which further boost aforestation initiatives. There are many Farmer's organisations in Indonesia and Bandung as well. They are a vital link between the government sectors and the farmers.

Overall, the interests of the people, planet and profit come together with this bottom approach involving all stakeholders in a clear manner.

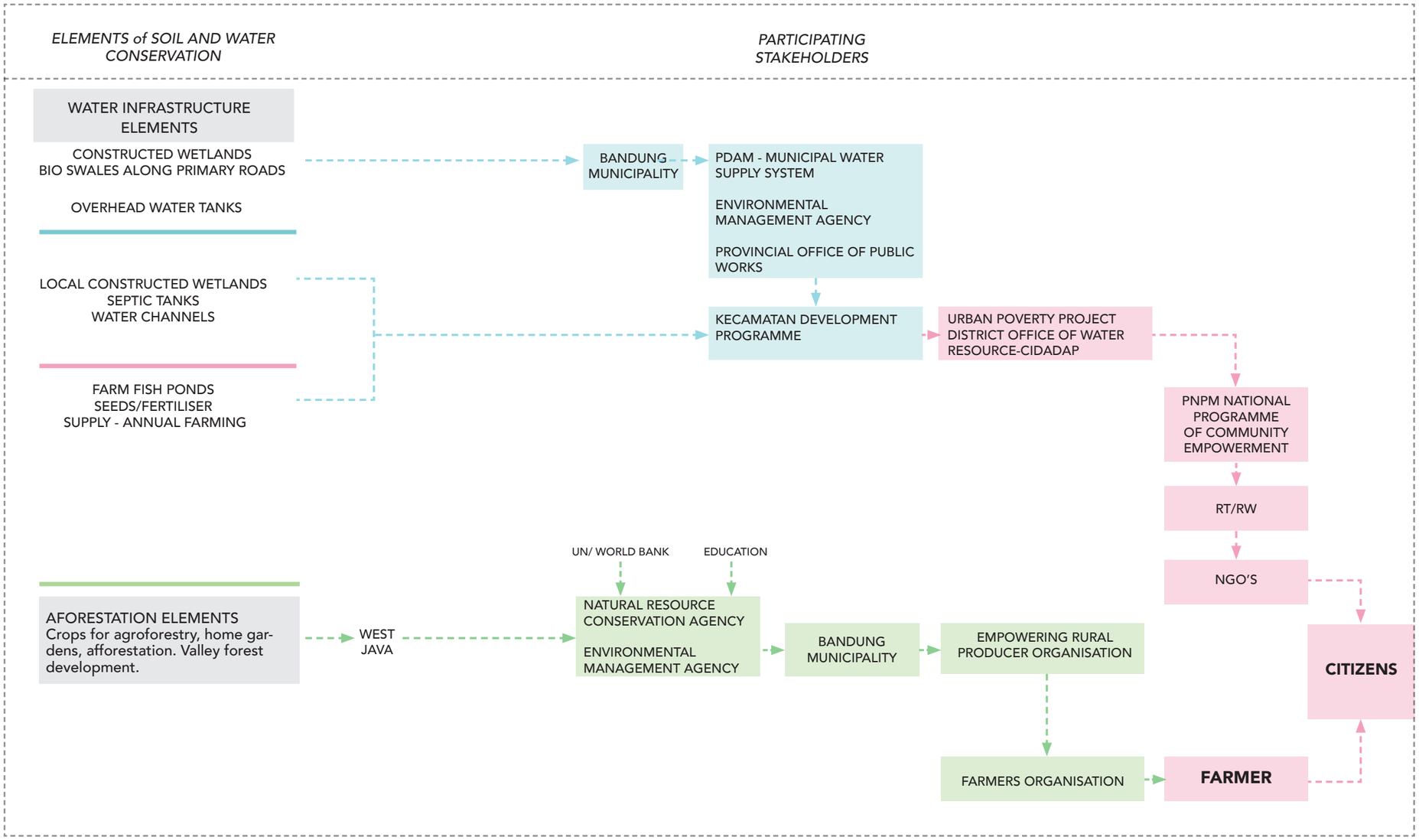


Fig 1.91 Stakeholders involved in implementation of Blue- Green infrastructures
Source : Author

05. 05 Reflection

Project Summary and relevance with wider context
Vulnerable Catchments in developing countries

The fast- expanding, complex urban city of Bandung is plagued by polluted rivers and the deteriorating public health due to lack of water and sanitation facilities is concerning. Due to several technical and social factors, there are many water related issues in the city. These issues contribute to the low performance of the over populated urban fabric. Additionally, uncontrolled, unregulated growth of informal settlements has led to overexploitation of natural resources.
This is resposible for fast denudation in the forest cover around the city.

There is now a limited green cover at the peri- urban area formed of volcanic hilly terrain. Unsusutainable landuse trends in these peri-urban hilly areas are responsible for reduction in sponge function of the catchment. This has led to rise of flood and drought scenario in Bandung city. Additionally, several areas in peri-urban Bandung are now highly prone to landslides. The issues faced here include land degradation, soil degradation and erosion. The urbanized area of Bandung relies on water supply from the rural areas located outside their administrative boundaries in Bandung. For this reason, It is essential to improve the health of the peri urban environments in Bandung. Environmental health and socio- ecological condition can be improved by addressing the issue of water resource management through surface and subsurface strategies. Soil and water conservation measures in such fragile peri-urban areas are implemented. They include water infrastructures at different scales and afforestation strategies. A new blue-green layer facilitates an integrated landuse. Benefits of this landuse system include food sustainability and security, amongst other environmental and ecological benefits.

Additionally, new functions are facilititated by the blue-green layer lke fishing, silviculture, local markets, etc. Ultimately, the soil and water conservation measures helps the flood and drought situation from worsening by improving the health of Dago region in Cikapundung catchment.With this project, I have also addressed the issue of sustainability of informal settlements, and solutions for the same.

In conclusion, bad health of a city's catchment can have a catastrophic effect on the health of the city itself. Unfortunately, there is much less research about landuse in peri-urban areas of Asian cities. Strategies for living with water need great innovation in developing countries where the fast pace of city expansion and population growth cannot keep up with the very slow pace of infrastructure development. However, the health of the city can be improved through a series of relatively cheap solutions and active participation by its citizens. This creates a case study for vulnerable catchments around the world. There is great promise that landscape infrastructural solutions and circular systems can transform the developing world.

Social and Scientific relevance of the work

The societal relevance of this investigation hides both in the social and environmental field. It is expected that the negative consequences of the changing climate(e.g. increase in rainfall) will increase in the future. These consequences will further damage the existing, pressured, dense urban environment. In case of Bandung, deteriorating public health due to lack of water and sanitation facilities is already a major concern. Hence, it is necessary to integrate blue-green layers at the regional and neighborhood scale to adapt to the climate change and improve the overall resilience of the entire city.

If the formal and informal neighborhoods are transformed with soil and water conservation measures, it will lead to a long term environmental security and steadily increase the quality and livability of the living environment,both for its current and future inhabitants.

Awareness about this issue plays an important role, especially in socially and economic vulnerable environments. To involve all stakeholders in a clear manner in this process, this investigation takes place on the regional scale of the city. If the formal and informal neighborhoods are transformed in such a way to cope with the impacts of climate change, it will lead to a long term environmental security and steadily increase the quality and livability of the living environment, both for its current and future inhabitants.Much research has already been done on the fact that our urban environment must adapt to changing circumstances and what the damaging effects could be.

This graduation project would like to add a participatory strategy on the regional-scale. In the economic circumstances of today, investments are decreasing and bottom-up initiatives are desired. But in what way can various actors contribute to an integral strategy? This investigation tried to examine what link could be established between the results of research in the field of landuse change, the field of landscape infrastructure and strategy and in (citizen) participation and how this could be translated to a spatial solution existing out of a strategy and design, to contribute to the body of knowledge.

Relationship between Graduation topic, Studio topic, Master Track

Flowscapes studio addresses relevant sociocultural, ecological and technological issues from the perspective of spatial planning and design. Urbanization, ecological crisis and climate change are complex problems that only can be addressed transdisciplinary and from an international perspective – in particular regarding environmental issues and sustainability. (Nijhuis et al., 2017).
Landscape infrastructure facilitates meaningful interaction of man with his environment. Through the flowscapes studio, it is a valuable opportunity to address the issue of the slow pace of infrastructural development, which is a peculiar problem of many south-east Asian cities.

As a result, the cities face severe stress of lack of resources like water, soil. Hence, it is of utmost necessity to harvest, conserve and reuse them. Circular water stories studio gave technical and innovative isights regarding sustainable use of natural resources. The need for surface water infrastructure, linked to improved water circularity makes this project directly relevant to the Circular Water Stories studio. Implementation of strategies to make room for the rain water, by reducing hard surfaces, building buffers to hold the rain, install biophores to recharge deep aquifers, promote sawah- wetland agriculture and possibly permaculture and aquaculture.

Landscape interventions designed, allow building with nature, and can promote a sustainable method of agri-'culture' through the Agroforestry and Silvipastoral system, which has already been witnessed in some other cities in West Java.

—
The ultimate goal of the studios is to create a better environment for its society and to improve the resilience of a city.

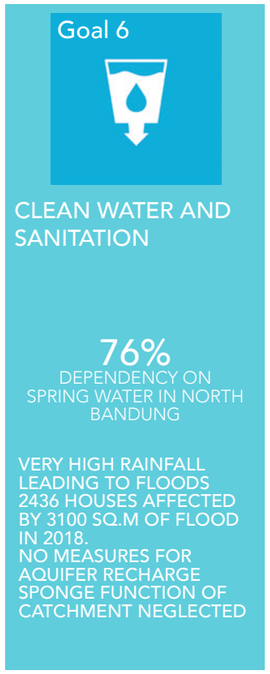
Ethical Issues and Dilemmas

As with any interventionist solutions, there is a cost- both financial, with a complex stakeholder network. While implementing said solutions, care must be taken to minimize human costs as it is easy to neglect them when proposing large scale changes. To affect change, the people affected by the changes must be systematically brought on-board and their needs and anxieties properly addressed.

Sustainable Development Goals

Outlined below are the most relevant SDG'S that are addressed in my project.

Aforestation and integrated landuse measures aim for sustainable food production locally. - Goal 2.
Water harvesting measures aim for clean water and sanitation- Goal 6.
Agroforest community development approach aims for sustainable cities and communites - Goal 11.
Soil and water conservation measures aim to improve the quality of the environment and life on land - Goal 15.



05.06 Application of similar landscape infrastructural strategies in Peri-urban areas of the world.

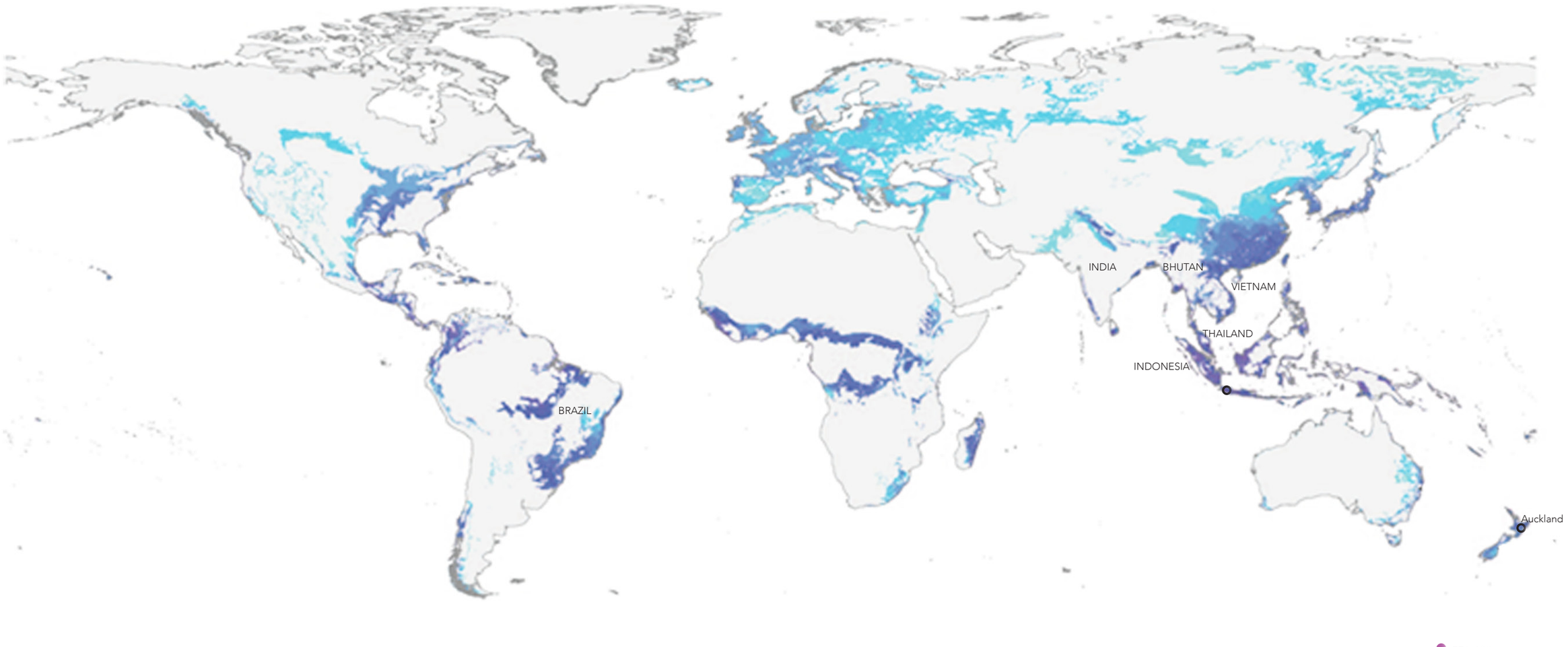
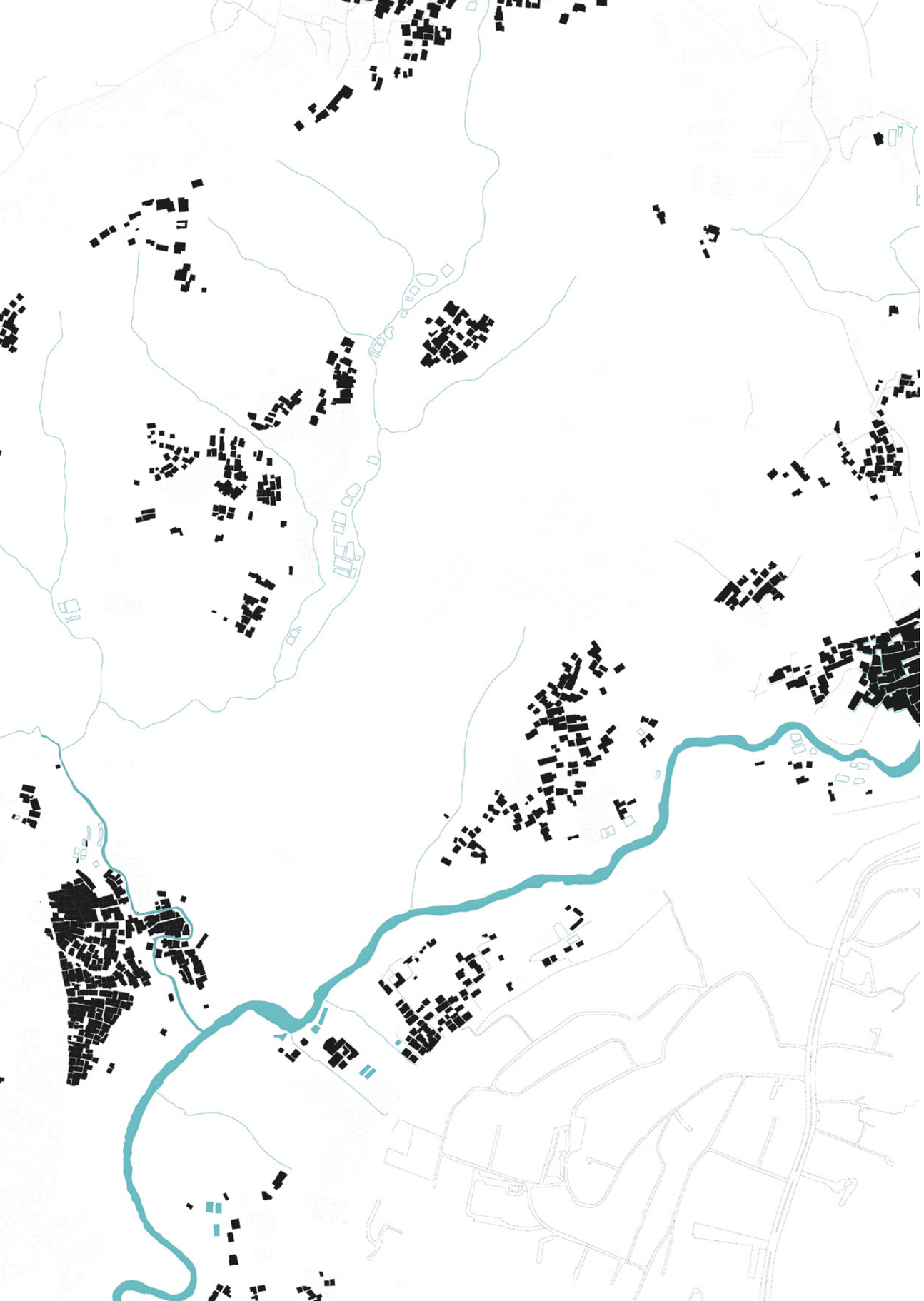


Fig 1.92, Global water yield map. Credits : drawing by Craig Woodward in the study *'Effect of Deforestation on Global wetland Hydrology.'*

Fig. 1.92. shows areas susceptible to hydrological changes due to deforestation in the catchment. The hydrological change is calculated by the amount of Increased Catchment water yield in millimeters as a result of deforestation. Higher milimeter of water discharge can be attriibuted to , high deforestation rate, ranging from 2.3% to 27.4%.

The strategies outlined in this project are applicable in other countries with similar context of tropical climate, rapid urbanisation pressure on the city, and cities dealing with the issues of flood and drought, like Thailand, India, Brazil,



06 GLOSSARY, REFERENCES.

06.01 Glossary

GENERAL TERMINOLOGY :

CIKAPUNDUNG CATCHMENT ZONE - is one of the largest catchments of Java. It comprises of the catchments of the rivers Cikapundung and Citarum, which flow through Bandung, and forms the main drainage system of Bandung city.

PERI URBAN AREA - a specific and non-neutral space, a peri-urban area refers to a transition or interaction zone, where urban and rural activities are juxtaposed, and landscape features are subject to rapid modifications, inducing by human activities (Douglas). A peri-urban area is not only a zone of direct impact experiencing the immediate impacts of land demands from urban growth and pollution, but is also a wider market-related zone of influence that is recognizable in terms of the handling of agricultural and natural resource products, which determine the health of the city. (Simon et al., 2006). When urban grows disorderedly and sprawls to peri-urban area, this process can be referred to as peri-urbanization.

INFORMAL SETTLEMENT - Referred to as Kampungs in Indonesia. It is in area of dense cluster of houses of a more temporary nature, often constructed illegally. In some south east asian countries like Indonesia, the informal settlements on record occupy a large part of the built environment- 52%. According to UN-Habitat, informal settlements are caused by a range of interrelated factors, including population growth and rural-urban migration, lack of affordable housing for the urban poor, weak governance (particularly in the areas of policy, planning, land and urban management resulting in unregulated and unsustainable landuse trends. However, as shown in the project, I believe that there is great scope to improve the conditions of informal settlements through a mix of bottom up strategies for sustainibility of planet, people and profits.

INTEGRATED LANDUSE- Land-use planning is the process of regulating the use of land in an effort to promote more desirable social and environmental outcomes as well as a more efficient use of resources. General aims of integrated landuse include sustainable food production, improved water management, environmental conservation, ecological improvement, etc. Specific goals of the integrated landuse planning within the scope of this project are:
1. Promoting sawah farming instead of dryland farming.
2. Growth of informal settlements in symbiosis with nature.
3. Reduce dependence on agriculture as the main source of income by introducing Agoroforest as a link between forests converted to dryland farms.
4. Sustainable urban developments in the Cikapundung catchment.

RIPARIAN ZONE - A riparian zone or riparian area is the interface between land and a river or stream. (Wikipedia). In the case of this project, the riparian edges have seasonal water flow - from September- April every year. Riparian zones provide many environmental and recreational benefits to the streams, promote spring and ground aquifer recharge. This is facilitated by trees like Eucalyptus, Mahogany, which are deep rooted to promote water infiltration and improve the soil quality. In this project, Riparian zones of 15 m are aforested, to eventually become valley forests, beneficial to the soil and water conservation process, and improves the eco system and quality of the environment.

SECONDARY FOREST - Secondary forests are forests regenerating largely through natural processes after significant removal or disturbance of the original forest vegetation by human or natural causes at a single point in time or over an extended period, and displaying a major difference in forest structure and/or canopy species composition with respect to pristine primary forests. Secondary vegetation is generally unstable, and represents successional stages. (FAO). Hence, Agroforest serves as a stabilising factor for the secondary forest, by greatly helping the soil and water conservation process.

AGROFORESTRY - is a collective term for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence.It can also be defined as a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. In particular, agroforestry is crucial to smallholder farmers and other rural people because it can enhance their food supply, income and health. (FAO). In agroforestry systems there are both ecological and economical interactions between the different components.

COMMUNITY - refers to the people living in one particular area or people who are considered as a unit because of their common interests, social group, or nationality. The graduation project talks about a new Agroforest community to be realised in Dago region, by reorganising the land-use.

SPRING GROUND WATER SUPPLY - A spring is a water resource formed when the side of a hill, a valley bottom or other excavation intersects a flowing body of groundwater at or below the local water table, below which the subsurface material is saturated with water. (UGS). Most of Bandung falls in the shallow- moderate aquifer zone, with moderate to high productivity. The average water table is reached at 120-180 m below ground level. This is accessed by making borewells. However in the hilly terrain of Dago region, the water table level has lowered from 220m to approx 300m in the last 20 years. In Bandung city, 76% of the people depend on spring ground water reserves for water supply for domestic, agriculture and industrial use.

WATER INFRASTRUCTURE RELATED TERMINOLOGY:

SEPTIK TANK - A septic tank is an underground chamber made of concrete, fiberglass, or plastic through which domestic wastewater flows for basic treatment. Settling and anaerobic processes reduce solids and organics, but the treatment efficiency is only moderate. Which is why septic tanks are connected to constructed wetlands, which further purify the water for further domestic use. Septic tank includes a chamber which produces biogas from organic waste and sludge water.

CONSTRUCTED WETLAND - is an artificial wetland (of 7-10m long and 3-5m wide),to treat municipal or industrial wastewater, greywater or stormwater runoff. In this project, plants like Cyperus Palmera, Reet are used to purify the filterered water that it recieves from the Septic Tank. Water purified by this wetland further goes downstream to supply water to the houses at the lower level. This water flow concept design credit: Ooze Architects.

BIOSWALE - Bioswales are linear channels designed with a slope to concentrate and convey stormwater runoff while removing debris and pollution through plant based filters.(Wikipedia) Bioswales can also be beneficial in recharging groundwater, when installed with biophores.

FISH/ FARM PONDS - In case of the project, they are ponds that capture rainwater. They contain local fish, that helps to circulate water and keep it from stagnation. They act as water buffers and filters.

RAIN GARDEN - In this project, is the main water buffer of Dago region. It acts as a soak, planted with grasses and flowering perennials. Seasonal farming of maize, cassava, paddy is carried out along its edge. It is also a recreational attraction for Bandung city.

FARMING RELATED TERMINOLOGY:

SAWAH FARMING -The term sawah refers to a rainfed system of leveled and bunded rice fields. rice field surrounded by bund with inlet and outlet connecting irrigation and drainage canals. It is a traditional Malayo-Indonesian rice farming technique, a type of seasonal farming carried out in the Monsoon season in Indonesia, from September - April. It is a lowland farming system, that helps to stabilise the dryland farms in the upland areas, as greatly enhances the soil and water management of that area, which is essential for sustainable farming.

DRYLAND FARMING - is associated with drylands, areas characterized by a cool wet season followed by a warm dry season. This is a common farming practice in peri- urban Bandung. It involves an annual farming practice, which, in Bandung is dependent on spring ground water resources.

HOME GARDEN- The home garden is traditionally a very important piece of land for rural households of Indonesia. Covering an area of about 500 to 1 500 m2, the structure and function of home gardens are similar throughout the region. The home garden can be defined as a farming system which combines different physical, social and economic functions on the area of land around the family home. Within the typical home garden are social areas for meetings, children's play and gardens for display; economic areas for growing food, medicinal plants and trees and for raising animals and fish; physical areas for storage, living, washing and waste disposal. It is a place for people to live in but it also produces a variety of foods and other things for both home use and income.
The major part of this session covers a home garden survey which concentrates on three important aspects - the home garden as:
- the most direct way of providing daily food;
- a source of income for the purchase of other foods;
- a means to produce non-food items such as medicinal herbs, spices, fuelwood and building materials.
(Source : FAO)

COMMUNITY ORCHARD- is a collection of fruit trees shared by communities and growing in publicly accessible areas like the public greenspaces in the Agroforest Community. It serves as a meeting place for community activities and improves liveability by making the environment pleasant.

PADDY CATTLE FARMING - It is an integrated farming ystem. It is a rice farming system that is integrated with cattle where there is a reciprocal relationship. Rice plants provide straw and bran for cattle as feed and cattle produce feces that is useful for rice plants as organic fertilizer, so that it can increase the production and productivity of rice and cattle and can increase farmers' income.(ResearchGate). Studies suggest that corn integrated in the paddy cattle farming system is environmentally beneficial, and gives higher income to farmers. Maize is a common, nutritious feed for cattle.

06.02 References

McHarg, I. Design with Nature (1995) : New York, USA; John Wiley and Sons Inc.

Ohgaki S.,Takizawas., Herath G., Kataoka Y. G., Hara K., Kathiwada R. N., Moon J., H. Sustainable Groundwater Management in Asian Cities: a summary report of Research on Sustainable Water Management in Asia [Alternative Water Resources and recycle program to strenghten groundwater management in Metropolitan Bandung] : (2006) : Tokyo, Japan, Springer Verlag. Retrieved from : https://www.jstor.org/stable/resrep00865?refreqid=excelsior%3A8189ef1fc7b9d6b2b2f637cf0866e9a0

Nastiti A., Roosmini D., Sudradjat A., (2017), Household Water Supply Strategies in Urban Bandung Indonesia Findings and Implications for Future Water Access Reporting, Journal of Engineering and Technological Sciences, 49(6):811DOI: 10.5614/j.eng.technol.sci.2017.49.6.8, Bandung, Indonesia. Retrieved from :https://www.researchgate.net/publication/322857754_Household_Water_Supply_Strategies_in_Urban_Bandung_Indonesia_Findings_and_Implications_for_Future_Water_Access_Reporting/stats

Paramita B.,(2016), The land-use of Bandung: Its density, Overcrowded area and Public Facility Toward a Compact City; Conference: International Conference on Innovation in Engineering and Vocational Education; Indonesia; DOI: 10.1088/1757-899X/128/1/012034. Retrieved from : https://www.researchgate.net/publication/303486599_The_land-use_of_Bandung_Its_density_Overcrowded_area_and_Public_Facility_Toward_a_Compact_City/citations

Kuntoro A., Putro A., Kusuma M., Natasaputra S.,(2017), The effect of land use change to maximum and minimum discharge in Cikapundung River Basin : Conference: PROCEEDINGS OF THE 3RD INTERNATIONAL CONFERENCE ON CONSTRUCTION AND BUILDING ENGINEERING (ICONBUILD) 2017: Smart Construction Towards Global Challenges; DOI: 10.1063/1.5011621. Retrieved from : https://www.researchgate.net/publication/321077030_The_effect_of_land_use_change_to_maximum_and_minimum_discharge_in_Cikapundung_River_Basin/citations

Wiegandt, E. 2008. Mountains : Sources of Water, Sources of Knowledge : Sion, Switzerland; Springer Press. Retrieved from: https://www.springer.com/gp/book/9781402067471

Younos T., Parece T., (2017). Sustainable Water Management in Urban Environments, Switzerland; Springer Press. Retrieved from : https://www.researchgate.net/publication/303667185_Sustainable_Water_Management_in_Urban_Environments.

Yokohari, M., Murakami, A., Hara, Y., Tsuchiya, K., & (2017). Sustainable Landscape Planning in Selected Urban Regions, Japan : Springer.
Yokohari, M., Murakami, A., Hara, Y., Tsuchiya, K., & Springer Japan KK. (2017). Sustainable Landscape Planning in Selected Urban Regions. Retrieved from : https://www.worldcat.org/title/sustainable-landscape-planning-in-selected-urban-regions/oclc/971237998

Hooimeijer, F. L., & Maring, L. (2018). The significance of the subsurface in urban renewal. Journal of Urbanism. DOI: 10.1080/17549175.2017.1422532. Retrieved from : https://www.tandfonline.com/doi/full/10.1080/17549175.2017.1422532?scroll=top&needAccess=true

Corner, J. Recovering Landscape (1999) : New York, USA, Princeton Architectural press.

Shannon, K. & De Meulder, B. (2013). Water Urbanism : East. Zurich : Park Books.

Kang, B.T., (1996), Sustainable agroforestry systems for the tropics; concepts and examples. IITA research guide, No. 26. Ibadan, Nigeria. Retrieved from : https://cgspace.cgiar.org/bitstream/handle/10568/97286/U96BkKangSustainableNothomNodev.pdf?sequence=1&isAllowed=y

Effendi H., Agaton M. (2015). Land use/land cover change detection in an urban watershed: a case study of upper Citarum Watershed, West Java Province, Indonesia. Retrieved from: https://www.academia.edu/24608925/Land_use_land_cover_change_detection_in_an_urban_watershed_a_case_study_of_upper_Citarum_Watershed_West_Java_Province_Indonesia

Prestasia A. (2018). The Living Estuary: A Study of Developing Landscape Spatial Adaptive Strategies to Integrate the Water, Ecosystem and Anthropo-Dynamics in the Estuary of Volta Delta, Ghana. Retrieved from : http://resolver.tudelft.nl/uuid:10b4bf06-1842-436f-939e-8e325f1cb96c

Paramita, B. (2016). The land-use of Bandung, Its density, Overcrowded area and Public Facility Toward a Compact City (Vol. 128). Retrieved from: https://www.researchgate.net/publication/303486599_The_land-use_of_Bandung_Its_density_Overcrowded_area_and_Public_Facility_Toward_a_Compact_City/citation/download

Mukhlis, M., Noer, M., Nofialdi N., & Mahdi, M. (2018). The Integrated Farming System of Crop and Livestock: A Review of Rice and Cattle Integration Farming. International Journal of Sciences: Basic and Applied Research (IJSBAR). 42. 68-82. Retrieved from : https://www.researchgate.net/publication/328841067_The_Integrated_Farming_System_of_Crop_and_Livestock_A_Review_of_Rice_and_Cattle_Integration_Farming.

Stokes, A., Spanos, I., Norris, J., Cammeraat L.H. (2007). Eco- and Ground Bio-Engineering: The Use of Vegetation to Improve Slope Stability. Developments in Plant and Soil Sciences vol. 103, Dordrecht; Springer Press. Retrieved from : https://www.researchgate.net/publication/273136802_Eco-_and_Ground_Bio-Engineering_The_Use_of_Vegetation_to_Improve_Slope_Stability_Developments_in_Plant_and_Soil_Sciences_vol_103_Springer_Dordrecht_pp_460_Stokes_A_Spanos_I_Norris_J_Cammeraat_LH_Eds_2

Damayanti, E., Prasetyo, L., Kartodiharjo, H., Purbawiyatna, A. (2013). Transitions to Sustainable Forest Management and Rehabilitation in the Asia Pacific Region-Indonesia Country Report. Retrieved from : https://www.researchgate.net/publication/322265601_Transitions_to_Sustainable_Forest_Management_and_Rehabilitation_in_the_Asia_Pacific_Region-Indonesia_Country_Report/citation/download

Sharma A., Gardner T., Don Begbie. (2019).Approaches to Water Sensitive Urban Design,Chapter 2 - Water Sensitive Urban Design Approaches and Their Description. Australia: Woodhead Publishing.
Retrieved from: https://doi.org/10.3390/w8070272

S. Suhari, M. Siebenhüner.(1993). Environmental geology for land use and regional planning in the Bandung Basin, West Java, Indonesia, Journal of Southeast Asian Earth Sciences, Volume 8. Retrieved from : https://doi.org/10.1016/0743-9547(93)90053-R.

Ekhuemelo, D. (2016). Importance of forest and trees in sustaining water supply and rainfall. Nigeria journal of education, health and technology research Njehetr. Retrieved from: https://www.researchgate.net/publication/310458060

Republic of Indonesia (1984). Upland Agriculture and Conservation Project. DOI: 4501A:6/13/845291-IND. U.S. Agency of Internation Development.

Frenken, K. (2012). Irrigation in Southern and Eastern Asia in figures - AQUASTAT Survey 2011. Food and Agriculture Organization of the United Nations (FAO) Publishing. Retrieved from: https://www.researchgate.net/publication/276058427_Irrigation_in_Southern_and_Eastern_Asia_in_figures_-_AQUASTAT_Survey_2011

Wangsaatmaja S., Sutadian A., Prasetiati M., A Review of Groundwater Issues in the Bandung Basin, Indonesia: Management and Recommendations, IRES Vol.6 No.2. Retrieved from : https://iges.or.jp/en/pub/review-groundwater-issues-bandung-basin

Hal V. A., A Merger of Interests (in the Existing Housing Stock). (2011) Retrieved from: http://misbe2011.fyper.com/uploads/File/MISBE%20Keynote_vanHal.pdf

Nijhuis, Steffen. (2013). Landscape as Infrastructure. DOI:10.13140/RG.2.1.1446.3126. Retrieved from: https://www.researchgate.net/publication/287331409.

North A., (2013). Operative Landscapes. Birkhauser Publication.

Nijhuis, Steffen. (2013). Urban Landscape Infrastructure - Designing Operative Landscape structures for the Built environment. DOI:10.13140/RG.2.1.1446.3126. Retrieved from: https://www.researchgate.net/publication/287330653

Skinner, J. (2009). (Rep.). International Institute for Environment and Development. Retrieved from http://www.jstor.org/stable/resrep01430

Lohuizen, J. (2014). Climate adaptive solutions for the neighbourhood. Retrieved from : http://resolver.tudelft.nl/uuid:5c3a35e0-365a-4e71-8148-03909a83bbbd

Erina R., Wiyono, E. (2012). Domestic Wastewater Treatment using Constructed Wetland as a Development Strategy of Sustainable Residential Solution. Retrieved from : http://www.ipcbee.com/vol33/022-ICEEB2012-B062.pdf.

Elzein, Z., Abdou A., Abd El Gawad, I. Constructed Wetlands as a Sustainable Wastewater Treatment Method in Communities. Retrieved from: https://doi.org/10.1016/j.proenv.2016.04.053.

Rani, Medria & Lange, E. & Cameron, R. & Schroth, Olaf. (2018). Future Development Scenarios for Adaptation to Climate Change in the Ci Kapundung Upper Water Catchment Area, Bandung Basin, Indonesia. Retrieved from: https://www.researchgate.net/publication/324890232

Shinichiro O., Satoshi T., Yatsuka K,. et.al. (2007)Sustainable Groundwater Management in Asian Cities. Retrieved from : https://www.jstor.org/stable/resrep00787

Sugandi, Dede. (2018). Reducing runoff volume by increasing rainfall infiltration in the inflitration wells in bandung basin. DOI: 10.31227/osf.io/s8qvu. Retrieved from : https://www.researchgate.net/publication/326143345_REDUCING_RUNOFF_VOLUME_BY_INCREASING_RAINFALL_INFILTRATION_IN_THE_INFLITRATION_WELLS_IN_BANDUNG_BASIN

Adipurnomo, S. (2018). Pray for Rain. Retrieved from : http://resolver.tudelft.nl/uuid:916c8b7e-2308-4e16-a3cf-c45215bf213d.

Sugandi, D. (2018). Reducing runoff volume by increasing rainfall infiltration in the inflitration wells in bandung basin. DOI: 10.31227/osf.io/s8qvu. Retrieved from : https://www.researchgate.net/publication/326143345_REDUCING_RUNOFF_VOLUME_BY_INCREASING_RAINFALL_INFILTRATION_IN_THE_INFLITRATION_WELLS_IN_BANDUNG_BASIN

Wansleeben, K. (2016). Spatial consequences of circular water systems. Retrieved from: http://resolver.tudelft.nl/uuid:db96ae81-cef5-4956-b961-cfb319b6905d

Marten, G.Traditional Agroforestry in West Java: The Pekarangan (Homegarden) and Kebun..Talun (Annual.. Perennial Rotation) Cropping Systems. Reprinted from Gerald G. Marten (1986), Traditional Agriculture in Southeast Asia: A Human Ecology Perspective, Westview Press (Boulder, Colorado). Retrieved from: http://gerrymarten.com/traditional-agriculture/pdfs/Traditional-Agriculture-chapter-06.pdf

Christanty, L., Abdoellah, O., Iskandar, J., et. al. (1986). Traditional agroforestry in West Java: the Pekarangan (homegarden) and Kebun-Talun (annual-perennial rotation) cropping systems.

Adiningsih, J.Sri., Karama S. A sustainable upland farming system for Indonesia.

Reference Projects:
1. Kampung Naga, Indonesia - Self study and site visit.
Drawings Credit : Boomi Kim, as part of the Research on Circular Water Stories Studio.

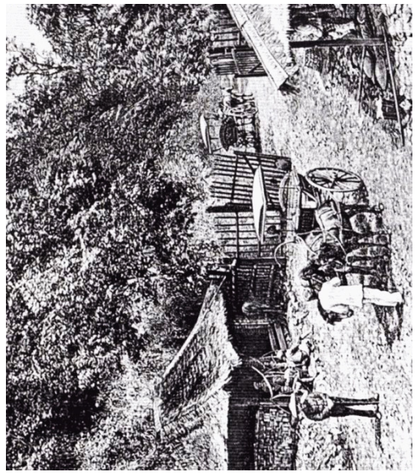
2. Agua Carioca, Brazil - Desk study and Analysis.
Drawings Credit : OOZE Architects. Images of Agua Carioca Project retrieved from : http://ooze.eu.com/en/urban_strategy/gua_carioca_rio_de_janeiro/.

3. Subak System, Indonesia- Self study and site visit.
Drawings and content credit : Author.

4. Schakelmodel Cascade System.
Drawings and content credit : Sybrand Tyangii.

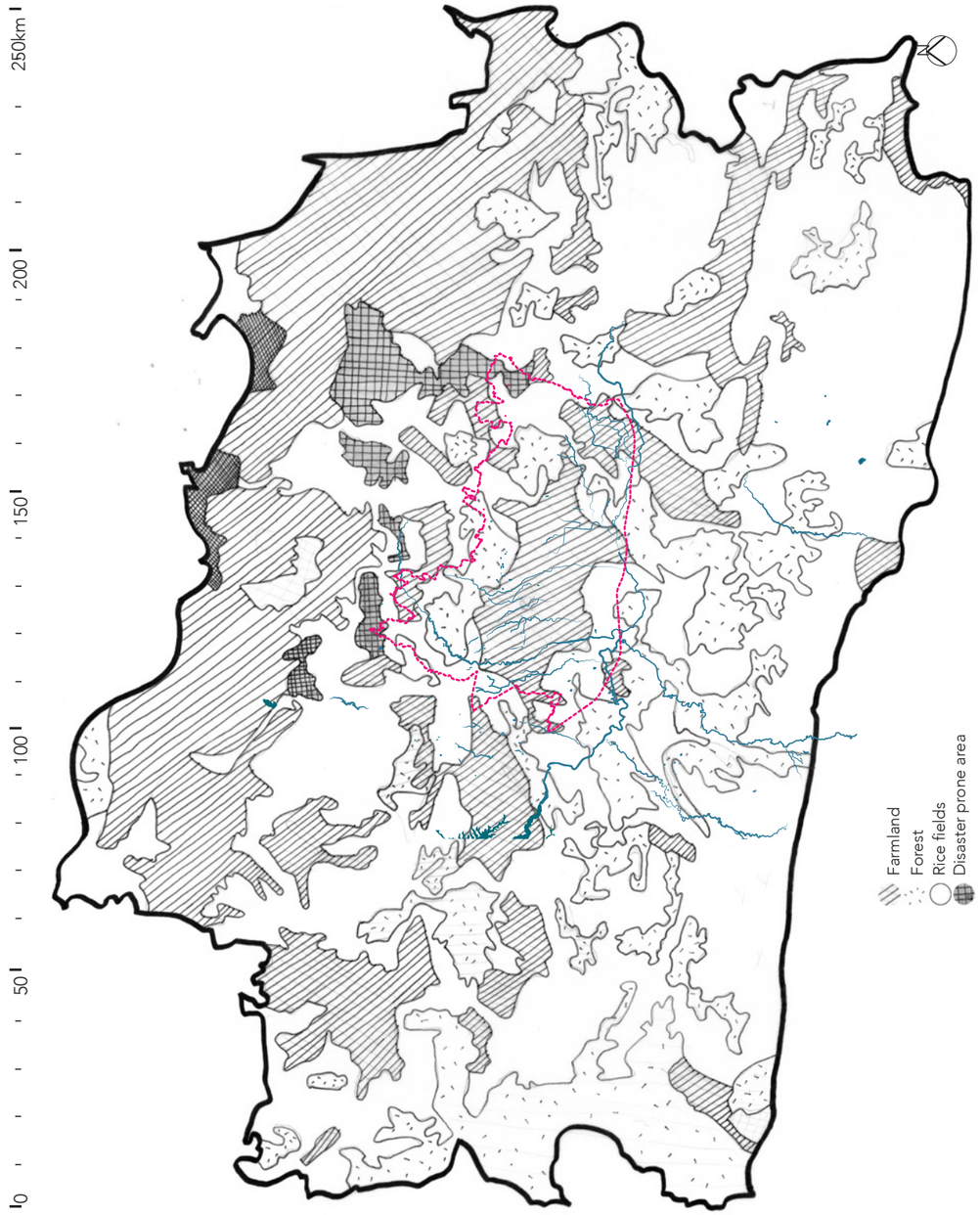
07 ANNEXURE

Analysis of Bandung Metropolitan area landscape features



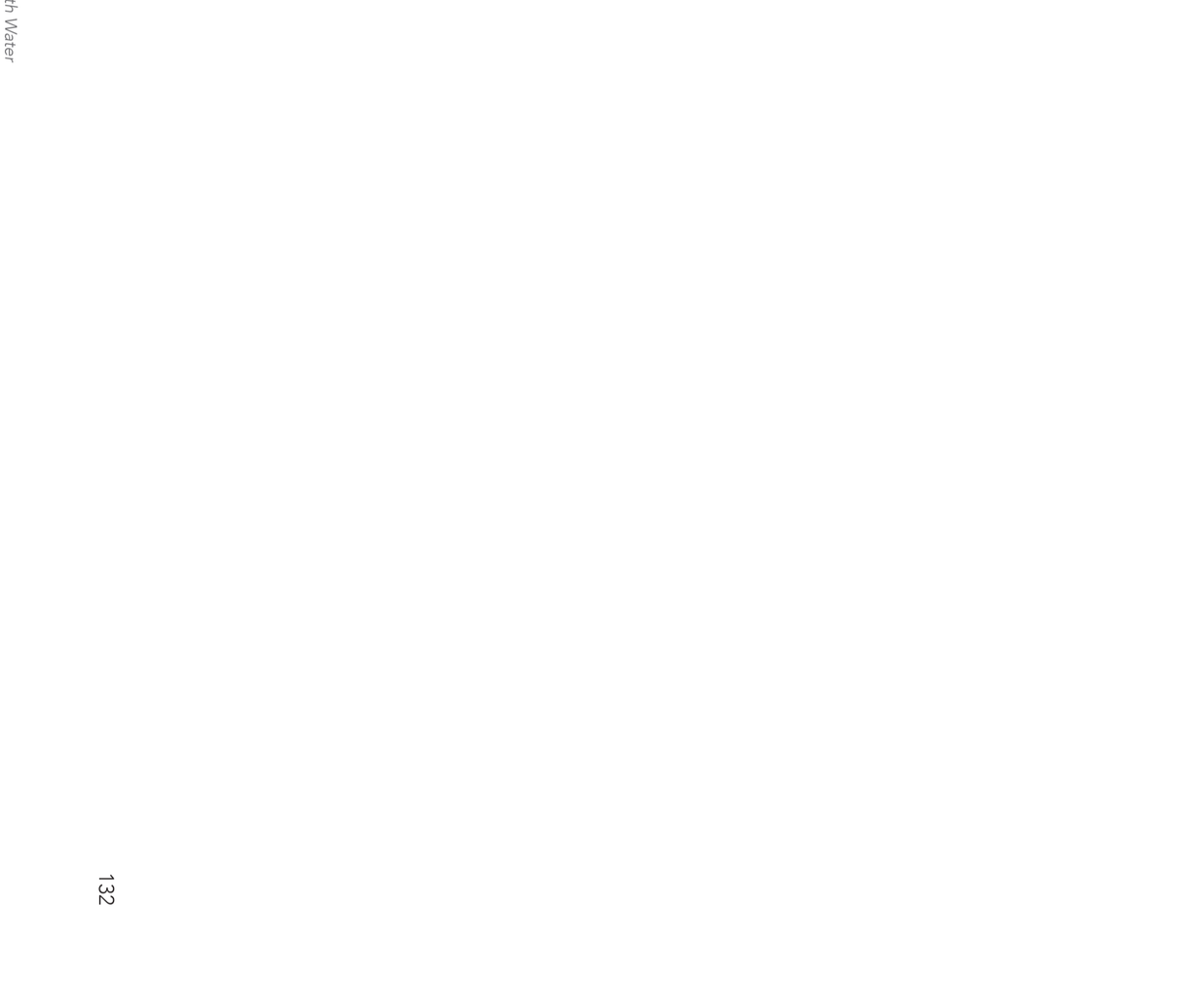
Change in the landscape of the city.

Bandung changes from an idyllic town into a dense metropolitan area.



Landuse in 1950

Landuse in 2004



Bandung changes from an idyllic town into a dense metropolitan area.

Soil types in and around Bandung city

Volcanoes form the spine of Java. They formed the landscape and gave the island it's fertility. The numerous eruptions caused fertile ashes to spread over the island, as well as the lava. This process caused the soil to renew over and over again. Three types of soil are found in Bandung peri- urban area, and they require different measures to improve/ retain their fertility. They are:

-Latosols are soils are high in iron oxide, it relies on rainforest to maintain its fertility. Top ayer is called Podsol.

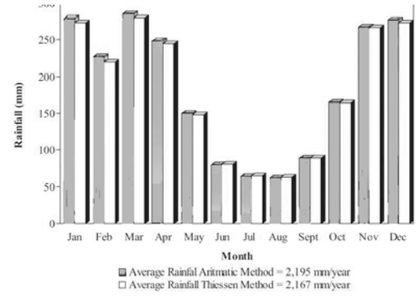
-Andosols are found in volcanic areas, fertile and support intensive cropping.

-Regosols are weakly developed mineral soils, best left under the forest, as they do not regenrate quickly.

Rainfall pattern in and around Bandung city

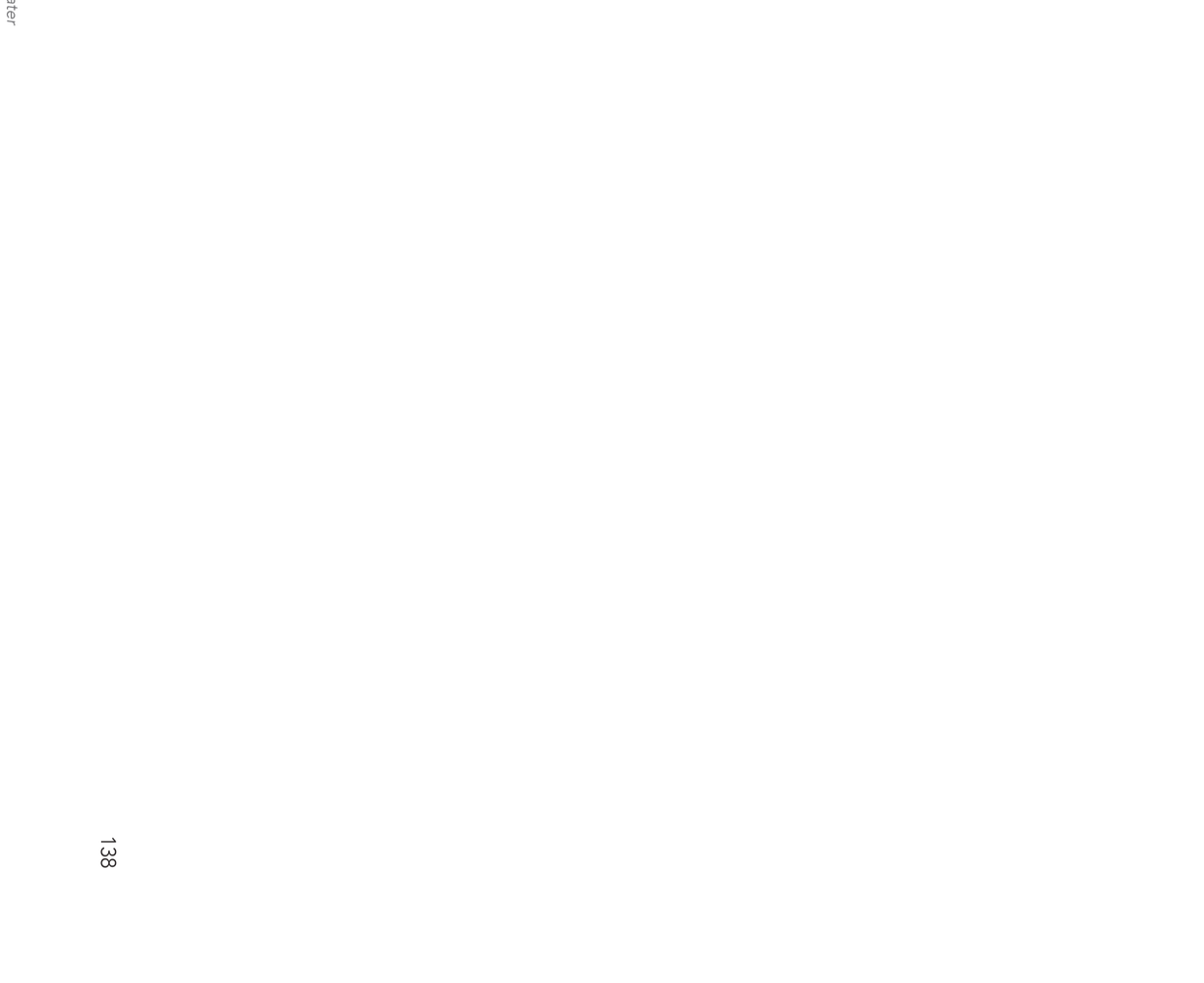
-Mean annual rainfall in Bandung Basin : 1000mm/ year in Central Bandung.
-North Bandung : 3500 mm/ year and 2700mm/year in the South.

Surface run-off from Northern Bandung (800-1100mm high) collects in Bandung Basin which is at 670m height. Recent changes in landuse- basically change of forest cover to agricultural land or hard surface in real estate development has led to a large amount of surface water run- off. With active participation of the population in rain water infiltration efforts, runoff will reduce, thus minimizing the risk of flooding. It will also provide for drinking water, which is a pressing issue in the city.



Comparison rainfall monthly average in Bandung basin
Source: Raw Data coming from Metrological and Geophysics Bureau, 1950-2005

Types of aquifers in and around Bandung city



A large part of the population of the Bandung Basin derives water, for daily purposes, from private or local sources such as dug wells, shallow water boreholes, and small springs. At present, the Municipal Water Work Enterprise- PDAM, because of limitation of capacity and distribution networks, is able to supply only a limited quantity of water for the people.

The groundwater aquifers of the Bandung basin can be divided into two major groups, according to their depth and thickenss, namely shallow and deep aquifers. The shallow aquifer system appears at the depth between 10 and 40m. It distributes throughout the Bandung plain and lower slopes of mountainous areas.
Its productivity ranges from low to high. Some aquifers are discontinuouslaterally. The deep aquifer system is at the depth between 40 and 250 m. It occurs mostly in the center of the plain,with less lateral extension compared to the shallower aquifers.

The shallow aquifers in the major part of the Bandung Basin are highly vulnerable against contamination due both to domestic sewage and untreated industrial waste water.

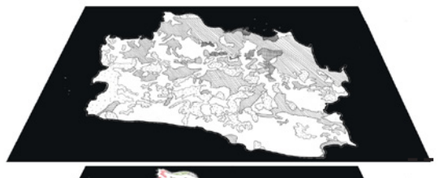
Inference of existing landscape value mapping

This analysis takes into account the values of rain and soil that could be integrated into the design.

This framework of Design with Nature deals with identification of landscape 'values', their guidelines for ecologically sensitive planning. It aims to *Improve man's relationship with the environment - and make it a more interactive one.*

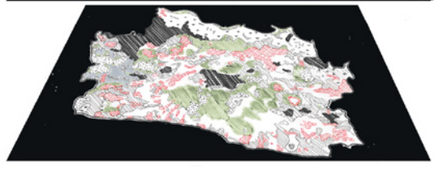
Guidelines on regional planning using natural systems with respect to:

_traditional environmental practices
_land suitability model
_scientific insight on future trends



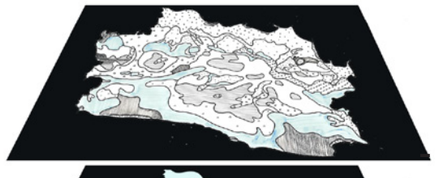
Land Use Map - 1960 - an insight into site specific landscape traditions.

-predominantly agrarian society: mixed type, wetland + dry
-forests - teak forests, coniferous forests
-colonial plantations, community ownership



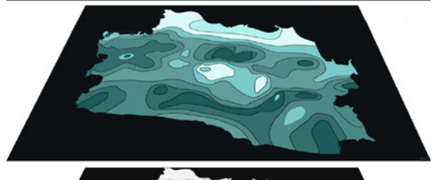
Land Use Map - 1990 - an insight into urban trends relevant to landscape processes .

-large scale deforestation resulting in landslide
-fragmented scenario of agriculture and urban expansion



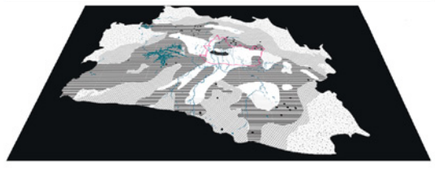
Soil Value Map - understand the qualities of soil

-planning in accordance with which soils need to be conserved, which have high and low regenration values.



Rain Value Map - rainwater management and harvesting as at asset to drought and flood ridden Bandung .

-1500-2000 mm rainfall withinin Bandung city
-above 2000 mm rainfall in the mountainour terrain of Bandung



Aquifer Value Map - essential to recharge aquifer, given the current trend of water abstraction

-In the hilly terrain of North Bandung Shallow and deep aquifers are present and there is scope to recharge them.