Eco Moyo Education Centre

Strategic plan

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Eco Moyo

INGENIØRER UTEN GRENSER

ARKITEKTER UTEN GRENSER
AUG
NORGE
ARCHITECTURE SANS FRONTIÈRES

Table of content

Eco = Ecology

(Organisms relation to the environment)

Moyo = Heart (Swahili)

1. Introduction

The strategic plan

Photo previous page: Lindsay Sanner

Eco Moyo Education Norway (Eco Moyo) has cooperated with Architects Without Borders (AWB) and Engineers Without Borders (EWB), hereon called the project group, in defining strategies for the development of Eco Moyo Education Centre in Ezamoyo, Kenya. The project group has prepared a document regarding overall long-term goals and desires for the school.

A strategic plan is needed due to the school's rapid growth. Student enrollment went up from 20 in 2017) to 230 in 2022. This makes it necessary to compile a document that clearly communicates the future needs for the sustainable development of the school grounds.

Our strategic plan includes land use recommendations linked to school functions, landscape measures, school gardens and farmland. Future infrastructure measures such as water supply, energy supply, and surface water management are defined. The plan also explains in short terms the necessary expenses and financial needs of Eco Moyo.

The project group's goal is that the strategic plan gives an overview of the schools plans and needs in an easy and understandable way, inspiring future contributors and stakeholders to support and engage in our collaborative effort to further develop the school.

Socioeconomic situation

Eco Moyo Education Centre is a private elementary school located on the east coast of Kenya, a country in eastern Africa. Kenya is bordered by Tanzania in the south, Uganda in the west, South-Sudan in the northwest, Ethiopia in the north, Somalia in the northeast and the Indian Ocean in the southeast.

Kenya has a fast-growing population of 50 million people. Kiswahili and English are the official languages, but there are 42 tribes with their own unique language. About 83 percent of the population are Christians, approximately 11 percent are Muslims and less than 1 percent are Hindus.

The school is in Kilifi, which is one of the poorest regions in the country with a population of just over a million people. The unemployment rate is high, and the few available jobs are largely connected to tourism and fishing. 70 percent of the people live below the poverty line. When it comes to education, income, and occupation there are huge inequalities in access to resources, plus issues related to privilege, power, and control in this rural community.

There are 252 public elementary schools and 64 public high schools in the region. Also 81 private elementary schools, 5 private high schools and 2 private international schools. There are not enough publicly funded schools of sufficient quality and many of the lowest income families cannot afford the cost of books, uniforms, and food.

Ill.: Afrika - Kenya - Kilifi

How did Eco Moyo start?

Eco Moyo Education Centre was founded as a Norwegian-owned association in 2013 and became a CBO (Community Based Organization) in Kenya in 2014. Lindsay Sanner, the founder, worked as a volunteer in an orphanage in Mombasa the previous year. Meeting children without a family made a strong impression on her and she decided to dedicate her time to helping them with their education. After several attempts to cooperate with both the orphanage and local networks, it was obvious that corruption was difficult to avoid unless she established a professional accountability system separate from the institutional

fraud that is normal in Kenya. Corruption has a disproportionate impact on the poor and most vulnerable, and the highest standards of integrity are needed to help the powerless.

Shocked by the quality of the public schools and the enrollment cost for private schools, Lindsay eventually decided to start her own school in Mombasa. At the same time, she took a course in permaculture and natural construction techniques. The dream of building a sustainable free school with a green profile for kids from low-income families began to take shape.

With the help of family and friends, she purchased property in a rural village a few hours north of Mombasa and found partners in Norway to finance the first two classrooms on the plot. Twenty of the students from Mombasa were invited

Founder Lindsay Sanner with students
Photo: Lindsay Sanner

to live on the new school premises. Gradually local children from the Dzunguni area that surrounds the school have become the main student body. A very poor area, most children live without electricity and running water. The school's amenities give children clean drinking water, shelter, and a safe environment for learning. The students are given uniforms and meals along with all the necessary tools for classes: books, writing materials and access to computers.

The school has a staff accommodation on the premises. In addition to the teachers, the school hires additional staff to ensure good maintenance routines, food preparation, agricultural initiatives, and guard patrols during the night.

Eco Moyo´s goal is to give the students a solid foundation in life so that they can find work and make a living as adults. The result is a better future for the students and their families, and a generational shift out of poverty.

Organizing the project

The strategic plan was initiated by Lindsay Sanner from Eco Moyo in cooperation with AWB (Architects Without Borders - Norway) during the spring of 2019. AWB the was the project leader, organizing both the work and resource groups. The project was split into two different phases. Phase one created an overview of the school's needs, challenges, and frameworks. Phase two addressed land use and assessments connected to the school's infrastructure. EWB (Engineers without Borders – Norway) participated with professionals competent in architecture and landscape design throughout the process. Lindsay Sanner worked closely with AWB and EWB in the development of the strategic plan and was an integral member of the working group.

Use of the strategic plan

The plan provides a status on the existing situation and then points towards future development possibilities. Chapter 2 explains the starting point for the plan and lists long-term needs. Chapter 3 describes the underlying vision for the physical development of the Eco Moyo property. Chapter 4 contains an overview of recommendations for future area usage, buildings, and infrastructure. Several of the recommendations must be verified and designed in more in-depth follow-up plans. Chapter 5 contains a prioritized list of all the measures and their respective dependencies to different parts of the plan. Chapter 6 includes budget and financial plans.

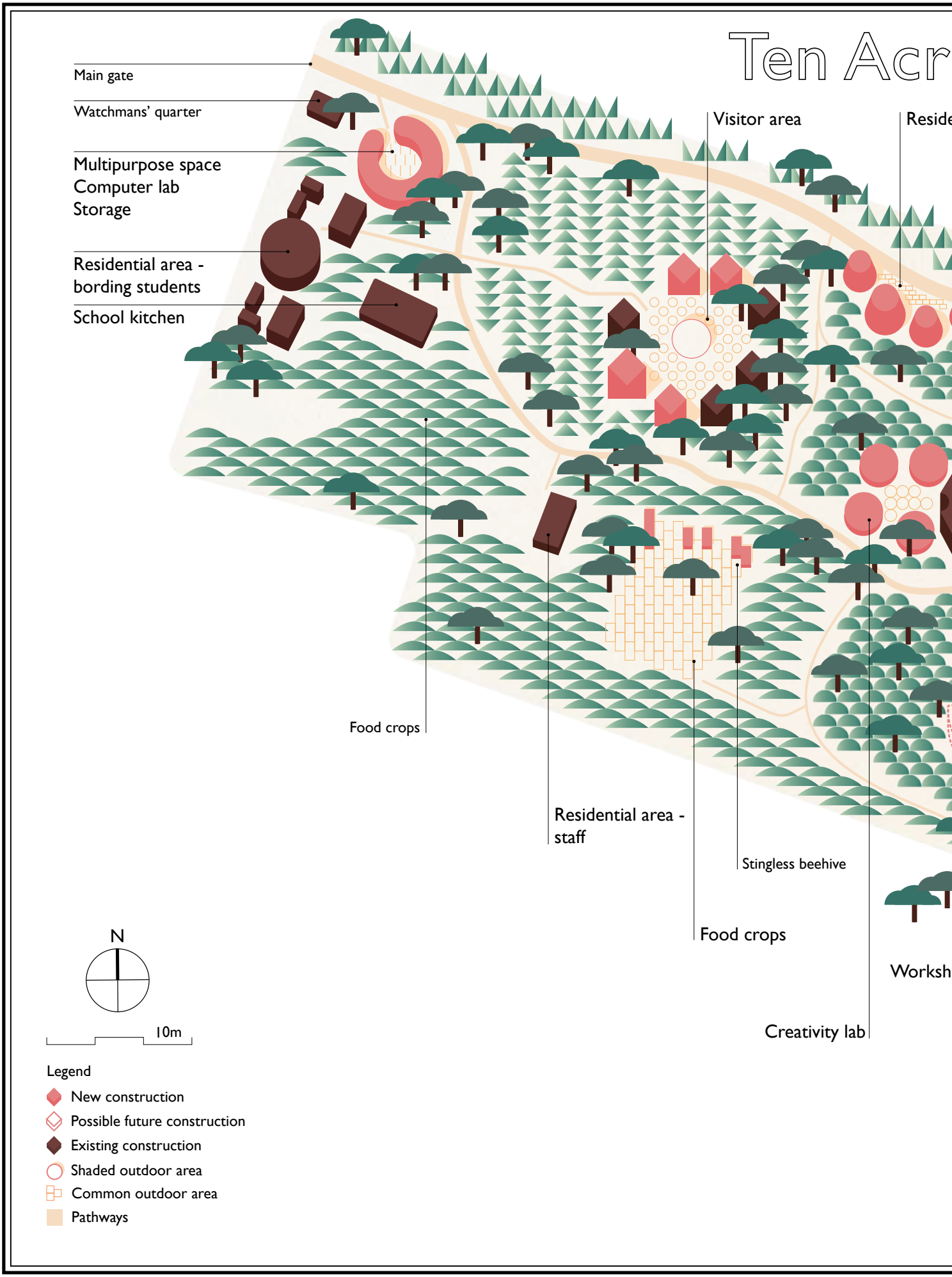
The most important task of the project group is to observe, prioritize, and to make a solid plan to solve the needs and problems the school faces. Some building solutions are easy to implement. Others demand a test-phase to verify if the recommended solution is suitable for the tropical climate in Kenya. Some challenges demand a larger financial plan and process to solve. It is the project group's goal to make a plan that can be used as an encyclopedia and a guide for the further development of the school.

Photo: Lindsay Sanner

Eco is short for Ecology (the scientific study of interactions among organisms and their environment). Moyo means heart in Swahili.

The name Eco Moyo therefore, refers to showing love for our environment.

- Lindsay Sander, Eco Moyo founder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Main gate
Watchmans' quarter
Multipurpose space
Computer lab
Storage
Residential area - bording students
School kitchen
Visitor area
Reside
Food crops
Residential area - staff
Stingless beehive
Food crops
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Creativity lab
N
10m
Legend
New construction
Possible future construction
Existing construction
Shaded outdoor area
Common outdoor area
Pathways

e Wood


ential area
Assembly area
Staff room
Office
Numeracy and Literacy lab
Teachers' housing
Lower primary
Kindergarten
Food crops
Borehole
School toilets
Football field
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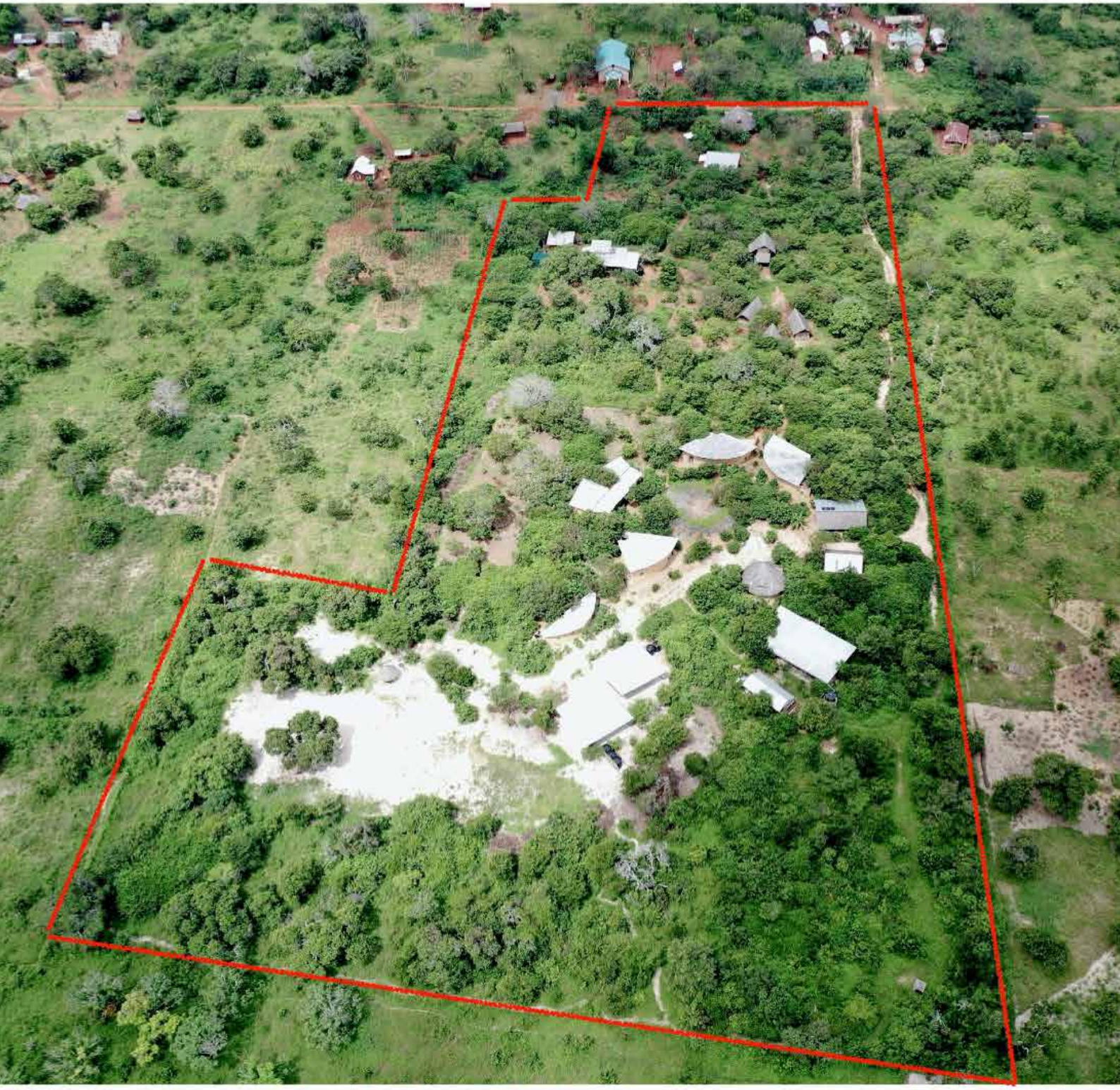
Storage and pavilion
Volleyball field
Multipurpose hall



Drone photo from 2019: Lindsay Sanner

2. Todays situation and future needs

A SWOT-analyses of the strengths, weaknesses, opportunities, and threats for Eco Moyo Education Centre is shown below. Lindsay Sanner has analyzed and synthesized findings about today's situation and future needs relevant to the strategic plan. A detailed description is found in chapter 3 and 4.

SWOT

Strengths

Campus

The school has a wonderful location in a rural environment with clean air, rich vegetation, and the Arabuko Sokoke National Reserve close by. Beautiful and quiet surroundings make a good framework for children's education. The school property is large and has plenty of space for the development of new building clusters and agricultural initiatives.

Human resources in four countries

The Kenyan administration consists of hardworking and responsible people intevested in the school's development and committed to realizing the school's vision of improving the conditions of poor children.

The Norwegian foundation has a competent and active board of directors. Many private donors and other foundations support Eco Moyo.

In USA and Netherland, groups of family and friends are helping to raise funds for running costs.

A supportive local society in Kenya

The local society appreciates having the school in the village and makes sure that students and teachers are safe and well taken care of. The leaders of the village and the elders appreciate the work that the school does.

A pioneering school

The school consists of numerous buildings with an aesthetic architecture and sustainable profile. In addition to providing education and shelter, they reflect the school's identity and ambitious vision.

Photo: Lindsay Sanner

Weeknesses

Unpredictable economic situation

Today, the school has a narrow financial buffer and lacks longtime sponsors and investors. There is no 'plan B' if sponsorship decreases.

Underutilizing digital marketing potential

The school could profitably promote ongoing work more often on social media to gain more donors and engagement in a variety of projects.

Photo: Lindsay Sanner

Fragile operational infrastructure

There is no plan for who will run the school if something were to happen to operational manager and founder Lindsay Sanner.

Sustaining teaching staff

It's difficult to keep a stable educational staff, especially for the higher grade levels, as many of these teachers wish to work for the Kenyan state. Eco Moyo cannot compete with incentives such as state-financed loans. In consequence, Eco Moyo functions a training arena for qualified staff whom might only stay for a few years.

Opportunities

Volunteer work

Visitors show interest in paying for their stay at the school's visitor's center while they volunteer at the school.

Exchange program

Students, both in Kenya and abroad, can stay at the school's visitors center when the school is otherwise closed during vacations. Exchange programs and cultural development projects can be organized.

Basecamp

During the school vacation, the visitor's area at Eco Moyo can be used as a basecamp for tourists who would like to visit the neighboring nature reserves. The nature reserves are known for their bird population and attract many birdwatchers.

Building a bigger network

There are a variety of projects along the Kenyan coast, but little exchange between them. Eco Moyo Education Centre could become an inter-disciplinary

melting pot for education, agriculture, architecture, and engineer projects.

Strengthening women's and girl's rights
The school can offer training in different skills to better local society. For example, initiating projects that combat the unemployment rate among youth, reading and writing education for adults or skills-training for women.

Practical education in sales and marketing
The school is planning to establish a business where the students learn to develop products for sale. This could be a farmers market selling produce from the school plot such as vegetables, fruit, herbs and mushrooms. Also, sale of crafts from the school workshops. The project will both support the school economically and teach the students how to create an income.

Practical skills can become a profession.
Photo: Lindsay Sanner

Threats

Water supply
The school greatly depends on municipal water for drinking, but the municipal water is unpredictable and can occasionally be absent. A well was drilled in 2016, but unfortunately the water was too salty to use. A large water storage capacity for the drought periods is needed.

The climate crisis and water management.
98 % of the agriculture in Kenya depends on rainwater and the rainfall pattern is becoming increasingly unpredictable. In addition, deforestration has resulted in large scale erosions on the earth's surface; this pollutes the water, increase evaporation, and lowers the groundwater capacity.

Adolescent pregnancy
Health and sex education are particularly important topics, but difficult to implement since the Ministry of Education has strict rules for what is allowed to teach.

Building plan for the property

Eco Moyo owns a large property of 10 acres in rural, quiet surroundings. There are many opportunities for the further development of the school. The school has eight classrooms, a dormitory for 20 boarding students, cabins for 15 guests and staff housing. Furthermore, there is a school kitchen, an office, teacher's lounge, storage room and sanitary functions. A larger area for games and sports has been created on the southeastern part of the plot. Building structures are spread over the whole property. Larger and smaller clusters are organized

around pre-existing clearings and separated by relatively dense vegetation.

In the future, Eco Moyo wishes to focus the teaching more on creative work, practical knowledge, and digital skills. Furthermore, the school has an ambition to increase the students' awareness and knowledge of the environment and sustainability.

The Architecture of Eco Moyo
The Architecture of Eco Moyo is based on local building customs and materials, designed in collaboration with students from the Oslo School of Architecture and Design and NTNU in Trondheim, as well as architectural offices and Architects without Borders in Norway. Several of the buildings are presented in Archdaily, a digital magazine profiling outstanding architecture all over the world. Adaptation to the local climate is an important premise for building design. The architecture on the site has an playful expression with open structures for light and air, and sufficient shielding from sun and rain. The strong heat requires adequate ventilation in walls and ceilings, preferably with a lifted roof. Each building must have large overhanging roof surfaces to protect the room during the rainy season and stop water from entering the building's many openings. The roof surfaces are used for collection of rainwater in large tanks.

Building materials are both heavy and simultaneously light. A heavy base is built of coral stone to support solid strong walls; coral is a local and efficient material. For light walls, both sisal sticks and palm leaves are used. Roofs are either made using corrugated steel sheets or palm leaves carried by Casuarina poles (local wood) or other timber.

The use of color in the architecture is expressive. The playful color palette emphasizes the creative school environment and Eco Moyo as a place for children.

To summarize, the school's future needs regarding structures and their organization:

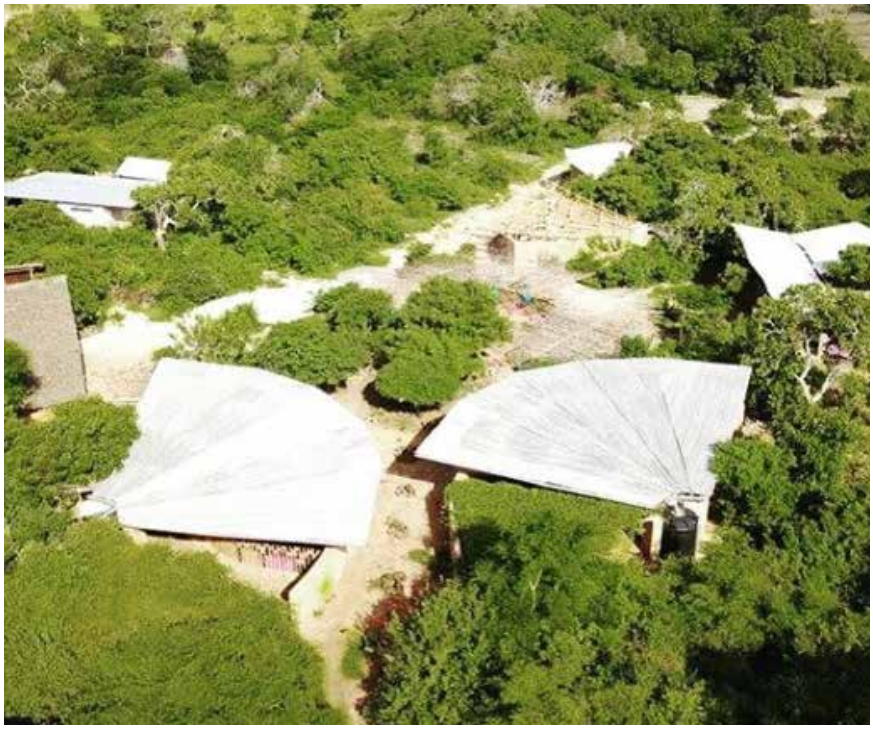
- A guideline for the organization of structures that will ensure financial flexibility and room for growth.
- A configuration of the structures that will conserve existing forest and vegetation.
- Facilities that can host computer classes, and practical subjects. More space for the visitors and teachers, and space for meetings with parents, and the village residents.

Climate change, vegetation, and agriculture

Nature is at the heart of Eco Moyo providing beautiful surroundings, shade, and food. The site consists of 10 acres of lushness close to a nature reserve and the coast. The coastal climate of Kilifi is warm and humid, with big differences between the rainy and dry seasons. But the climate is changing. Widespread precipitation and longer dry periods are changing the nature and the landscape in and around Eco Moyo. Droughts threaten the replenishment of groundwater reservoirs, a major source of drinking water. A key energy source in the country, charcoal producers, are cutting down trees in Kenya at an accelerating rate.

Climate change in the Kilifi region

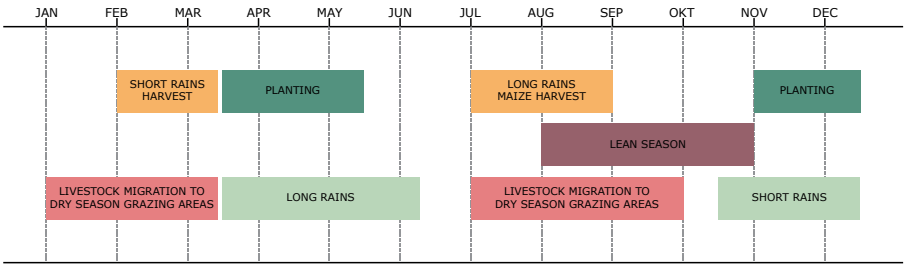
Agro-ecological Zoning (AEZ) is a method that maps climate, land formation, soil, etc, in different geographical areas. The aim of dividing such areas into



Some examples of the classroom architecture at Eco Moyo
Photo: Lindsay Sanner

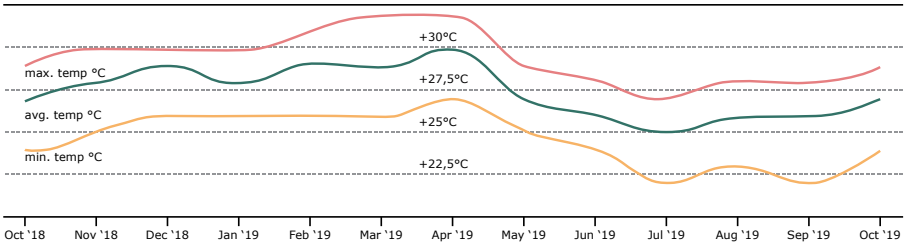
different zones is to determine the differences between their growth periods, temperature fluctuations and soil quality. This is important so that there is an understanding of the area's vegetation and agricultural potential.

Figure 1: Dominating weather trends throughout the year in Kenya. Based on information from http://fews.net/east-africa/kenya/seasonal-calendar/december-2013



Kilifi County is divided into five AEZ-zones and Eco Moyo Education Centre is

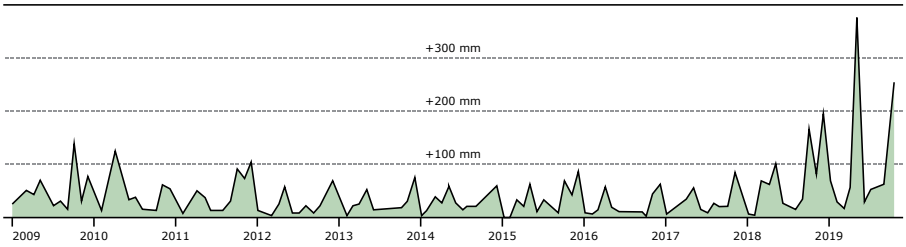
Figure 2: Temperature fluctations in Kilifi county. Based on a figure from https://www.worldweatheronline.com/kilifi-weather-averages/coast/ke.aspx



localized in a zone called Cashewnut-Coconut. This area extends north along the coastline to the Arabuko Sokoke forest, and receives an average of 900mm of rain per year with an annual average temperature of 24°C. As a result of climate change, the borders between these zones are moving. Therefore, it is recommended that Eco Moyo is considered a part of a zone called: Livestock-Millet. This zone as annual average rainfalls between 700-900 mm and has less agricultural potential. The zone is well suited for agriculture with crops that manage to survive longer periods of drought and grazing. If we view the Kilifi county as a whole, the annual temperature fluctuates between 21°C and 30°C in the coastal belt and between 30°C and 34°C inland. Since Kilifi lies along the coast, the wind varies from 4.8km/h along the coast to 12km/h inland. The Kilifi county has what is called a bimodal precipitation pattern, which in practice means that they have two annual rainy seasons. The annual precipitation varies from between 300 mm inland to 1300 mm by the coast. The shorter rainy season takes place in October, November, and December, while the long rainy season is from March to May. Inland, the short rainy season is essential for grazing regeneration and water storage in the ground, while the long rainy season is critical for the crops at the coastal belt.

The difference between the AEZ-zones is most evident when looking at precipitation. In Kilifi the precipitation can vary from 7 mm to 1300 mm during the long rainy season and from 200 mm to 700 mm during the short rainy season. The precipitation patterns are changing at an increasing rate. This has caused great challenges for crops, livestock production, water and forest resources where increased climate-related threats have major consequences.

Figure 3: Average rainfall in mm and rainy season days. Based on information from https://www.worldweatheronline.com/kilifi-weather-averages/coast/ke.aspx



Climate change is visible in all parts of the Kilifi county, such as livestock production, agriculture, the fishing industry, in the natural environment, etc. This entails that climate-related disasters like drought, floods, disease, and conflict make up the biggest threats in Eco Moyo´s local area.

Landscape

Eco Moyo consists of lightly sloping terrain from northwest to southeast. The vegetation is rich and varied with a mix of large cashew trees, smaller trees, and dense bottom vegetation. There is no natural water source on the property.

The Soil Quality

The quality of Kenya's soil is varied and depends on factors like geological conditions and climate. The soil varies from dusty to muddy, from shallow to deep and from rich to nutritionally poor. The biggest challenges on the school site occur when the soil is acidic, has large quantities of salt, drainage difficulties and is simultaneously poor in minerals. Large parts of the property consist of mud and sand. The color of the sand changes based on the elevation. In the top northwest corner, the sand is mostly red, which is typical for this location. At the bottom of the school area, the sand changes to a light color, similar to the coast. The soil is drier in the northwest and moist in the south where the rainwater gathers. The rainwater collects nutrients and humus as it washes over the surface. This distributes good nutrients for the vegetation at the bottom.

Surface Water Management

Surface water management is insufficient at Eco Moyo. There is no structured system to remove the rainwater, which causes large and frequent erosions during heavy rainfall. The school has made individual water ditches, but these must be constantly repaired after heavy rainfall.

Agriculture

The school is approximately 10 acres (40 000m2). Sections of the property are planted with a large variety of crops; species that work well in the local climate and soil are corn, cassava, kale, bananas, passionfruit, aloe vera, sisal and bamboo.

In 2018, PRI Kenya, a consultant service for permaculture, was engaged to investigate Eco Moyo Education Center's potential to further develop the school's Eco philosophy with permaculture as a method. A report was prepared which came with several suggestions. One suggestion was to measure and divide the school's agricultural areas into five zones, each with their own plant community based on growth and use. Overall, the advice was to increase storage for agricultural equipment and cultivate plants such as bananas, sweet potatoes, cassava, corn, legumes, nitrogen plants, herbs, flowers, and fruit trees.

The report gives input on how agriculture can be incorporated to a greater extent into the school's pedagogy; aquaponics could be an aspect of the process along with animal husbandry. In the visiting area, agriculture can be used to teach and train visitors and volunteers at the school. Additionally, the report recommends better rainwater collection, a more thorough investigation of the well's potential, and an area set aside for composting. PRI Kenya is a potential partner in the further development of agriculture.

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Summarized, Eco Moyo has the following future needs related to landscape and agriculture:

- A sturdy landscape plan and the implementation of agriculture that can withstand large fluctuations between droughts and rainy seasons
- A strategic plan for development of agriculture with a focus on management and follow-up
- Better utilization of the varying soil on the property. Improving the nutrient-poor soil and experimenting with methods.
- Evaluate other income-generating purposes for the beautiful green surroundings other than school activities. Complementing area usage.
- Manage the rainwater to reduce erosions.

Water supply and management

Drinking water is currently supplied through the county's pipe system, an unstable and unreliable system. In 2016 a borehole was drilled on the northeast side of the property. Unfortunately, the water was quickly deemed too saline for drinking, irrigation and other desirable purposes. Consequently, the well has not been used; the school's only source of safe drinking water is the county's pipe system. In periods of drought, between November and April, the pipe system is especially unreliable, making water scarcity a big challenge for the school.

In correlation with demographics, retention tanks with a capacity of 80 000 liters have now been installed to collect rainwater. When rain falls it is clean, but the moment it encounters any other media or surface it becomes tainted. The contamination of the collected rainwater due particles and organic material entering the tank is a challenge. Cases of algae boom have also been discovered. A simple drip line irrigation system was also installed but the system no longer operates as desired. Consequently, the school's farming areas in need of irrigation are now watered manually or depend on rain. Banana plants are today watered with greywater, household water from cleaning facilities.

Summarized, Eco Moyo Education Centre has the following needs, related to water supply and -management:

- A safe and reliable water source for drinking purposes and other needs. The source needs to function throughout the whole year, even in periods of droughts.
- Larger capacity for storing of rainwater as well as quality collecting systems.
- A safer better practice for greywater use and disposal.
- A more robust and operative irrigation system for the school's premises.

Energy Supply

As a green school, Eco Moyo strives to have its power needs met by using renewable energy, in particular solar power. This is a huge investment to cover the needs for the project as a whole. Therefore, a collaboration with Engineers Without Borders in Norway has been initiated to look into the concept of designing a microgrid for the different clusters on the site.

As of 2022, the site is equipped with a bigger system in the staff room and a medium size system in the kitchen. Smaller solar kits for light and phone charging are distributed throughout the site.

Summerized, the school has the following needs, related to energy supply

- A robust and well-functioning energy supply system with an adequately capacity is needed. Electrical self-sufficiency is a priority.

Waste Management

Generally, schools and local communities in Kenya lack an organized system for managing waste; it is usually burned on their own property. There is no organized system for collecting waste in the area of the school, but in Kilifi town, a 30 min drive from site, there is a recycling centre where waste can be delivered.

Eco Moyo has the following needs, related waste management:

- Implement recycling stations on different areas of the school site
- Organize the waste that can be recycled and transport it to the center in Kilifi town.
- Involve the students in recycling project to create awareness on waste

3. Vision

Eco Moyo's vision integrates six different leading points to create a sustainable and comprehensive plan for the school's development. The vision pictures how Eco Moyo will be when everything is built. Wishes and goals are fulfilled, values and synergy are created. The vision has guided the project group's work with the strategic plan. The plan builds on the Eco Moyo foundation's overarching vision: To increase the quality of life for underprivileged children through education.

Photo previous page: Lindsay Sanner

In the future, Eco Moyo is:

1. The children's space

Eco Moyo is a safe, stimulating environment that gives room for play and inspires learning and innovation. Beautiful and functional buildings reflect the playful and curious childish mind – surrounded by lush green outdoor areas.

The students are engaged in activities that allow for a practical approach to learning. Younger students learn from the older ones and together they ensure that everyone is taken care of. In the school's learner-focused work environment, teachers are concerned with student progression and participate in the children's amazement and creative exploration of the world. Visiting pedagogues observe and participate in school activities with joy and wonder.

2. Self-sufficient

Food self-sufficiency is a fact, and through intelligent and sustainable farming methods the school produces an abundance of crops that also rejuvenates the local environment. The students and the school's employees eat home-grown organic food, and no one is hungry. Waste management, food, water, and energy supply are integrated systems that are scalable, but also adaptable. Buildings and installations preserve as much of the school's nature as possible.

Reuse and recycling are an integrated part of life in Eco Moyo. The school offers curricula in the conservation of the natural environment and climate adaptation and utilizes the Kenyan countryside as part of the knowledge base.

3. Creative

The school teaches practical skills and inspires students to think independently while at the same time teaching them to be responsible team players.

Computer labs, school gardens and workshops are a natural part of the school's teaching facilities and local craftsmen teach part-time at the school. In the school's innovation lab, students are encouraged to solve challenges through critical thinking and smart design. The creative power of the students is visible in how the students create their own treehouses, outdoor games and works of art that constantly change the school's visual character.

All photo: Lindsay Sanner

4. Engaged in the local community

Eco Moyo is not just a school - it is also a place that enriches and supports the local village. A multi-purpose community house, Eco Moyo focuses on the welfare of the whole family, and is a meeting place for learning and fun. In the school's multi-purpose house, people from the community can share ideas in supporting networks. Entrepreneurship training assist both woman, men and young adults to create new sources of income for themselves and their families.

5. A role model

Eco Moyo, with its green and rich learning environment, sets the standard for primary school facilities on the Kenyan East Coast. The school is regularly visited by curious people who want to experience how it operates on a day-to-day basis. Exchanging knowledge with the outside world contributes to Eco Moyo always being updated, and experienced as forward-thinking and inspiring for students, staff, and visitors. The school becomes an oasis, founded by love and learning.

6. Financially independent

Eco Moyo is financially independent. With a professional accountability system and a broad income base, Eco Moyo can plan costs over time with greater accuracy and reduced risk. The school collaborates with other destinations in Kenya, using the school's beautiful facilities for visitors exchanges and other income generating purposes.

The school's green products such as fruit, vegetables, and mushrooms, give the students training in sales and marketing while ensuring jobs for people from the local community. The visitors area and the fantastic school facility are used for other income-generating purposes when the school is closed during holidays. Eco Moyo summer camps offer great experiences and close contact with the peaceful nature and fantastic architecture of the place.

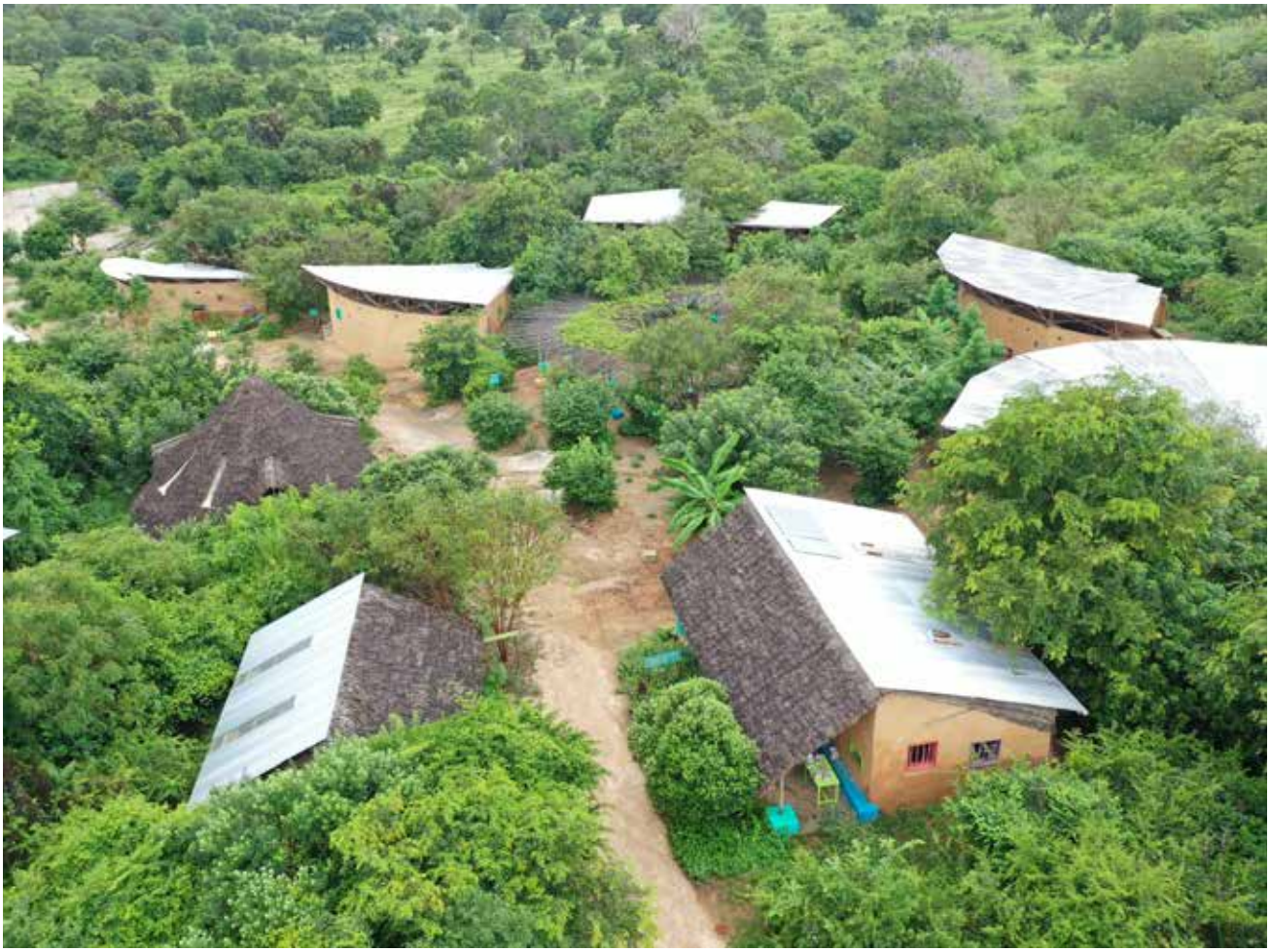


Photo: Lindsay Sanner

Pretty much every visitor is shocked by how secluded we are in the bush. All of a sudden, these incredible buildings appear, with bright colors and modern design. Kids playing, surrounded by lush trees and the sound of birds. No traffic or noise. People are just blown away. And with reason. It´s a magical place.

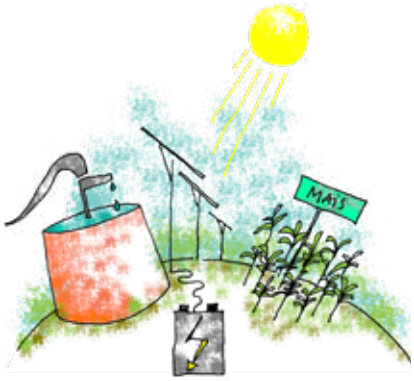
- Lindsay Sander, Eco Moyo founder

4. Strategy

Based on the analysis of today's situation and the vision described in the previous chapter, the strategic plan proposes six strategies for further development of the school.

Photo previous page: Lindsay Sanner

Strategies for Eco Moyo



1. The "Ten-Acre Wood"

The "Ten-acre Wood" is a spatial strategy that can be implemented gradually and adjusted according to the school´s needs and financial capacity. The strategy consists of scattered clusters of school buildings located in clearings in the green landscape so that existing nature and vegetation is conserved. The goal is to make room for the children's exploration and play in safe and inspiring surroundings. The strategy should preserve open space and protect ecological resources.

2. Self-sufficient oasis

A scalable microgrid is provided for water, waste management, energy, food production and tree planting so that the school can become self-sufficient. The infrastructure in the Ten-Acre Wood must be durable and rugged enough to meet climate change challenges

3. Holistic learning environment

To maintain Eco Moyo's plans for expansion, certain areas on site are reserved for future clusters of school buildings. Space is set aside for classrooms, workshops, computer labs. Proximity to school functions and overlapping multipurpose buildings is a consideration. Eco Moyo fosters a positive pedagogical and holistic environment for children.

4. Gathering place

A land use strategy provides the framework for other plan components in Eco Moyo's "Ten-Acre Wood". By setting aside an area for building a flexible-use neighborhood house, we invite residents to be a part of our development. The community house should include multi-purpose living space for guests and gathering places for the people in the village. The community center could be a place where connections are formed, cultural events take place, and a variety of classes are held.

5. Pioneering school

As a progressive learning organization, Eco Moyo strives to become a pioneering school and forward thinking changemaker. Refining the many strengths and qualities, Eco Moyo's reserves a mysterious green world for the next generation. The holistic design implements robust strategies for building infrastructure, constructing buildings and planting crops on the school property. At the same time, the school works in socially sustainable ways and strengthen the community with free education, local employment opportunities and educational tourism.

6. Business development

The comprehensive land use plan provides a blueprint for future building scenarios over time and keeps stakeholders in the loop. Land allotment and building footprints facilitate the systematic development of a circular economy and self-sustaining school operation. The complex design structure provides a variety of spaces for education, recreation, open space, community gathering and business development. Multiuse areas will provide a breeding ground for new business ideas. By collaborating with local craftsmen, artists, farmers and cooks, the groundwork is laid out for student internships, visitor courses and exchanges.

This chapter reviews Eco Moyo's proposals for further development. Measures listed here are based the SWOT analysis together with supplementary mapping documents. The strategic plan is long-term and has a holistic approach that sees assessments in context with the school vision, securing areas for future needs, both known and unknown. The masterplan provides an overall framework that can be tactically executed in a step-by-step development. The order of building projects can be adapted depending on resource allocation.

This chapter proposes measures related to building construction, landscape, surface water and infrastructure. The measures are at a superior level needing a phase two follow-up plan. Design details must go through quality control before implementation. During phase two, the measures can be adapted to local conditions and materials costs. The construction time can then be clarified, and the project implementation priced more accurately. Under some of the topics, various options are listed to show a breadth of opportunities for development. The final solution is drawn in a subsequent phase.

Building a development plan for the property

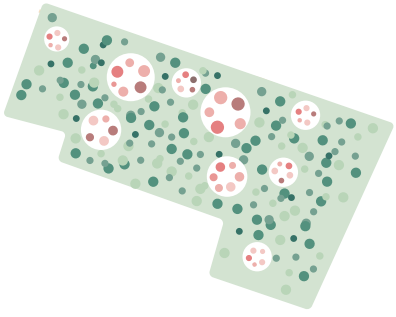
As previously described, Eco Moyo Education in Kenya has a good foundation for development. The school has a favorable location, ten-acre property and lush vegetation in a beautiful rural landscape. Within a five-year period, classrooms and school functions have spread out over large parts of the property. The settlement consists of buildings clustered around existing clearings and separated by relatively dense vegetation.

However, climate change is becoming a huge challenge in Kenya. The local climate in Kilifi is changing rapidly, with rising temperatures and extreme variations in drought and precipitation. Further development of the property is vulnerable regarding water supply, erosion, surface runoff, and access to fertile soil. Existing trees and new vegetation play a very important role in counteracting erosion and preventing the depletion of nutrients in the soil. Lush foliage filters the water and preserves the quality.

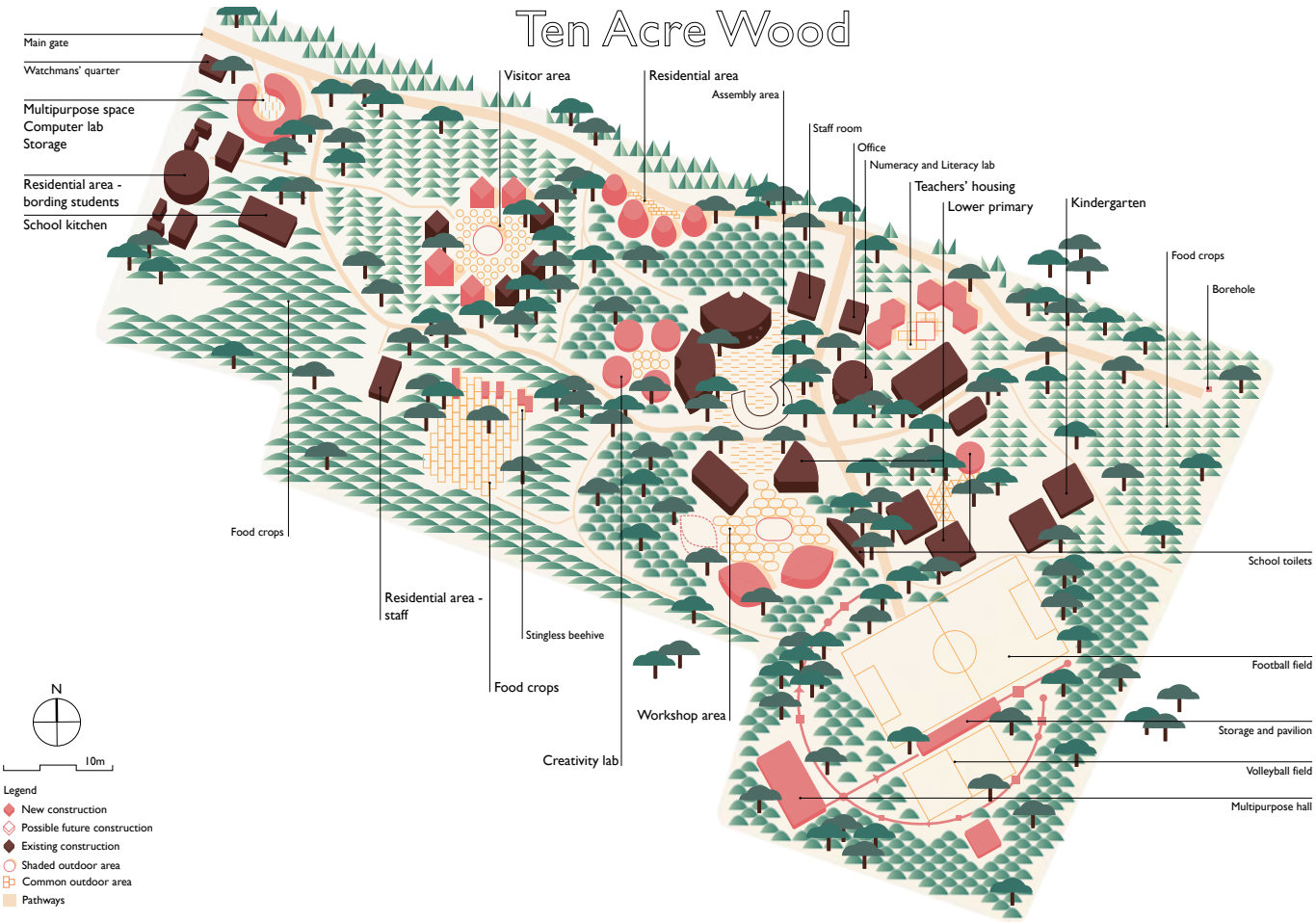
The project group suggests a strategy that strengthens the existing structural organization of the settlement, and more importantly highlights the preservation of trees and vegetation – a self-sustainable oasis. This ecological approach, robust infrastructure and sustainable organization of the settlement will be critical for the survival and happiness of the school's children: water, food, shelter, education, play and social life.

The "Ten-Acre Wood"

The "Ten-Acre Wood" refers to the lush vegetation as the location for the village children's learning. First and foremost a children's place, our interventions create small worlds with a scale and distinct design that form an exciting framework for play, exploration, and social meetings. The trees create a natural spatial concept and flexible scalable approach to land use organization on the property (see previous page). New buildings, as far as possible, are clustered around existing clearings to avoid chopping down trees. The clusters can be built step by step and the pace of the development can be adapted to changing needs and financial situation.



Ill.: Principle diagram small and distinct villages in the wood



Ill. Hundred-Acre Wood,
strategy for future organization on the property

Clusters

The buildings are organized as small and distinct villages in the forest and efficiently placed near infrastructure systems such as water supply, electricity, waste disposal, and surface water management. There are currently four distinct clusters - the dormitory, the guest houses (visitors area) the classrooms for upper primary, then for lower primary. New buildings and functions consist of the school area for the youngest children, school workshop, multi-purpose building and staff housing. Part of the property is managed as small sports area. In connection with existing lighting, areas have been designated for future unknown land use. The plan on the next page must be understood as indicative.

The list shows primary assessments and openings for new possibilities. In the landscape and infrastructure chapter, new guideways and installations for pre-water management and water supply are shown. Clusters are placed close to existing and future infrastructure. The school areas will still have access via the path in the north, though separate from the staff housing.

The land use plan for the "Ten Acre Wood" recommends new buildings that fill out and further develop the cluster principle. Exact and final placement must be considered in connection with:

- efficient connection to the drinking water system
- limited consequences for existing vegetation
- surface water management: water ditches and diversion
- energy supply requirements and routes
- the need for new latrines
- driving access to the cluster depending on functions

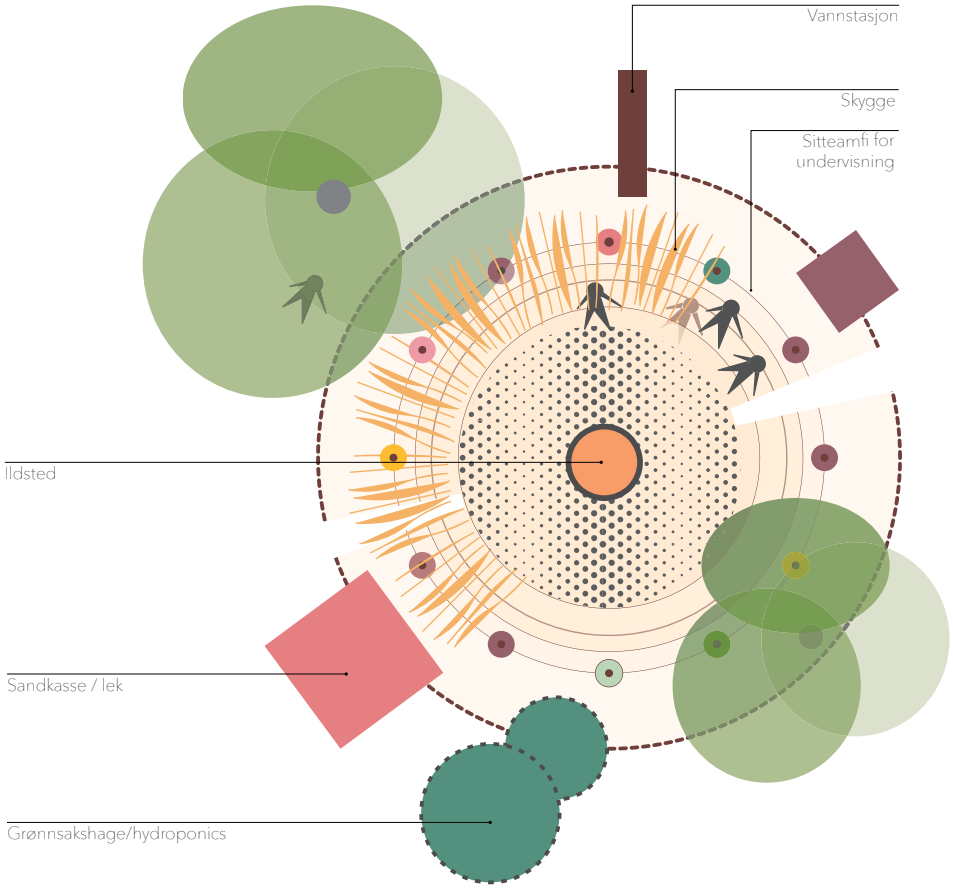
Open space

The buildings are organized around a series of open spaces. In a tropical climate, outdoor areas are essential and meet a variety of needs: meeting spots, vegetable gardens, hydroponics area, seating amphitheater for resting and teaching, shady seating, a fireplace, exhibition areas, play areas or half-covered interconnected space. Shade is essential in Kenya and the main outdoor areas must have shelter from the sun and rain. Central outdoor spaces are designed as pavilions with roofing made of sail, pergola or fixed roof design that filters sunlight and protects from heavy rainfall.

In the autumn of 2019, large parts of the ground in the current assembly area were destroyed by rainfall. In the future, public space should have a solid ground of concrete, paving stones or similar. Areas that are often flooded must also be made with a small slope that directs the rainwater away from the surface. Raingardens or catches can store water and hinder soil erosion. Outdoor space can be furnished and filled with content related to functions within the cluster. For example, in a classroom cluster, there may be a need for a small seating

Ill.: Principle section and common outdoor space

Ill.: Principle plan common outdoor space uterom



amphitheater for outdoor teaching and lunch break, a school vegetable garden and a drinking water tap. A public gathering place for guests in the visitor center could include a small outdoor kitchen, hammocks, a long table for meals and workplaces, and perhaps a sitting amphitheater with a fireplace for gatherings after dark. The workshop cluster could be designed with a patio, exhibition tables for students' crafts, public artworks or elements that demonstrate local building techniques.

It is also possible to imagine open space as a part of an overall system for surface water management. For example, the sitting amphitheater can also become a collection pool for surface water in the event of heavy rainfall. Such ideas will have to be investigated further in the landscape plan. In the same way as space is reserved for future buildings, Eco Moyo should also preserve land in each cluster for open space needs such as public gatherings, eco-system education, gardens, and outdoor activities.

Recommendation:

- The land use plan should preserve existing trees in the "Ten Acre Wood" and use the forest concept in storytelling and marketing the project. A situational plan showing proximity to the Arabuko Sokoke National Reserve and other national landmarks can raise interest for visitors, birdwatchers, and environmental activists.
- The outdoor areas should be part of an overall landscape plan showing terrain formations that divert rainfall away from buildings to avoid flooding. Nature and ecology must be an integral aspect of the strategic plan for the property. Landscapes for learning should be integrated into the pedagogical plan.
- Open space in the clusters should be planned as pavilions. The flow of indoor-outdoor space is important for playing, sitting and rest in the shade. The pavilions should be built in connection with future buildings and have durable floors, roofing, and lush plants.

Today's classroom
Photo: Lindsay Sanner

Functional programming

This section describes the building projects, implementing the school's ambitions. A children's place, the school shall be self-sufficient, unlocking the pupils' potential and connecting with the local village. A pioneering school, our goal is to be financially independent within a decade.

This description is a rough overview and indication for subsequent architectural assignments and financial proposals. It contains an overall account of benefits and qualities that are important and an approximate cost estimate. The projects are prioritized in terms of an assumed time horizon, but spatial strategy, flexibility and effectivity are important. The order can consequently be reshuffled, and the buildings constructed project by project. Costs calculations are based on a rough estimate using the average of NOK 1,400 per square meter. This does not include electrical work, outdoor work, or fixtures.

Computer lab

The computer lab should have room for 30 students and a design that balances the need for daylight and a good indoor climate with comfortable temperatures and natural ventilation. The roof surfaces should be used for collecting rainwater and solar energy. The lab should be able to easily lock and secure. It should be in a cluster of classrooms, but also close to the future community center so parents and other adults in the village can be a part of the education program over time.

Time horizon:	3 years
Approximate size:	50 sqm
Approximate cost:	NOK 70 000
Contributes to our ambition to:	be a pioneering school, connect with the local village and be financially independent.

Multi-purpose house

The multi-purpose building should have room for about 150 people with a design that opens up for different types of community use and events. The multi-purpose building should be able to be used as an indoor meeting room for the students as well as host group lessons for Taekwondo or yoga. The building should balance the need for daylight with the need for a comfortable indoor climate, temperature, and natural ventilation; the entrance area is especially important. Roof surfaces should collect rainwater and produce solar energy. The cluster should contain a storage area for equipment. In connection with the buildings, an outdoor space for cooking, fireplace, play, shade, and seating is necessary. The multi-purpose building should also be equipped with a water pump and water storage options - described more detailed in the following chapters on infrastructure.

Time horizon:	3 years
Approximate size:	200 sqm
Approximate cost:	NOK 280 000
Contributes to our ambition to:	connect with the local village

School workshop

A workshop for metal, wood, ceramics, and various crafts should have room for 30 students and be located with drivable access and proximity to the entrance and multi-purpose building. The buildings should balance the need for daylight with other considerations such as indoor climate, temperature, and natural ventilation. The roof surfaces should collect rainwater and produce solar energy. In connection with the buildings, facilities for a water pump, and outdoor areas for exhibiting/selling student work should be established. The building facades bordering this public outdoor space should be able to be completely opened for good workflow and the installation of workshop equipment.

Time horizon:	5 år
Approximate size:	150 kvm
Approximate cost:	NOK 210 000
Contributes to our ambition to:	unlocking the students' potential, connecting with the local village and attaining the status of a pioneering school.

Visitor center

Today's guest cabins have beds for 12 people, with toilets and showers in a separate building. There is a need to build a co-living house with kitchen facilities where guests can relax, cook, chat etc. Guests will typically be a group of students with teachers or volunteers contributing to school projects. In the long run, it may be relevant to offer accommodation for tourists as well. Land use should allow for expansion, with areas for more cabins. All buildings should balance the need for daylight with other design considerations such as indoor climate, temperature, and natural ventilation. Roof surfaces should collect rainwater and produce solar energy. An attractive outdoor pavilion with facilities for cooking, fireplace, tables, seating, and shade should be built. A vegetable garden and lush vegetation should be planted. The visitor center should also be equipped with a water pump and water storage options - this is described in more detail in the following chapters on infrastructure.

Time horizon:	5 years
Approximate size:	100 sqm
Approximate cost:	NOK 140 000
Contributes to our ambition to:	be self-sufficient, be a pioneering school and be financially independent.

Teacher's housing

The teachers housing should be extended with 5 new rooms, 5 showers, 2 toilets and a common indoor living room and kitchen. Residential buildings and shared living areas should be given a design that balances the need for daylight with other aspects such as indoor climate, temperature, and natural ventilation. The roof surfaces should collect rainwater and produce solar energy.

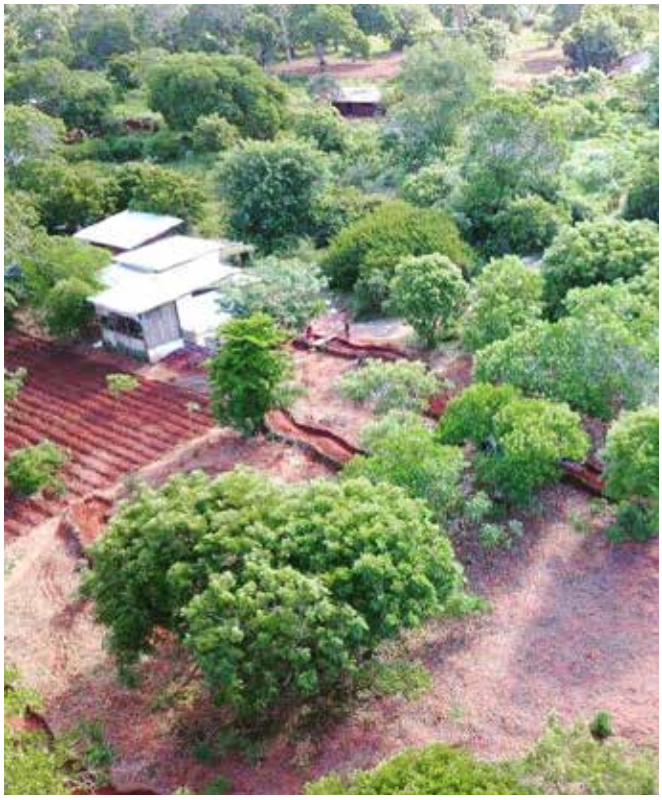
Time horizon:	2 years
Approximate size:	150 sqm
Approximate cost:	NOK 210 000
Contributes to the ambition to:	be a pioneering school

Creativity lab

Leap learning-rommene bør ha plass til fire klasser og gis en utforming som balanserer behovet for dagslys med inneklima, temperatur og naturlig ventilasjon. Takflatene bør brukes til samling av regnvann og solenergi.

Time horizon:	5 years
Approximate size:	200 sqm
Approximate cost:	NOK 280 000
Contributes to our ambition to:	realize the students' potential and to be a pioneering school


CLASS FIVE
FLOWERBED



Landscape

Previous pages: Cultivation at Eco Moyo
All photo: Lindsay Sanner

Permaculture

Eco-philosophy is a key value for Eco Moyo. Our goal is to further develop the school with respect for nature, native ecosystems, and organic values. The schools' landscape preservation and development should utilize nature-based methods.

Photo: MetsikGarden from Pixabay

Permaculture was first mentioned in the 1970s when two Australians, Bill Mollison and David Holmgren, created the concept from the words "permanent and "agriculture". The philosophy behind the term is a nature-based approach to the way we shape our environment. By studying how nature itself regenerates the soil, protects and stores H20, we can design a system that imitates Nature and takes on a life of its own[1]. Permaculture practices can yield a variety of high-quality food and energy to meet basic human needs without harming the environment. Permaculture principals can be foundation for developing the landscape at Eco Moyo.

Photo: WhisperingJane_ASMR from Pixabay

Major climate challenges such as prolonged droughts and floods make ecological design essential. The use of nature-based methods can strengthen biological diversity and create optimal conditions for plants, insects, and animals. The following pages review various nature-based methods with proposals for Eco Moyo's green development strategies. Hiring an agronomist is highly recommended. A knowledgeable person with a background in permaculture can improve the school's farming and gardening practices. The goal of the landscape strategy is to generate ideas for cultivating Eco Moyo's "Hundred Acre Wood" into a lush and self-sufficient oasis. The development of the landscape must be seen in the context of the following factors:

- An overall plan for management of surface water that reduces the extent of erosion.
- Excellent water supply and storage that provides irrigation opportunities, even during droughts.
- Defining the metrics for success, following up on landscape and agricultural milestones.
- A plan for the types and extent of plantings for food supply for the school.
- Testing innovative permaculture methods that enhance the school's reputation as a pioneering school.

Sources permaculture:
1. Never Ending Food. Permaculture – Designing a Sustainable Culture. 2019. Tilgjengelig fra: http://www.neverendingfood.org/b-what-is-permaculture/

Agronomist

Eco Moyo would like to employ an agronomist with an interest in permaculture to create a long-term vegetation strategy. In a tropical climate, the position demands daily follow-up, maintenance, and planning. As well as applying for funds and support, the job requires collecting partners who can help find the best nature-based methods for Eco Moyo.

Reccomendation:

- Apply for funds to establish an agronomist position with a relevant degree and experience from similar work in Kenya. If possible, hire a person who has a network that can contribute to exciting green projects.

Hugelkultur

In german, Hugelkultur means mound culture or hill culture. This is a form for permaculture which exploits the decomposition processes in the soil to make good growth conditions at the surface. Wood is buried in the ground to imitate the way deadfall naturally occurs with fallen trees. The decaying wood provides new nourishment to the soil and creates a hotbed for new vegetation[1].

Example of Hugel trench.
Photo: Jon Roberts fra Austin TX, USA - Garden, 12 Apr 2012Uploaded by zellfaze, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=31402143

- Hugel mound: Wood is placed directly on the ground and is covered by soil.
- Hugel trench: A more popular method where trenches are dug out and filled with wood, covered with smaller pieces of wood and leaves and then topped with soil.

Both methods provide good growth conditions for plants due to decay. Inside the hugel mound or the hugel trench, the rotten wood will hold the humidity from rain and slowly release nutrients. Fungus and other microorganisms help this process. The hugel principles also provide[2]:

- Aeration of the soil since the decay causes the wood to collapse and the soil to move.
- Slightly larger ground area due to including the sides of the hugel mounds for cultivation.
- By orienting the mounds in a north south direction, the south side can be used for vegetation needing sun, and correspondingly the north side can be used for plants that thrive in the shade.

Hugel techniques are recommended in areas with lots of water, for example near a diversion pool or trenches for surface runoff water (see figure section below). The humid climate accelerates the decay.

Ill.:Hugel hill connected to the surface water ditch

Sources Hugel culture:
1. Wildlife Gardening Forum. A New Apporach – Hugelkultur. Tilgjengelig fra: http://www.wlgf.org/Hugelkultur.html
2. Ibid

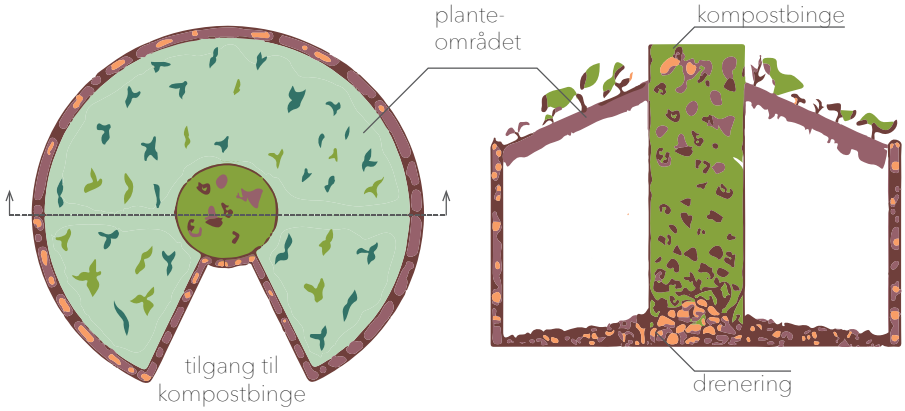
Recommendation:

- Establish a test project to investigate the effect of hugel mounds on EcoMoyo's agriculture
- Look at the possibility of building hugel mounds in combination with new trenches for surface runoff water management.

Keyhole Horticulture

Keyhole Horticulture was invented by the CARE organization in the 1990s in Zimbabwe and was further developed by the Consortium for Southern Africa Food Security Emergency (C-SAFE). The garden principle was designed using easily accessible material such as bricks, soil, leaves, ash etc. This is a closed system for composting where decaying wood provides nourishment for the plant crops that are grown in the keyhole garden. More than 20,000 such gardens have been built in Africa.[1] Vegetable waste, greywater, and animal excrement are used as resources and filled into a container located in the center of the circular garden. This provides nutrition for the plants. The principle is well suited to dry climates and for intensive agriculture on small areas.[2]

Sources Keyhole-gardens:
1. Wikipedia. Keyhole Garden. 2019. Tilgjengelig fra: https://en.wikipedia.org/wiki/Keyhole_garden
2. Ibid.



Ill.: Cross section of keyhold-garden

Recommendation

- Establish a test project to investigate the effect of the keyhole gardens.

Hydroponics

Hydroponics is the cultivation of plants in water with nutrient supplements. The advantage of this method of cultivation is rapid growth over a small area. Hydroponics has a 20% faster growth rate with 20-25% larger crops than with traditional soil cultivation. By cultivating in water that is stored in closed containers, evaporation is prevented, and water resources are saved. There are many different systems that feed water, oxygen and nutrients to the plants.[1]

Hydroponics can be a supplement to the school's agricultural investment, especially if planned as a source of income for the school's agriculture initiative.

Sources Hydroponics:
1. https://www.advancednutrients.com/articles/easy-hydroponics-beginners-guide/

Hydroponics
Photo: Pixabay

Reommendation:

- Test hydroponics

Soil improvement

In the African climate, soil depletion is a big problem. According to a study from the Food and Agriculture Organization of the United Nations (FAO) from 2001, soil in Africa loses an average of 48 kg/hectars of nutrients each year, which is equivalent to 100kg of fertilizer annually. Agriculture is fertilized with approximately 90 kg of mineral fertilizer on a global basis, whereas Africa uses only 10 kg. Ensuring stable and nutrient-saturated soil is a key measure for the success of an agricultural program. Its success depends upon the knowledge of local soil, sustainable farming methods, and methods for conservation of the soil.[1] It is relevant for Eco Moyo to investigate measures to improve and optimize soil conditions on the property. Two possibilities are presented, which can be investigated further in a phase 2.

Know - your - soil!

See link: https://www.infonet-biovision.org/EnvironmentalHealth/Soil-monitoring-Know-your-soil

Worm composting

The use of micro- and macro-organisms to decompose organic mass is a good way to create nutrient-saturated soil. Larvae play a central role in the formation of nutrients from organic material. The earthworm eats and digests dead plant matter and excretes feces that is nutritious food for the propagating soil. The earthworm accelerates the decomposition process through their digestive system, improves soil conditions thus providing better growing conditions. This nature-based way of converting organic source material into a rich and saturated fertilizer is ideal for our project.[2]

The following earthworms may be suitable for use in Eco Moyos soil:

- The tiger worm (Eisenia foetida). This species is cultivated by several flower farms in the central highlands and in the Rift Valley in Kenya. This worm produces the best known soil type and is commonly used in commercial larval composting and waste reduction.
- Kenyan highland forest pigmented earthworm. An earthworm that has not yet been given a Latin name, but has its origins in Muguga, Kenya. It produces finer larval compost than E. foetida, but with a similar chemical composition.
- African night crawler (Eudrilus eugeniae). This is a large type of worm that is cultivated in the United States, among other places. Its use is limited to tropical and sub-tropical regions as it prefers warmer temperatures, although considered somewhat challenging to cultivate.

Recommendation:

- Investigate the possibility of using earthworms to optimize composting and improve soil conditions for agriculture.

Biocoal

"It can perhaps be called the world's simplest environmental technology: Planting in biochar", writes Sintef.[3] Biochar binds CO2 in the soil at the same time as it fertilizes. The material is clean and organic, and it can be produced from local materials such as sawdust, manure, and straw.

The conversion process takes place under a high combustion temperature of between 500-700 degrees in an incinerator with a limited supply of oxygen. This is a very sustainable fertilization method in the fight against global warming.[4]

Recommendation:

- Investigate the possibility of using biochar to improve the soil.

Tree planting

Tree planting is not only a valuable initiative for increasing the general well-being in an area but is also a social process and a climate measure which fits well into Eco Moyo's eco-philosophical approach.

Tree planting contributes to stabilizing the ground, reducing the erosion of soil, and creating dependable habitats for insects and animals. Major climate changes and droughts make tree planting an important activity for Eco Moyo as we cultivate the school as a green and stable oasis.

Kenya has lost great parts of its forest, and the children and youths in Kenya will need to learn about sustainable farming and nature-based methods to

Sources Soil improvement:
1. Infonet Biovision. How to improve soil fertility. 2019. Tilgjengelig fra: https://www.infonet-biovision.org/EnvironmentalHealth/How-improve-soil-fertility
2. Infonet Biovision. How to improve soil fertility. 2019. Tilgjengelig fra: https://www.infonet-biovision.org/EnvironmentalHealth/How-improve-soil-fertility
3. Sintef. Dette kullet gjør planter og bytrær til «klimaaktivister». Tlgjengelig fra: https://www.sintef.no/siste-nytt/denne-kulla-gjor-planter-og-bytrar-til-klimaaktivister/
4. Oregon Biochar solutions. What is biocha and other frequently asked questions. Tilgjengelig fra: https://www.chardirect.com/what-is-biochar-and-other-frequently-asked-questions

actively preserve the nature in Kenya[1] and fight climate change. Tree planting may become its own project in the school's educational program, a tree planting strategy encompassing the school property and/or in the local area.

The following information is taken from a guide on tree planting developed by scientists from Kenya Forestry Research Institute (KEFRI) as a manual for farmers planting trees in Kenya. The guide explains the framework for different tree species depending on the soil, climatic zone, use and life expectancy.[2]

Deciding between tree species depends on their function along with site characteristics:

- The purpose of planting: to improve the water and soil conditions, provide shade, produce salable goods (nuts, fruit etc.). Or if the wood is to be used as firewood or production of bio coal, construction materials etc.
- Growth conditions: The environment the tree is planted in must be assessed with respect to climatic zone, soil, and altitude.
- User-friendliness of the species: The tree should preferably fulfill several purposes.

The Kenya Tree Seed Centre, a program run by KEFRI, can deliver seeds to Eco Moyo. They can also assist with deciding between tree species. The centre has a local subdivision i Gede, north of Kilifi[3].

Recommendation:

- Establish a tree planting project as a part of the educational program.
- Enter into a cooperation with local educational partners, for example The Kenya Tree Seed Centre.
- Approach tree planting as an active measure against erosion of open landscapes in Eco Moyo
- Evaluate how tree planting in the school's local area may be a social engagement run by Eco Moyo.

Kenya has lost almost half of its forests since 1963.

Read more here: https://www.theafricareport.com/16150/kenya-has-lost-nearly-half-its-forests-time-for-the-young-to-act/amp/?__twitter_impression=true

The red soil at Eco Moyo which is charecteristic for Kenya. Photo : Lindsay Sanner

The lush Eco Moyo
Photo: Lindsay Sanner

Surface water management

A strategy for surface water management is described here, which must be verified and detailed in a follow-up landscape plan. The solution has four elements:

- Ditch system
- Flood protection
- Diversion pool
- Erosion protection of ditches

Movement of surface water

There is a proposal to establish a system of ditches that runs from the northwest, through the school area, and ends up in the southeast at the existing well.

The ditch system for drainage of surface water is seen in context of the proposals for artificial infiltration of surface water into the groundwater (see section for wells).

Sources Treeplanting:
1. Kaluki Paul Mutuku 2019. Kenya has lost nearly half its forests – time for the young to act. The Africa Report. Tilgjengelig fra: https://www.theafricareport.com/16150/kenya-has-lost-nearly-half-its-forests-time-for-the-young-to-act/amp/?__twitter_impression=true
2. Infonet Biovision. Guide to treeplanting in Kenya. Tilgjengelig fra: https://www.infonet-biovision.org/EnvironmentalHealth/guide-tree-planting-Kenya
3. Ibid.

Ditch system:

- The first phase will ensure rapid implementation and low costs. Ditches with a certain depth are excavated and planted with grass/plants that delay the water. The channels can be supported by mounds that benefit from being adjacent to the humid environment.
- In the second phase, primary ditches can be strengthened with solid materials that make them less vulnerable to erosions. The upgrade can be done bit by bit, and with available funds. Such an upgrade is recommended to be done in consultation with a landscape architect.

Secondary paths for flood water

New building clusters must be built on a slope so that water runs out to the ditches. For existing buildings, it becomes a question of how to renovate outdoor areas so that the water supply is lead away under controlled circumstances.

Flood protection

Flood protection is intended to protect the clusters against flooding and can be carried out according to two principles:

- Physical measures such as landscape embankments that lead the water to the ditch system.
- Lifting the terrain locally for new clusters. This means that the entire surface, including all school buildings and the common outdoor area, is lifted before execution. In this way, the cluster will be higher in the terrain than adjacent areas. The cluster's "floor" must have a slope to the nearest surface water ditch. In the same way as other clusters, the common outdoor area should be worked up with a type of pre-fixed coating that reduces the erosion of the outdoor areas.

Diversion pool

Sufficient area should be set aside for the delay and diversion of surface water during heavy rainfall. In areas that are a good distance from the buildings, places with the right topography, diversion pools can be built. These pools can be designed to function as reservoirs during periods of drought.

Erosion control of ditches

The ditches should have the capacity to handle flood situations and divert floodwater from school areas, avoiding permanent damage to buildings and roads. Erosion can unfortunately occur in and around the ditches themselves, and Eco Moyo experiences this type of problem with today's ditches. Erosion means that particles are torn free and transported to another location by water because water has a greater speed than the ground conditions can withstand. There is a connection between the roughness (what material the ditch is made of) and critical water velocity where erosion occurs. The critical speed is for example much lower for soils with clay or sand content than for ditches that are covered with rock, covered with dense grass or have been made erosion-proof.

Erosion most often occurs when there is a:

- Change in the direction of the waterway (outer turns are most exposed)
- Transition to narrower waterways (water gets a higher speed at narrowings)
- Expansion of the cross section, which can lead to great turbulence where the water slows down

- Obstacles in the waterway

To reduce the water speed, you can:

- Increase the width of the ditch
- Lessen the gradient of the side slope (slower slope)
- Increase the roughness of the ditch
- Add steps or thresholds to locally reduce energy and lessen water speed
- Make water-level jumps

The most common solution for erosion prevention is to increase the width or roughness of the ditch and thereby increase the erosion resistance. If stones are placed in the bottom and sides of the ditch, it is important to make sure that the water does not start digging out the soil or gravel underneath. Knitting the stones can lock them in place. If steps or thresholds are built, it is important to ensure erosion protection along the sides of the ditch. The height of the steps is significant, and both low and high steps can lead to problems. Steps that are too low do not give the desired effect when it comes to erosion protection while steps that are too high can cause problems below the step. The same goes for the thresholds. The thresholds can consist of many different materials: stone, wall, or twig. Twig ponds can capture sediments, reduce the energy level in the water and thus also the speed of the water. Twigs can to a certain extent function as a flood mitigation measure and a series of twig ponds can be used in the ditches to slow water flow. It is important to take into account that the water level will increase, and twig ponds can only be used where there is no danger of flooding. Erosion at and below the twig pond can also be a problem, and erosion-preventing measures must be assessed.

Surfacewater connected with the rainy season being a big challenge. Photo: Jan Kazimierz Godzimirski

Masterplan for the landscape

Eco Moyo needs a landscape plan that designs the school outdoor areas, terrain, vegetation, agriculture, and management of surface water.

A landscape plan proposes concrete solutions for infrastructure, constructions and area usage and should be a separate project with high priority. Assistance from a landscape office in collaboration with an environmental engineering firm with experience in surface water systems is needed.

The landscape plan must show elevations, slope gradients and a new canal system. The plan should be easy to implement at low cost without large machinery since Eco Moyo uses local manual labor.

Recommendation:

- A detailed landscape plan must be made that assesses ditch systems and flood paths in relation to further development of the area. Erosion-preventing (speed-reducing) measures should also be considered here.

Water supply and management

The well

A borehole has been dug on the north-eastern corner of the property and is 25 meters deep according to the driller, and it has a water table approximately 22 meters below the water surface. Its capacity is unknown and there is no documentation of a sample pumping.

Sources: Surface water management:
"Lærebok - Drenering og håndtering av overvann"
Rapport 681. Februar 2018

The well was established based on a hydrogeological survey carried out by Smart Systems Consultants in 2016. Resistance measurements were carried out which indicated sand masses down to approximately 14 meters, then sandy clay down to approximately 40 meters underground. The measurements indicated that the water quality would be poor and could be characterized as "brackish groundwater". Groundwater with little movement is exposed to significant evaporation and therefore has a high mineral content. It was assumed that the conductivity of the water, which is a measure of the total ionic content of the water, would be approximately 3000 mS/cm - too high to be used as drinking water.

The borehole was dug as a result of the recommendations from the hydrogeological report. After drilling the borehole, it turned out that the water was so salty that it could neither be used as drinking water nor for watering plants or any other purposes and has therefor been left unused.

Assessment of the situation

Groundwater can have high levels of salt mainly for two reasons: penetration of seawater or dissolved salts from loose materials and rocks. This borehole is located several kilometers from the coastline, so most likely the salinity is due to dissolved salts in the soil. Low velocity of the groundwater stream and evaporation may contribute to increased concentration of salt in the groundwater.

The well is located on a gentle slope, and the groundwater most likely moves parallel to the terrain slope, but the permeability of the soil and loose materials is not known.

According to the borehole driller, the well's capacity is over 8000 liters per day. The surface of the property is very hard and not very permeable, so that a large part of the precipitation disappears as runoff. A significant proportion also disappears as evaporation and transpiration, so that only a small proportion of the precipitation infiltrates the groundwater reservoir. Therefore, high evaporation and lack of new groundwater are considered as the governing mechanisms for the salt concentration in the groundwater.

Possible solutions

Improvement of the situation around the existing borehole can be considered. Drilling a deeper borehol may also be viable. Or drilling a new borehole in a different location.

Drilling of a deeper borehole

The existing borehole has a depth of 25 meters. If making it deeper is to be considered, it must be assumed that groundwater in the deeper part of the loose materials either has a higher velocity of the groundwater flow, has a lower ion content due to other mineralogy in the loose materials, or consists of water originating from another catchment area (eg isolated from overlying groundwater due to dense layers in the loose materials). Based on information in hydrogeological reports, there is no indication that this is the situation. We can also drill even deeper into the rock itself. Groundwater in rock occurs primarily in cracks and other cavities and can originate in water from other catchment areas than the local ones. This can give water with a different quality than what is in the loose materials above. However, the capacity and water quality of such a well is difficult to predict in advance, and the success very uncertain.

New well at a different location of the property

Drilling a new borehole in a different location on the property must presuppose that the ground conditions vary or that parts of the property are in a different catchment area than the existing borehole. Based on available information, there is no indication of this.

Improvement measures in existing borehole

Conditions in the existing borehole can be improved by increasing the formation of new groundwater in the reservoir. This can lead to improved water quality and increased capacity for extraction in the well. Increased groundwater formation is carried out by directing water from the surface down to the groundwater reservoir in as efficient a manner as possible, also referred to as artificial infiltration. Artificial infiltration has been used in several places to avoid the ingress of salt water into wells, especially in connection with seawater. Improvement measures in the existing borehole through artificial infiltration is therefore the alternative discussed further here. It is assumed that artificial infiltration in this case could contribute to the following:

- Increase the extraction capacity in the borehole
- Improve the water quality in the borehole
- Contribute to better usage of surface water

Recommendation:

- Improvement measures in the existing borehole through artificial infiltration can have a positive effect on the salinity.

Artificial infiltration in general

Artificial infiltration is a technique used to improve the capacity and/or water quality in wells, and involves a number of different methods. The main idea behind improving water quality through artificial infiltration is to use infiltrated surface water to displace the salt water, so that the water surrounding the well is of good quality and low salt content.

The methods can be divided into direct and indirect methods. For this project, direct methods, meaning methods where surface water is led directly into the groundwater reservoir, as well as measures below the surface, are assumed to be most relevant. With little impact on the area in the permanent phase, this type of improvement will be effective in achieving better water quality in the borehole.

Selected methods

Infiltration borehole

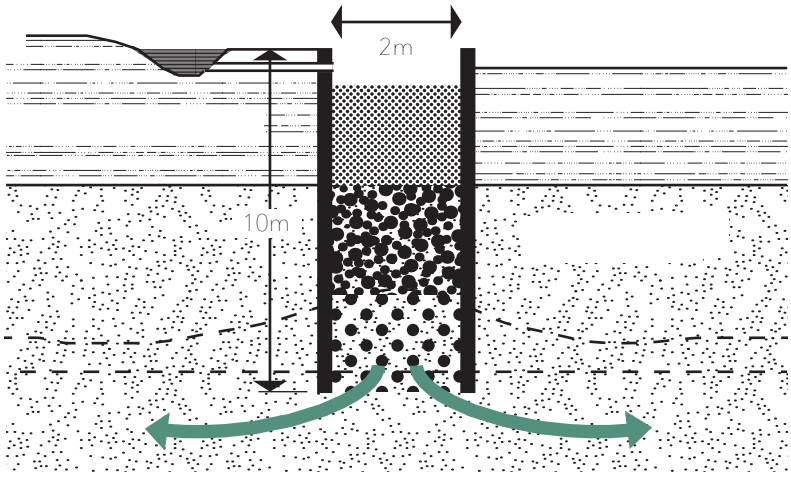
This alternative establishes a separate borehole just upstream of the existing one. Surface water can be introduced into the borehole and infiltrated into the groundwater reservoir. The depth of the groundwater table in this case will probably allow water to infiltrate through the borehole without pressure, ie only by means of gravity. The infiltration well must be built with filter pipes for most of the length of the borehole, so that infiltration of water takes place in an almost completely unsaturated zone.

Infiltration pit

This is an excavated pit that is deep enough that it penetrates dense layers of wood at the surface. Infiltration water is then led into permeable masses in the unsaturated zone. The pit can be refilled with coarse stones and gravel, with a

sand filter on top. The dimensions of an infiltration pit are flexible, but the larger the diameter of the pit, the more efficient the infiltration will be.

Figure 1: Infiltration pit (based on a illustration from www.engineeringcivil.com)



Infiltration directly into existing borehole

Infiltration can also be implemented directly in existing borehole. For example during the rainy season, when ample water can be stored in the ground for later use.

Prerequisites for successful infiltration

An important prerequisite for artificial infiltration is that any spring water used must be free of silt and other fine sediments. Sediments in the water source will cause the sand filter to become clogged, preventing effective infiltration. Some maintenance of the infiltration solution will also be required. The type and level of maintenance will depend on the solution in question. For an infiltration pit, for example, periodic cleaning of the surface for silt is necessary.

Suitable method in this project

Artificial infiltration could lead to a better surface water situation, improve the water quality in the borehole and easily be integrated into the landscape, leaving a marginal print in the terrain (Figure 2 for an example).

The landscape plan and surface water management strategy should explore artificial infiltration as a solution. Varying permeability in the ground, surface conditions and other local conditions must first be mapped to find the most efficient solution. As mentioned above, it is very important that the water used as spring water is free of silt. Rainwater collected from roof surfaces would be particularly suitable for infiltration. For example, rainwater is first collected in tanks and when tank capacity is reached, the water is led to the well area and infiltrated into the ground. In this way, an infiltration solution will store rainwater in the ground for later use.

The existing borehole is a good starting point, but not the best solution in the long run, as the borehole´s filter pipe has a limited length. However, the method can test the effect of infiltration on the water quality. It is very important that the water that is infiltrated is completely clean throughout the test.

A survey of how water quality and groundwater levels in the well vary over time can provide a picture of how periods of increased new groundwater formation (for example during the rainy season) affect water quality. This can be done by installing a CTD logger in the well. A CTD logger automatically monitors the groundwater level and water conductivity. Optionally, this can be done by manual

measurements from season to season. Information on artificial infiltration used on other wells in the area will provide a good basis for any planning of artificial infiltration in this project.

Recommendation

- Lokale forhold bør kartlegges for å vurdere hvilken metode for kunstig infiltrasjon som egner seg best.
- Løsninger for oppsamling av regnvann må ses i sammenheng med en infiltrasjonsløsning for brønnen.

Sources:
1. Hydrogeological survey report. Smart Systems Consultants, 2016
2. Manual on artificial recharge of ground water. Government of India, Central Ground Water Board, 2007
3. www.engineeringcivil.com
4. www.indiawaterportal.org

Figure 1: Existing and planned pipeline network for water at the school area. Continous lines indicates existing pipelines and dashed lines indicates suggested future expansion of the pipeline network The green pipes is where the water is filtered and used as drinking water. The pink pipes leads the water that is not filtered and can be mixed with the rainwater in the tanks by the different buildings.

Future pipe network and water consumption

If the groundwater is unusable, municipal water is feasible solution. Since the price of municipal water is now lower, the pipe network can be expanded in step with the development, as shown in Figure 1. Not all the clusters need access to water, such as classrooms or areas where food is not cooked or washed. A future waterpipe network should connect prioritized areas under development.

Water Consumption

A rough estimate has been made of the maximum water consumption, assuming it is not raining, and stored water must be used for irrigation. Calculations are based on values from similar projects, but there is great uncertainty associated with them. The calculations show that if both the school and visitor cabins are in full use, it does not rain, and irrigation is necessary, the school's water storage will only last for two days. Normally, the water would probably last a little longer, but if there is a drought and the municipal water is turned off, it will not take long before the water storage is empty. Therefore, it is important to increase the water storage capacity at the school. The calculations and experiences of Eco Moyo are that irrigation requires a huge amount of water. The school has a dripline irrigation system, but this is not currently working. A dripline system has potential for more efficient irrigation and water conservation than manual irrigation. A working dripline system can contribute to reduced water consumption.

Users	Quantity (pers)	Food and drinks (l/pers/dag)	Hygiene (l/pers/day)	Watersupply (l/pers/day)	Total (l/day)
Students, living at the school	20	50	50	10	2200
Students, other	240	20	-	-	4800
Adm., living at the school	3	50	50	10	180
Teachers, living at the school	6	50	50	50	660
Guesthousings	20	50	50	10	1000
Cultivation	2200 (m2)	10	-	-	22000
Sum					30840

Tabel 1: Estimated wterconsumption

Recommendation:

Create a rationing plan for water during periods when neither rain nor municipal water is available. Although the storage capacity can always be increased, there are spatial limitations to collection surfaces. There are also limitations to storage time before water quality deteriorates. Proposed measures in periods when the supply of water is critically low:

- Irrigation is reduced to a minimum by installing a more efficient irrigation system. Plants that need larger amounts of water can be kept to a minimum if droughts become more common.
- Greywater is used as far as possible for watering plants (see chapter on greywater for what considerations must then be taken)
- Emphasize water saving when showering and washing - more focus on collecting the greywater that is formed. Eco Moyo currently collects rainwater from the various roof surfaces in the school area. The school has problems keeping the stored rainwater clean. Leaves, particles, and organic material come down into the tanks and pollutes the water and there have also been cases of algae blooms.

Rainwater harvesting

Eco Moyo is currently harvesting rainwater from roofs in the school area, but the school has problems holding the stored rainwater clean. Leaves, particles, and organic material is entering the storage tanks and polluting the water. There have also been cases of algae blooms.

Improving water quality

Rainwater collecting is an easy and reasonable method to store water. Removing rainwater from the ground and storing it in stone magazines or feeding it into the ground water are good options discussed in the section about water wells. This chapter addresses collecting rainwater from roofs.

Rainwater is relatively free of impurities except for atmospheric pollutants. The quality can however by reduced during the collection, storage and use in household activity. Dust and dirt that has been transported with the wind along with leaves, feces from birds and animals, bugs and contaminated waste in the catchment area can pollute the rainwater. This can pose a health risk when the water is used. Poor hygiene when storing water or using water can also be a problem. It is important that the rainwater system is well designed, has clean catchment areas and good storage solutions.

Collected rainwater has been shown to contain E. coli, especially immediately after a rain event. Several other pathogens (disease-causing viruses and bacteria) can also be found in rainwater. Rainwater still has a lower content of such pathogens than unprotected surface water. The highest concentrations of bacteria and viruses can be found in the first water that is collected after a rain

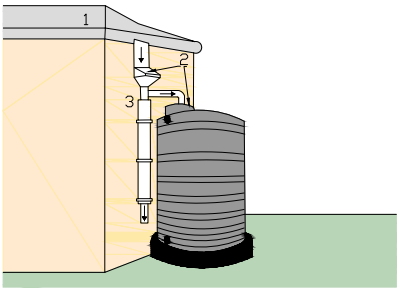
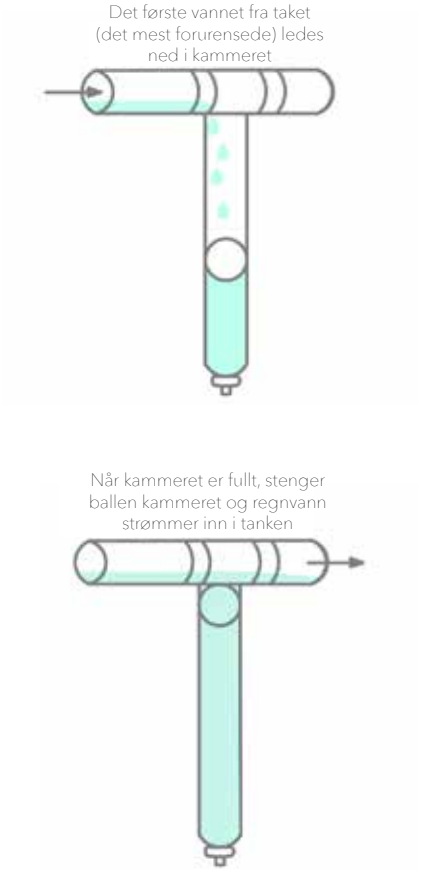


Figure 1: Standard setup for rainwtaer collection from the roof (based on Jojo's Rainwater Harvesting Solution)

Sources:
1. "Guidelines for drinking water quality, 3rd edition: Volume 1 – Recommendations" World Health Organization (WHO), 2008
2. https://www.jojo.co.za/water-storage-solutions/water-storage-solutions-rainwater-harvesting-above-ground/ (hentet 04.12.19)

Figure 2: Prinsiple for first flush diverter



shower. Concentrations decrease with time during rainfall. The rainy season is perfect since the concentrations of pathogens are greatly reduced when there are frequent rain showers that wash e.g. roof surfaces clean.

Collection tanks (or collection ponds) can be areas where mosquitoes live, and this must be considered if malaria mosquitoes are a problem in the area. Rainwater is often somewhat acidic and thus aggressive, dissolving heavy metals and other impurities from materials in the catchment area and in the storage tanks. Mostly the chemical concentrations in rainwater are within recommended values, apart from high values of zinc and lead. Zinc and lead can come from roofs or storage tanks made of metal. The collection tanks must therefore be made of a material that is ideal for contact with drinking water.

Rainwater has low values of important minerals such as calcium, magnesium, iron, and fluoride. This can be problematic if rainwater is used as drinking water in areas where the diet consists of few minerals.

Recommendation:

Improve the quality of the rainwater by implementing:

1. Regular washing of collection areas - the roofs and gutters / pipes - to prevent sediments and particles in the water
2. Mount meshing or filters at the tank inlets to prevent leaves and other contaminants from entering - these must be cleaned regularly to prevent them from clogging
3. Flush the first 20 - 25 liters of diverted roof water to prevent the most polluted water from entering the tanks. A moveable manual pipe can also be used if standardized ones are not available (see figure 2).

In addition:

- Regularly clean the tanks to remove sediments
- Cover the tanks to prevent mosquitoes from breeding. Prevent the sun from shining on the water, since this causes algae blooms. Any openings must be covered with mosquito nets.
- Avoid cracks/openings in the tanks where contaminants can easily enter. When water is drained from the tanks, it must be done in a hygienic manner.
- The tanks should be placed on a solid foundation, elevated from the terrain.
- If the water is to be used as drinking water, it should be checked regularly for the content of bacteria and heavy metals.

Increase capacity of the water storage

Currently, Eco Moyo can store approximately 80,000 liters of water at once in several tanks. Often that is not sufficient, especially in dry periods when the school needs to irrigate crops. Eco Moyo has considered establishing a larger buried storage tank at the top of the school area. This is a suitable way to collect a lot of rainwater to be distributed around the area using the existing pipe network. A buried water tank will, to a greater extent than plastic tanks on the surface, be able to keep the water cool and thus counteract algae and bacterial growth. A tank that is one meter deep, five meters wide and six meters long has the capacity to store 60,000 liters, doubling the current water storage capacity at the school. A building or a roof-covered space can be built on top of the water

tank so that the run-off from the roof leads directly down to the buried water tank.

Recommendation:

- A buried water tank should be established at the very top of the property so that the natural elevations are utilized to direct stored water downhill and as needed.
- • The water tank should be made of a material that is dense and prevents contaminants from entering the tank. Plastic or concrete reservoirs are recommended.
- • There is a constant downward fall. Water is led from the roof, through gutters and pipes, to the top of the reservoir. The outlet is placed at the bottom of the tank.
- • Water entering the tank must be as free of contaminants as possible; the measures mentioned in the chapter about improving water quality also applies here.
- • The outlet from the new water tank must be lower than the outlet from the existing water tanks at the top of the area. A non-return valve should be mounted on the outlet to the new buried tank to prevent water from existing tanks to drain into the new tank. A shut-off valve can also be installed at the outlets of both old and new tanks to control which water source supplies the area.
- • In addition to a buried reservoir that significantly increases water storage capacity, we recommend overflow tanks be installed adjacent to the existing water collection tanks around the area. Overflow tanks prevent water from being wasted if tanks in the area are already filled when it starts to rain.

Greywater management

Greywater is the part of the wastewater that comes from the kitchen, bathroom, and laundry room. Sewage water from the toilets has a separate system and is not connected to the greywater. In Eco Moyo, greywater will mainly consist of water used in cooking, water that has been used for hygiene, for washing dishes and for laundry. Normal use of products such as soap, shampoo, toothpaste, food scraps, cooking oil, dishwashing detergents and detergents is not harmful to plants and plant soil if the greywater is used for irrigation.

The most obvious contaminant in greywater is powdered detergent. Detergents contain a high concentration of salts and phosphorus. Use of water containing such detergents over long periods of time can lead to high salt and phosphorus concentrations in the soil and reduced growth propagates with low phosphorus tolerance. Areas with a regular flow of rainwater will not have as problems with buildup of the salt concentrations, as they will be flushed out regularly. Alternatives to detergents in powder form should be considered. Liquid detergents often contain significantly lower concentrations of salts.

Greywater often has a higher temperature than before it was used. High temperature causes, among other things, microbiological growth. It also has a different color and turbidity (particle content) and can therefore be difficult to reuse.

The following problems may occur when using greywater for irrigation:w

- Danger of ground contamination and polluting the underlying groundwater since greywater has a composition of many different types of chemical compounds and microorganisms. To assess the risk, it is necessary to know the composition of the greywater and the structure of the soil and the water flow in the ground.
- Clogging the pores in the soil - greywater contains larger particles or substances that can form even larger particles in the soil. This can be prevented by allowing the particles to settle before watering.
- The properties of the soil can be affected by using greywater for irrigation; the buffer capacity may decrease, the chemical composition may change, and the ability to retain contaminants may weaken. Some plants may suffer when the soil has elevated pH values and excessive amounts of phosphorus due to the greywater.

There are several problems associated with reusing untreated greywater. The risk of spreading diseases, as there are often microorganisms in the greywater, is especially important to consider if the greywater is to be used for irrigation. Pathogens such as viruses, bacteria, and parasites such as tapeworms and roundworms may be present in the greywater. These microorganisms can be transferred to the greywater during handwashing after a toilet visit. There are strong indications that such microorganisms can survive in the soil and in ponds for so long that they can pose a risk to those who work there. The microorganisms live significantly shorter on the soil surface, as they are exposed to sunlight and dehydration. Infection through greywater can occur through direct ingestion (for example on hands that have been in direct contact with greywater) or through indirect intakes that have been in contact with contaminated objects such as grass, soil or vegetables that have been irrigated with greywater. It can also be done by inhaling greywater particles that are in the air after watering.

The health risk of using untreated greywater cannot be eliminated, but can be minimized through satisfactory treatment, good management, and responsible use of the greywater. Reduced health risks are achieved by:

- Separating out laundry that has clearly been defecated on, and keeping it away from greywater.
- Avoiding the use of greywater on crops to be eaten raw
- Preventing greywater to accumulate in ponds, as this will attract insects and pests that can spread the infection.

Always wash your hands after contact with greywater. Greywater must also be of satisfactory physical quality if it is to be reused. Large, suspended particles can lead to re-sealing of the soil. Another problem can be sulfide production, which is produced when the oxygen is broken down, giving off an unpleasant odor. The overconsumption of untreated greywater for irrigation can lead to unappetizing areas of grey-green mucus. This mucus comes from soaps, shampoos, detergents, and grease. It is important to make sure that the greywater does not flow outside the irrigation area. Storage of greywater is generally not recommended, as there is potential for bacterial growth, anaerobic conditions (which create a strong odor) and environments breeding mosquitoes.

Storage of greywater in ponds is challenging and poses a health risk if not handled properly. Surface ponds with greywater along with poorly maintained greywater treatment plants breed mosquitoes. If the greywater is stored, it must be in tight tanks where mosquitoes cannot enter. If the greywater is to be collected and stored over time, it must be purified before use.

Cleaning methods

Wastewater treatment is often divided into three different levels: primary, secondary, and tertiary. We will only discuss primary and secondary cleaning methods here. Tertiary cleaning is considered too extensive and unnecessary for greywater irrigation.

Primary cleaning

Sedimentation ponds

Sedimentation ponds can be used as a solution for cleaning greywater if space is not an issue. The greywater is led to the pond and the larger particles sink to the bottom while the liquid stays on the surface and is led out of the pond. Retention time in the pond is usually long. Therefore, it is not only sedimentation of larger particles, but also an anaerobic decomposition of substances in the greywater that improves the quality of the greywater. Both sludge and sediments must be removed from the pond regularly. The sediments should be removed after the pond is emptied so that the pond has an opportunity to dry up. At least two parallel ponds are required to have continuous operation.

Sludge separator

The septic tank or sludge separator is the most common method of purifying wastewater for small and decentralized areas. It consists of a subterranean sedimentation tank with two or three chambers. The sludge that has been separated from the greywater must be pumped out regularly

Imhoff tank

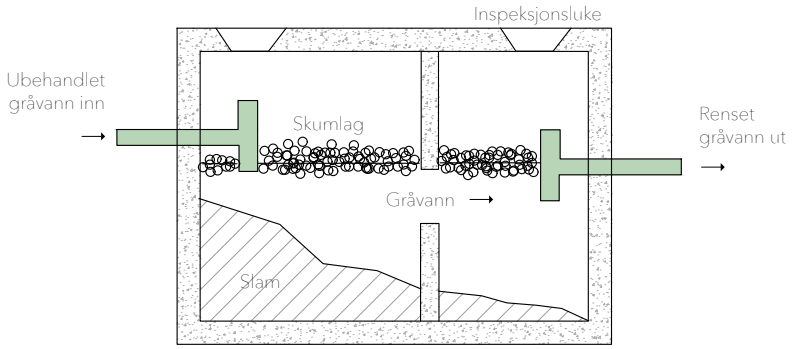


Figure 1: Principle for sludgeseperator

Imhoff tanks are used for volumes of greywater greater than three cubic meters per day. In such tanks, the sludge is separated from the liquid greywater. There are two chambers placed above each other, one chamber where the particles settle at the top, and one chamber where the sludge breaks down at the bottom. Diagonal walls inside prevent the sludge from re-entering the purified greywater.

Secondary cleaning

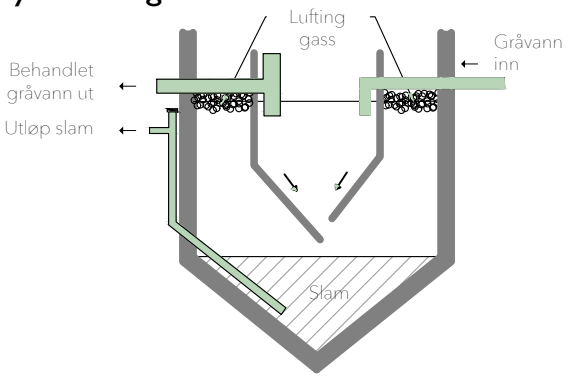


Figure 2: Principle for imhofftank

Restrained sludge separators

This is an improvement on the regular sludge separator, purifying greywater to a greater extent. They are built up like a regular sludge separator but contain two to five chambers in series with an anaerobic filter at the end. The first chamber is a sedimentation chamber, and the subsequent ones are agitation chambers. The sediments in the chambers decompose.

Fixed bed-filter

These only be used if primary treatment of the greywater has been carried out first. This filter is also built up as a sludge separator with several chambers, with a sedimentation chamber first. In the subsequent chambers there is a biological filter. This filter can remove particles and substances in the water that have not accumulated into larger particles. Greywater that is to be used for irrigation for subsoil need only have an initial particle removal and sedimentation.

Recommendation:

- For the time being, we recommend avoiding the storage of greywater due to possible health risks. Instead, implement keyhole gardening as described in the landscape chapter. Keyhole gardening not only helps in the cultivation of vegetables, but also improves the quality of the soil over time. Careful handling of greywater as described above is still important.
- If greywater is still chosen for irrigation despite the health risks, the next step may be to implement its storage and purification. The treatment process depends on how long the greywater is to be stored and what it will be used for. Area utilization and costs must also be researched. The system must then be assessed by knowledgeable engineers that are responsible for dimensioning and designing greywater treatment plants. Decentralized, heating areas must be installed.

Tabel 2: Evaluation cleaning methods

Rensemetode	Pros	Cons
Sedimentation ponds	Simple process Cheap construction Efficient for sedimentation Stabilizes the greywater and improves the quality	Takes a lot of space
Sludge seperator	Simple process Space efficient (underground) Cost-effictive metod of treatment	Not so efficient treatment of the greywater Can cause unpleasant smell
Imhofftank	Space efficient (underground) Odorless greywater after treatment Clear distinction between sedimentation and decomposition of sludge	More complicated than a septic tank Not so efficient treatment of the greywater Must remove the sludge relatively often
Restrained sludge separators	Efficient treatment Simole process Small chances of blockages Reliable and durable system Relatively cheap	Less efficint if the greywater is not especially polluted Long time to start it properly
Fixed bed-filter	Simple and durable system if it is constructed well and the greywater has alreay gone through primary cleaning Treats the greywater effictively Space efficient	High construction costs Risk of the filter getting clogged Risk of unpleasant smell from the cleaned greywater

Source:
"Greywater treatment on household level in developing countries – a state of the art review" Barbara Imhof & Joëlle Mühlemann, februar 2005.

Energy supply

The school has a greater need for electricity. Eco Moyo has grown substantially in a very short amount of time- and is still expanding. Erosion hazard and the local climate make it imperative to preserve the trees and vegetation, and not burn them for energy. That is why solar energy is the recommended source for electricity on the property. Solar panels should be mounted locally on the roofs of all the school buildings, rather than on larger farms which take up too much space and destroy the natural ecosystems.

Recommendation:

- Solar energy solutions should be established on the roofs of local buildings.
- A well-established professional key contact must be made. The contact should have knowledge about the subject, for example someone from Engineers Without Boarders (IUG) interested in developing a more detailed plan for the energy supply.noen fra IUG, for utarbeidelse av mer detaljert plan for energiforsyningen.

Waste Management

As described in chapter 2, neither the school nor the local village has a system for waste management. Some of the waste is handled locally by incineration, but it is mainly transported away from the area.

Recommendation:

- A professional with knowledge of the topic should be involved in making a more detailed plan for the waste management, for example someone from Engineers Without Boarders.

User Participation

Eco Moyo has multiple plans for the school's development. AUG (Architects Without Borders Norway) recommends user participation with the school's students and employees. The purpose with the participation is to engage the students, teachers, and employees in the development of Eco Moyo, and get input on how they experience the school grounds, how they use the area and what could be improved upon. The goal is increased knowledge about the site's values and resources. By integrating these qualities into the long-term plans for the school, we increase the general wellbeing of the users of the school.

There input can give valuable knowledge to the school's management, influencing the order of the projects to be carried out. Students and teacher input can also affect the placement of the projects and how they connect with the surrounding landscape.

Teaching at Eco Moyo
Photo: Lindsay Sanner

Depending on the ages, here are a few methods for user participation:

1. Drawing workshop, students aged 6 - 8 years old

The kids will draw their very own idea of a "Hundred Acre wood" (Winnie the Pooh reference) in Eco Moyo. The purpose is to know more about how the smaller kids experience Eco Moyo, which areas are important to them, and what kind of place names they like.

2. Name competition, students aged 8 - 14 years old.

The purpose of the competition is to acquire knowledge about how the older kids utilize the school grounds today. A feeling of ownership to the place emerges as they become involved in naming the areas or elements.

3. Questions for the teachers and staff

A short questionnaire distributed among the schools' employees can reveal how the school grounds are used, what the employees enjoy about the area and what they possibly miss.

Recommendation:

- Carrying out the user participation is important for input and feedback regarding the school's development. It should be carried out in an early phase, before future projects are started.

Summary of the strategy

Architects Without Borders Norway and Engineers Without Borders Norway have suggested a set of recommendations that is consider to be potential measures for building Eco Moyo's visjon. The recommendations are meant as a foundation for further developed in phase two. Necessary planning and analyses of the site will verify the measures. The measures in this chapter are summarized in the project list in Chapter 6.

A spatial strategy has been proposed, expanding the school with clusters of buildings around public covered outdoor spaces. Furthermore, the project group recommends an overall landscape plan that synthesizes functions such as agriculture, vegetation, surface water interventions and the improvement of the well as a whole.

A dedicated person should be hired, to further develop the school's green projects and secure a robust surface water management and agricultural initiative. Further development of the school requires an adequate water supply, so most of our emphasis is placed on studying and solving the water supply problem. Safe water supply is crucial in an area with fluctuating rain and drought. Engineers Without Borders recommends making a long-term plan for water storage and rationing during periods of drought. There should also be assessment about how greywater can be utilized better in the future, so that nothing goes to waste. Although not feasible now, greywater can be a part of a sustainable cycle for the school in the future.

Engineers Without Borders has considered possibilities for an additional water source. The conclusion is to improve the water quality in the existing well so that the water can at least be used for irrigating crops and possibly also as drinking water. Recommendations for artificial infiltration into the groundwater must be seen in connection to a plan for surface water management.

Three-, five- and ten-year plan

In summation, we recommend that the projects are prioritized by the following order:

Eco Moyo works towards all the sustainable development goals, except for number 14.

5. Project overview

The following chapter is an overview of recommended measures for Eco Moyo, visualized in this plan. The sequence of implementation is also listed since some activities are dependent on completed investigations. For example, a landscape plan with solutions for stormwater management will set the basis for later building and landscape projects. Measures are prioritized based on urgency. Short-term measures should be implemented within 1-3 years. Medium-term projects can wait 3-5 years. Long-term measures can be postponed 5-10 years until the school has funds and the needs are clearer. The project overview is meant to be a living document that is continually edited. The order can be changed if the framework is updated, for example economical issues or new needs that arise.

Priority

Short term (1-3 years)	1
Medium term (3-5 years)	2
Long term (5-10 years)	3

Project	Priority	Size (m^2)	Description	Dependence on other measures	Cost (NOK)
Buildings					
Classroom 1. grade	1	100	30 students	Systems for surface water, water- and energysupply	140 000
Classroom 2. grade	1	100	30 students	Systems for surface water, water- and energysupply	140 000
Computer lab	1	50	30 students	Systems for surface water, water- and energysupply	70 000
Common house	1	100	Common kitchen, dining area, workspace and assembly area. Can be considered as an covered outside area.		210 000
School workshop	2	150	30 students distrbuted on workshops for metal, wood, ceramic etc.		210 000
Creativity lab	2	200	The creativity lab should have space for many types of creative activities in several rooms.		280 000
Multi-purpose house	2	200	For varying purposes and events. Should be used as a covered assembly venue for students and the locals and contain a storage for equipment.	As a part of the project for underground water tank i the northwest	280 000
Teacher's housing	3	150	Extension with 6 rooms, 4 showers og 2 toilets. Indoor living room and kitchen.		210 000
Latrines	-		Extension of the latrines in line with the increasing number of students.		
Longterm development of the school	3				
Waste management plan	1				

Project	Priority	Size (m^2)	Description	Dependence	Cost (NOK)
Landscape					
Hugelkultur testlab	1		Test the hugelkultur in Eco Moyos soil and climate.	Considered in connection with the landscape plan	
Keyhole gardens	1		Test the keyhole horticulture in Eco Moyos soil og climate.	Considered in connection with the landscape plan	
Hydroponic testlab	2		Collaboration project with Ås		
Soil improvement 1: Larval composting	2		Examine the possibility for the use of larvas for composting.		
Soil improvement 2: Biocoal	2		Examine the possibilty for the use of biocoal for optimizing the agriculture		
Tree planting	2		Examine how tree planting can be a part of the schools activities and soscial engagement		
Surface water management	1		Prepare an overall longterm plan for the whole property.	Considered in connection with the landscape plan	
Footballfield 40x60 m	3	ca. 2400	Improve the conditions of today's footballfield		
Water supply					
Improvement of waterquality, rainwater	1		First flush diverter or equivalent		
Improvement of waterquality, well	1		Artificial infiltration to the ground water. Suitable methos for infiltration is decided by a closer examination of the site.	Has to be solved in connecting with the surface water management.	
Capacity increasement waterstorage: new underground tank	1		An underground magasine with the capacity of storing 60 000 liters of water.	Considered in context of the construction of the multi purpose house. The roof will be used for rainwater collection.	
New dripline system	1		Watering system for the agriculture.	Considered in connection with the school's watersupply- and storage capacity.	

Project	Priority	Size (m^2)	Description	Dependence	Cost (NOK)
Overflowtanksystem	1				
Extension of the pipe line network in line with the development.	-				
Rationing plan for water	1		For periods without municipal water and in periods of drought		
Reuse greywater 1: Keyholegardens	1		Use of greywater in the composting in the keyholde gardens	Cinsidered in context of the establishment of the keyhole gardens.	
Reuse greywater 2: Cleaning system	2		Storgae and cleaning of the greywater	Dimensioning and designing by professionals	
Energy supply					
Solar system staff room	-		Off grid solar and battery system, seven solar panels 450 watt each, four batteries 200 ah	The system can supply PCs, printers, lights and TV	
Solar system kitchen			Off grid solar and battery system, three solar panels 260 watt each, two batteries 200 ah	The system can supply lights, phone charging, PCs and other small devices	
Solar system staff housing			Off grid solar and battery system, seven solar panels 450 watt each, four batteries 200 ah	The system can supply PCs, printers, lights and TV	
Solar system visitor's area			Off grid solar and battery system, seven solar panels 450 watt each, four batteries 200 ah	The system can supply PCs, printers, lights and TV	
Staff					
Agronom / gardener	1		A full time position for further development and follow-up of Eco Moyo's landscape and agricultural measures.	Can with advantage be a part of the development of the landscape plan	1800 kr/month
Headmaster					5000 kr/month

Drone photo of the vistors area: Lindsay Sanner

6. Budget and finance possibilities










The budget for the school's operating expenses and investments in planned building construction and landscape projects are presented here. The time horizon is one to three years and the currency used is the Norwegian krone (NOK) updated in 2022. Currently, the school is 100 percent financed by donations. The role of education in ending extreme poverty and preventing the transmission of poverty between generations in the surrounding village is dependent on financial security for the running costs of the school. Flexibility and scalability for planning and budgeting is important in minimizing the risk to operational management.

Investment and running costs

The schools´ plans for project development are summed up in the overview in chapter 5. The table below shows an estimation of the size in square meters as well as an estimated cost per building. Landscape and water treatment are important measures in the strategic plan. Outdoor construction is difficult to price since the work varies in complexity, scope and use of materials. It has been calculated reasonable prices per square meter and a limited scope with estimated budget posts.

Construction costs		
Ca. construction price per m^2 per november 2022		
Buldings without power, inventory and outside area	NOK/m^2	1 400
Landscape incl. surface water management and agriculture	NOK/m^2	350
Estimated construction projects short term (1-3 år)		
900 m^2 (see projectlist chapter 5)	NOK	1 260 000
Estimated landscape projects short term (1-3 år)		
Outside areas in the new clunges: 1130 m^2	NOK	395 500
Surface water ditch, WxL ca. 1x300 m: 300 m^2	NOK	105 000
Div. outside areas incl. footballfield	NOK	150 000
Estimated construction costs		
Buildings	NOK	1 260 000
Landscape	NOK	650 500

Running costs	NOK
Annual running costs Kenya	
Average cost per student 2022*	3500
Expected annual cost with 240 students	840 000
Annual running costs Norway	
Accounting, auditing and other operational costs in norwegian	100 000
Salary manager incl. social expences	360 000
Expected annual running costs from 2022	
Running costs Kenya	840 000
Running costs Norway	460 000
Expected annual running costs from 2022	1 300 000
*incl. food, books, uniform, salaries, transport and more.	

Financial Plan

Future Sponsors

Eco Moyo depends on donations, both now and in the future. Securing new sponsors is essential. An important market is the Norwegian business community. The final section of this report lists the cost frame of the subprojects and makes it easier for potential sponsors to choose a project based on interests and price.

Design support

Architects Without Borders Norway and Engineers Without Borders Norway have assisted the Eco Moyo Education Centre with free hours in researching and designing buildings and infrastructure and will likely be able to assist with professional personnel in the future. The school has previously received design and building assistance from The Oslo School of Architecture and Design. In the future, landscape architectural design costs will probably be covered by volunteer work, and the project framework makes it possible to plan for professional assistance.

Possibilities for business development

Eco Moyo Education Centre has the potential to develop a series of spin-off business under the school leadership:

- Eco Moyo Basecamp: rental of the schools' facilities for tourism purposes
- Paid housing accommodations for volunteers
- Field trips for Folk High School students, encouraging personal growth
- School Farmers Market for locally grown produce and handcrafts

Volunteers and students
Photo: Lindsay Sanner

Eco Moyo Basecamp:

Eco Moyo Basecamp is an important business proposition that makes use of the property during school holidays. A beautiful destination filled with exciting and unique architecture, Eco Moyo has multiuse buildings can accommodate conferences, yoga classes, retreats, educational experiences, and pedagogical courses for educators in Kenya. In addition, the school has 25 guest beds in beautiful buildings that provide comfortable accommodation. Plans for community shower facilities, kitchen, and assembly areas with workplaces will add to the attraction.

Housing accommodations for volunteers

Developing a volunteer's program in Kenya offers a unique opportunity for visitors to help teachers, join skills training, garden, or work with ongoing projects. Volunteers can rent the school's visiting area for a reasonable sum.

Field trips for Folk High Schools

Folk High School students can contribute to the development of the school, be it in the teaching or in the construction projects.

School Farmers Market

An important part of the school's eco-philosophy is to be self-sufficient. The school could conduct commercial agriculture together with an in-house agronomist (see Chapter 5). Food artisans could volunteer to help student vendors. A Farmers Market at the school could sell homegrown vegetables, fruit, mushrooms, or herbs. In addition, it is easy to imagine that the school's workshops sell furniture and other items. Students not only learn a craft, but also receive instruction in marketing and sales. An important reference in this work is African Start-up and MyFarm in Gambia (see https://africastartup.org).

Recommendation:

- Invest in workshops with good tools, with experienced craftsmen to direct the project. Hire an agronomist who can participate in developing the new landscape plan. Research the demand for self-produced food: what sells, what is missing and what should the school focus on?
- Develop tourism products such as accommodations, meals and local experiences. Advertise facilities and opportunities on social media and the Eco Moyo website. Spread information about opportunities in relevant environments.
- Make the offer visible on social media and on websites.
- Develop a teaching program and advertise the scheme among Folk High Schools in Norway.

Field work for students and exchange programs

NTNU
Norwegian University of Science and Technology

INGENIØRER UTEN GRENSER

Meaningful Masters

Eco Moyo has collaborated with Engineers Without Borders since 2019.

Taking this partnership further, a pilot project was launched in early 2022. 6 students from the Norwegian University of Science and Technology to Eco Moyo came to Eco Moyo with 4 mentors to write their master thesis under the project "Meaningful Masters".

In this particular case, they investigated issues concerning water and power.

7. Key Individuals

Lindsay Sanner

Lindsay is the founder of Eco Moyo in both Norway and in Kenya. She is educated in film and TV production and has worked in the Norwegian media industry. After volunteering at an orphanage in Mombasa in 2013, she began developing the Eco Moyo school in Kenya. She has taken courses in permaculture and natural building techniques. Her dream is to continue developing a sustainable school with a green focus for children from poor families. Initially, Lindsay worked on a voluntary basis, supporting herself as a seasonal land surveyor assistant in Norway. Since January 2020, she has been hired by the Eco Moyo Education Norway association, spending about half of the year in Kenya. Lindsay is the employer for the Eco Moyo project and has contributed with text and quality control.

Maria Riddervold

Maria is educated as an architect (2014) and urban planner (2017) from The Oslo School of Architecture and Design. She has diverse experience with built forms and strategic site development. Maria is especially interested in how nature-based solutions, reuse and circular economy can contribute to the development of sustainable sites and social areas. On a day-to-day basis Maria is a freelancing architect, urbanist, and artist. Maria is a project leader for the strategic plan for Eco Moyo and has coordinated the work between "Architects Without Borders", "Engineers Without Borders" and the employer.

Jan Kazimierz Godzimirski

Jan completed his education at the Oslo School of Architecture and Design in 2018. Since then, he has produced architectural models, worked on web pages, and taught classes. In 2015 he led the organization of the world's largest architectural competition for students called 120 hours. In 2019, Jan became a member of EcoMoyo's board where he focused on the development and management of the school property in Kenya. Jan is responsible for condition assessments of existing buildings, development strategies, and coordination of new construction projects. In the Eco Moyo strategic plan, Jan has assisted the project group as a professional architect with excellent local knowledge and building experience.

Peder Eide Helgason

Peder works as Head of Mineral Resources engineering for Multiconsult Region Nord. He has worked in geotechnology for 15 years and extensive work experience. Peder is educated as a hydrogeologist and maps ground water resources and evaluates well development. His work has largely consisted of field work. He has international experience from project management in Iceland and geological mapping in Ethiopia. His role in the Eco-Moyo strategic plan has been to evaluate the existing well on the property.

Rebecca Martinsen

Rebecca graduated with a degree in Civil and Environmental Engineering from Norwegian University of Science and Technology in 2018, specializing in water and drainage technology. Today, she works at Asplan Viak in Trondheim, where her main task consists of planning pipeline network and surface water solutions at different levels of detail. She wrote a master's thesis in cooperation with Norwegian Church Aid, where she evaluated the sustainability of installed hand pumps in rural Tanzania. This involved six weeks of fieldwork in north Tanzania. The fieldwork consisted of interviews with the people responsible for water supply in the villages, technical evaluations of hand pumps, installations of water flow sensors on the pumps and an overall evaluation of why many pumps are out of order after such a short period. She has also participated in a former project with Engineer Without Boarders in Kenya March 2019. Here, the task was to evaluate an integrated water supply system. In addition, research the possibility for installing a solar array so that the entire school can be supplied with sustainable electricity. In the Eco Moyo strategic plan, she has been responsible for water supply and water treatment recommendations, as well as

Michal Jaszczyk

Michal is educated as a forest technician and landscape architect. His education has given him a good foundation for further development and practice as an arborist and landscape surveyor. He is curious about the world and how we can achieve global justice and ecological balance between people and nature. Michal has been a project worker on our Architects Without Borders team and was responsible for nature-based solutions for surface water management, improved soil quality and cultivation. Additionally, he has done research on climate and climate challenge in the area.

Grete Lyche

Grete is a certificated architect from Norwegian University of Science and Technology. She has a wide variety of experience in small-scale construction projects and executive planning, as well as a background in studies regarding human geography. This has made her scale-independent (the statistical measure of economic inequality in a population) and shaped her social engagement for humanitarian initiatives. Today, Grete works in the department of urban development at the Agency for Planning and Building Services in Oslo. During the work with the Eco Moyo strategic plan, Grete has been project assistant on the AUG-team and contributed with diverse text and illustration work. Her focus has been on the building development plan, space- and function diagram, as well as taking responsibility for completing this report.

Frida Rydland Fossum

Frida is an architect student at Norwegian University of Science and Technology. She is a member of IUG NTNU (Engineers Without Borders NTNU), where she has been working as a Master's with Meaning Coordinator and as the leader of the Project group. Frida has, with help from other members of IUG NTNU and Lindsay, been translating the Eco Moyo strategic plan from Norwegian to English.

Partners

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