COMPENDIUM ON

# NATURE BASED SOLUTIONS

## CASE STUDIES FROM KERALA

KERALA STATE DISASTER MANAGEMENT AUTHORITY

Compendium on

# Nature based Solutions

## Case Studies from Kerala

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# Summary

Earth's biodiversity and essential ecosystem services support are crucial for sustaining life on Earth - ensuring access to clean water, healthy soils, and a variety of nutritious food plays a key role in carbon storage and regulation of greenhouse gases and global climate.

Around the world, people are an integral, sometimes dominant, part of the environment. This realization has two implications. First, a key requirement for achieving the 2030 agenda lies in finding ways to meet the dual goals of conserving nature and providing for the well-being and quality of life of billions of people. Second, while conservation and stewardship certainly require acknowledging the pollution, climate change, and biodiversity loss driven by human activities, we can also tap into the considerable potential of humans, working with nature, to solve a range of environmental challenges. The need for collective action has never been greater. This report contains several inspiring stories from communities around the world, as they address and, in many cases, solve local challenges of environment and livelihoods through ecosystem-based approaches.

# Contents

# Abbreviations

| | |
|---|---|
| Eco DRR | Ecosystem-based Disaster Risk Reduction |
| NbS | Nature-based Solutions |
| DM | Disaster Management |
| DRR | Disaster Risk Reduction |
| UNFCC | United Nations Framework Convention on Climate Change |
| CBD | Convention on Biological Diversity |
| MEA | Millennium Ecosystem Assessment |
| IPCC | Inter-governmental Panel on Climate Change |

# Introduction

Human activities since the onset of the industrial revolution have upset Earth's fragile ecosystems, sparking an environmental crisis. Industrialization and urbanization have driven a relentless consumption of natural resources, leading to detrimental environmental impacts and anthropogenic climate change.

Climate change is now a pressing threat in the 21st century, worsening biodiversity loss and profoundly affecting ecosystems worldwide. The 2021 Sixth Assessment Report from the Inter-governmental Panel on Climate Change (IPCC) indicates that human-induced warming has reached approximately 1.09°C above pre-industrial levels. If current trends persist, global average surface temperatures are projected to exceed the critical threshold of 1.5°C by 2040.

While technological progress holds promise, it's widely acknowledged that technological solutions alone are insufficient to address climate change effectively. There's a growing consensus on the necessity for comprehensive, integrated approaches that account for the intricate dynamics of socio-ecological systems, prioritizing the utilization of nature to mitigate harm and enhance resilience.

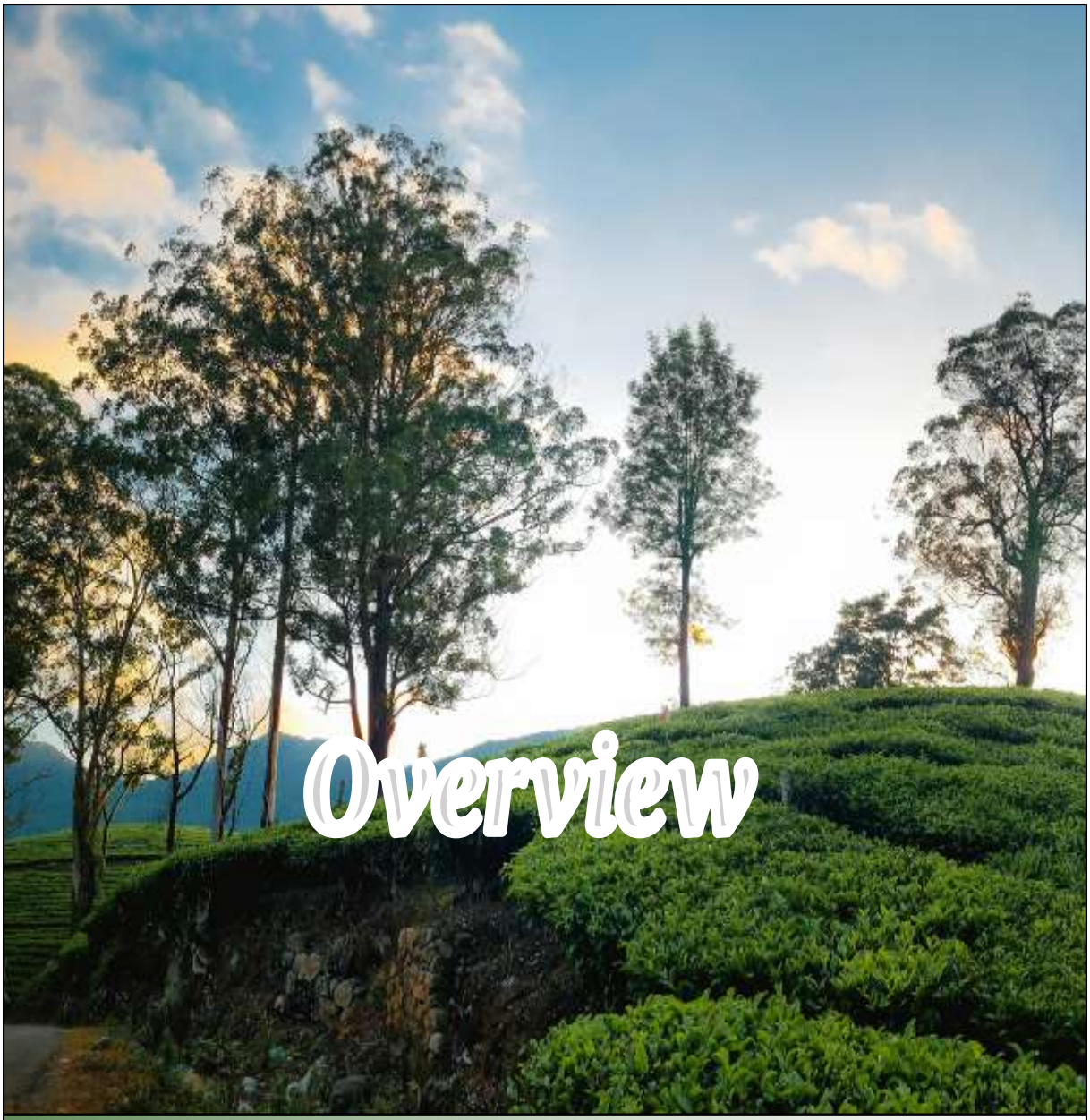
Over the past few decades, there has been a noticeable shift in perspective regarding the management of natural ecosystems and resources. The establishment of the United Nations Framework Convention on Climate Change (UNFCCC) and the adoption of the Convention on Biological Diversity (CBD) during the Earth Summit in Rio de Janeiro in 1992 highlighted the importance of integrating the concept of sustainability into natural resource management and global economic practices. With the release of scientific assessments like the Millennium Ecosystem Assessment (MEA) in the early 2000s, it has become clear that human activities have significantly impacted natural ecosystems in pursuit of economic gains. This highlights the urgent need for policy changes and concerted efforts to reverse the damage caused to our environment. Nature Based Solutions (NbS) have gained increasing attention in recent years as a way to address environmental challenges while also benefiting society. These solutions leverage the power of nature to provide sustainable and cost-effective ways to manage natural resources, mitigate climate change, and enhance biodiversity. NbS encompasses a wide range of strategies and practices, from restoring wetlands and forests to implementing green infrastructure and sustainable agriculture. By working with nature rather than against it, NbS offers a holistic approach to addressing complex environmental issues.One of the key advantages of NbS is their ability to provide multiple benefits. For example, restoring forests not only sequesters carbon and improves water quality, but also provides habitat for wildlife and recreational opportunities for communities. This integrated approach aligns with the idea of “nature-based” development, which seeks to promote sustainable growth that is in harmony with the natural environment.

The concept of Nature-based Solutions (NbS) was developed collaboratively by international organizations such as the IUCN, the

World Bank, and the European Commission. The term was first coined by the IUCN in the late 2000s. Recognizing the imperative to address the adverse effects of climate change and the risks to natural ecosystems, the IUCN introduced NbS in its position paper on the UNFCCC.

This concept underpins conservation efforts aimed at fulfilling the primary objective of the UNFCCC, which is to stabilize greenhouse gas concentrations in the atmosphere to prevent hazardous human-induced climate impacts.

As the world faces increasing environmental challenges, the importance of adopting nature-based solutions is becoming ever more apparent. By incorporating these strategies into our policies and practices, we can work towards a more sustainable and resilient future for both people and the planet.



# Overview

## Nature-Based Solutions

The principle behind NbS is the utilization of natural functions of a healthy ecosystem to provide benefits for both people and the environment. By working with nature, it is much easier to achieve solutions that are cost effective, adaptable and provide multiple benefits simultaneously. In the context of Nature Based Solutions environmental challenges can be addressed by blue, green or grey solutions.

**Blue Solutions**

These involve utilizing water bodies and aquatic ecosystems to solve environmental problems. For example, restoring wetlands and mangroves to provide flood protection, improving water quality, and enhancing biodiversity. Blue solutions can also include sustainable management of oceans and coastal areas to promote resilience to climate change and support livelihoods.

**Green Solutions**

Green solutions focus on using vegetation and ecosystems to address environmental issues. This can include planting trees to sequester carbon dioxide, reduce urban heat island effects, and improve air quality. Green infrastructure such as green roofs, urban parks, and permeable surfaces are also examples of green solutions that help manage stormwater, reduce flooding, and enhance biodiversity in urban areas.

**Grey Solutions**

Grey solutions involve infrastructure or technologies that mimic natural processes to address environmental challenges. While not strictly "natural," they are designed to work with natural systems or to mitigate human impacts on the environment. Examples include wastewater treatment plants that replicate the purification processes of wetlands, or engineered structures like seawalls and levees that provide flood protection similar to natural coastal barriers

# Approaches

Nature-based Solutions (NbS) is an 'umbrella concept' that can be implemented under the scope of a range of approaches. The International Union for Conservation of Nature (IUCN) has delineated specific approaches to ensure the effective implementation of NbS. These approaches, also known as ecosystem-related approaches, are categorized into five main groups, each consisting of specific sub-categories. The aim is to enhance the clarity and precision of NbS concepts and their practical application. This compendium adheres to the IUCN's categorization of NbS approaches and their corresponding definitions.

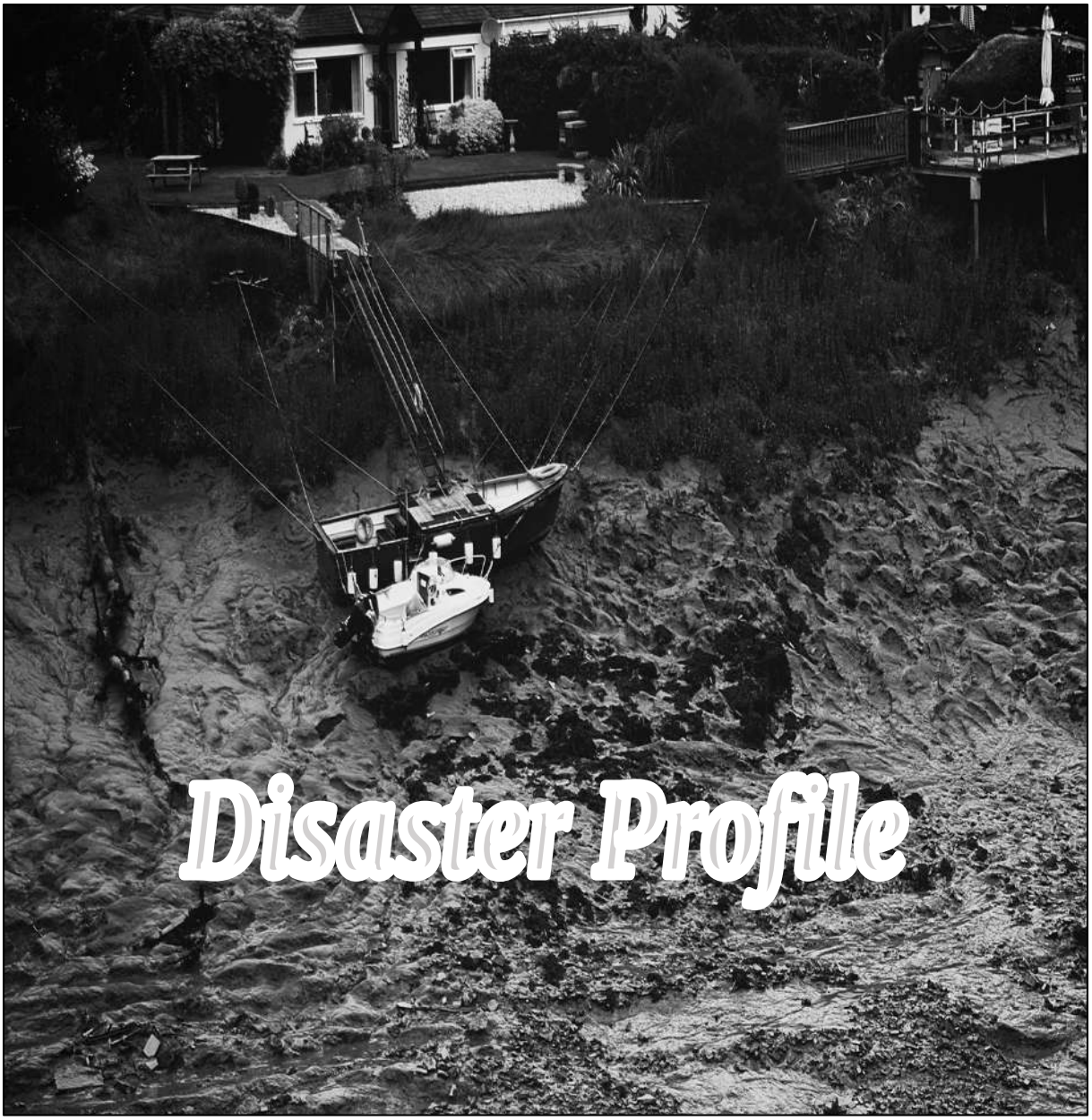
**Ecosystem-restoration approaches**
Ecological restoration / Ecological engineering / Forest landscape restoration

**Issue-specific ecosystem-related approaches**
Ecosystem-based adaptation / Ecosystem based mitigation / Ecosystem-based disaster risk reduction

**Infrastructure-related approaches**
Natural infrastructure / Green infrastructure approaches

**Ecosystem-based management approaches**
Integrated coastal zone management / Integrated water resources management

**Ecosystem-protection approaches**
Area-based conservation approaches including protected-area management



# Disaster Profile

Kerala, located in the southern part of India, and it is characterized as a multi-hazard prone region, faces a plethora of disasters that inflict significant harm on its populace and infrastructure. The state experiences heavy rainfall and flood during the southwest monsoon, with subsequent damage to life and property. Drought conditions have also become more frequent during the pre-monsoon period and at times with the failure of southwest monsoon and /or northeast monsoon. Coastal erosion along the coastal areas is very severe, necessitating frequent evacuation and rehabilitation of the coastal people.

Incidences of biological disasters such as epidemics, pest attacks are also on the rise. Fatalities in road and

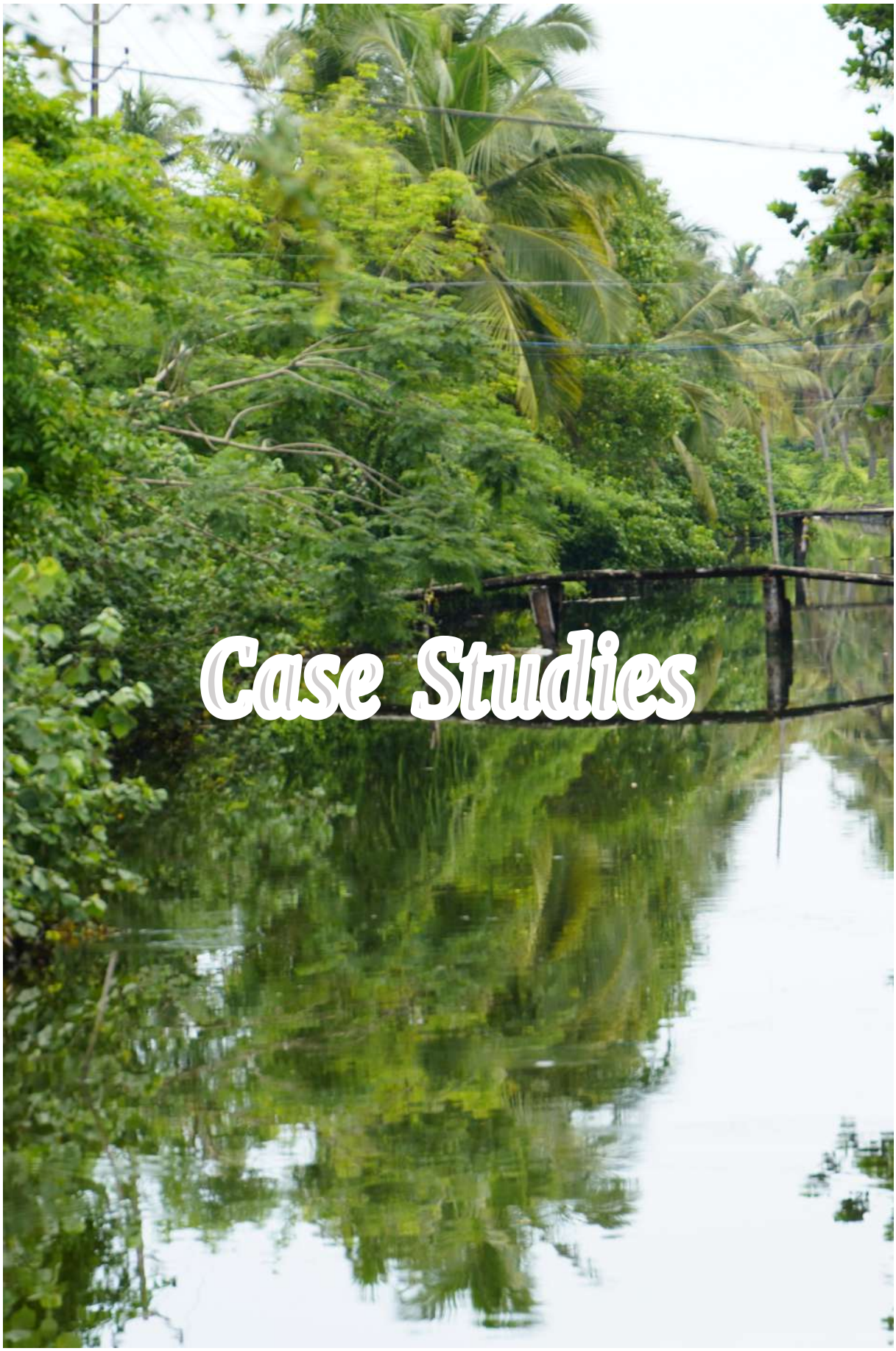
rail accidents, manmade accidents, lightning and boat capsizing are very high in the state. Landslide or landslip is another hazard of the hilly regions of the state. The tsunami that struck Kerala Coast in 2004 has added a new dimension to the disaster scenario of the state as most of the low lying and midland areas in the State are having an altitude of only 4 – 6 meters. The State is also vulnerable to cyclone and experiences high winds due to the westward movement of cyclonic storms crossing Tamil Nadu coast. The fact that Kerala falls under earthquake Zone III makes the state vulnerable to earthquakes of magnitude of 6.5 or more. Possibilities of chemical and industrial disasters and disasters like dam burst also cannot be ruled out. The threat of Global Warming and its resultant climatic variations such as inter seasonal variations in rainfall, environmental issues and rise in sea level increase the vulnerability of the state.

In conclusion, the disaster profile of Kerala serves as a sobering reminder of the pressing need to address the challenges posed by natural disasters. As the state continues to grapple with the consequences of these events, it is crucial that policymakers, disaster management authorities, and the broader community work collaboratively to enhance the state's preparedness and resilience, ensuring the safety and well-being of its residents in the face of these formidable natural threats.

# Need of NbS

Kerala, with its diverse topography and fragile ecosystems, is increasingly vulnerable to multiple and recurring disasters such as floods, landslides, droughts, coastal erosion, and extreme weather events. These hazards, intensified by climate change, unplanned development, and land use changes, underscore the urgent need for Nature-Based Solutions (NbS) and Ecosystem-based Disaster Risk Reduction (Eco-DRR) approaches. Unlike conventional infrastructure-based methods, NbS are cost-effective, sustainable, and offer long-term resilience by restoring and leveraging natural ecosystems. Forests, wetlands, mangroves, and traditional water systems such as ponds and canals play a critical role in regulating water flow, stabilizing slopes,

recharging groundwater, and reducing the impact of floods and landslides. In coastal areas, greenbelts of mangroves and vegetation buffers help in mitigating storm surges and sea-level rise. Similarly, sustainable agriculture, agroforestry, and terrace farming practices in hilly and tribal regions can minimize soil erosion and support water conservation. Integrating these nature-based strategies with local development plans, such as the Living Lab initiative in Kanichar Panchayat, can build community resilience and offer co-benefits for biodiversity, livelihoods, and climate adaptation. In the context of cascading and compound disasters, Kerala must move beyond hard engineering and embrace nature as a powerful ally in reducing disaster risks and ensuring sustainable development.



# Case Studies

# I KENI -Water Harvesting Structure
## Wayanad, Kerala

In the picturesque landscape of Wayanad, nestled in the Western Ghats of Kerala, the issue of water scarcity has become a growing concern. As a region renowned for its lush greenery and serene natural beauty, the impending water crisis poses a significant challenge to the local community and the delicate ecological balance.

The primary driver of this problem is the erratic rainfall patterns that have become increasingly prevalent in recent years. The once-reliable monsoon season has seen a marked decline in precipitation, leading to prolonged periods of drought and the depletion of vital water sources. This has had a profound impact on the region's agricultural sector, which is the backbone of Wayanad's economy, as well as the daily lives of its residents. Moreover, the increasing demand for water due to population growth and urbanization has further exacerbated the situation. The limited availability of groundwater and the strain on surface water resources have made it increasingly challenging to meet the basic water needs of the community. This has led to a heightened sense of urgency in addressing the issue and finding sustainable solutions.

To mitigate the effects of water scarcity some of the tribal communities relay on the water collection methods adopted from the old days which are completely eco friendly and crucial in ensuring a reliable and sustainable water supply. Keni an ancient perennial water abstraction structure developed by tribal communities in Wayanad district of kerala. Keni is a shallow wooden abstraction structure built in the soil zone where the water table is near or above the ground level

The tribal people use certain biological indicators to locate such places. The presence of trees such as *Vateria indica*, *Ficus virens*, and *Macaranga indica* and termite hills seen in a row are some of them. Once the site is located, it is developed by deepening to a maximum depth of 1-1.5m, and the bottom portion of the stem of the hardened palm tree, *Caryota urens*, is erected into the pit. The processing of the palm tree is usually done a year before Keni is built. The large palm is retted in

slowly flowing water so that the cellular tissues and pectins surrounding the bast-fibre bundles rot away facilitating separation of the fibre from the stem. The excellent filtration property of the fibrous palm tree is made use of to build Keni in clayey soils near the paddy field or swamps. Other than *Caryota urens*, *Artocarpus hirsute* (Anjili), and *Phyllanthus emblica* (Amla) are also used. If it was *Phyllanthus emblica*, instead of the cylindrical stem, square shaped blocks are cut and erected into the Keni. Amla blocks (Nellipalaka) are seen in wells dug in old times elsewhere in Kerala. It is efficient to filter and purify water in lateritic soil.

The water, which is tapped from a Keni, is crystal clear and the yield of the well is very high. Some of the Kenis are 600-700 years old but still yield water more than thousand liters a day throughout the year whether it is wet monsoon or dry summer. The water level in Keni is nearly constant irrespective of the season, as the Kenis tap water mainly from places where the sub-soil zone is submerged in water during most part of the year. Traditionally, the Keni water is used

only for drinking and cooking purposes by the tribal people. The tribal community considers these structures as ‘sacred’ and people are allowed to enter near the Keni only with barefoot and the water should be drawn in small clean mud pots. The premises of a Keni are always kept clean. The ‘Mullukuruma’ tribal community uses Keni water for special occasions such as festivals and marriages. It is customary to make food in Keni water in such occasions. The Keni is the property of the whole hamlet and the entire drinking and cooking water needs of the community is being met by the Keni water for more than hundred years. Tribal never use Keni water for any other domestic or recreational purposes so that the water remains unpolluted.

# II Coastal Erosion: Coastal Green Belts
## Valiyaparamba Panchayat, Nileshwar Block Kasargod, Kerala

Valiyaparamba fishing village is an island which is located in the district of Kasargod. The island is located in river Tejaswini. The island is about 16.14 square km in size. Valiyaparamba backwater is fed by 4 rivers. The island is greatly vulnerable to coastal erosion has lost most of its beach by the action of waves.

Most of the areas of Valiyaparamba panchayat face issues related to coastal erosion.Panchayat decided to alleviate the situations by using Nature based Solutions. The fund and workforce were arranged via the Mahatma Gandhi Rural Employment scheme and the threatening situation made the panchayat take action to protect the coast. Measures adopted by the panchayat included planting of Casuarina along the coast so as to prevent the erosion. They also erected sand filled geotextile bunds near the shore which were found effective to an extent. For the planting of casuarina a local nursery was set up by the villagers. They collected seeds of casuarina variety and saplings were cultivated within the nursery.

The project was done by incorporating it under the Mahatma

Gandhi National Rural Employment Guarantee Act (MGNREGA). Saplings were planted at specific locations and they are maintained until maturity. Dead plants are replaced by new ones and they were provided with shade during intense heat by woven coconut leaves. In such a way plants were nurtured until they became resilient to existing environmental conditions. Another method adopted which was the construction of bunds by the use of geotextiles which would aid in preventing the runoff of soil. Further developments in this project includes the introduction of a specific variety of plants with fibrous root systems to the geotextile to increase its strength. These methods are found to be effective and without degradation to the environment. Mangrove restoration is another initiative in which the panchayat is actively involved. The sustainable varieties of mangrove varieties were grown in the panchayat nurseries and planted in the degrading shores.

# III Rubber Check Dams
## Panathady, Cheruvathur, Kasaragod, Kerala

In the realm of environmental conservation and sustainable management, the utilization of rubber check dams has emerged as a promising solution to the pervasive issues related to flood and drought. These innovative structures, constructed primarily from recycled rubber materials, offer a unique and effective means of mitigating the detrimental effects of flood and drought. Rubber check dams, with their inherent flexibility and resilience, are capable of withstanding the dynamic forces of flowing water, while simultaneously trapping sediment and slowing the erosive process. Unlike their traditional counterparts, made of concrete or stone, these rubber-based structures are adaptable to the fluctuating nature of riverbanks and streambeds, ensuring a more harmonious integration with the surrounding landscape.

By repurposing discarded tires and other rubber products, the environmental impact of their disposal is significantly minimized, while simultaneously creating a practical and cost-effective solution to the pressing issue of drought and flood.

The first rubber check dam in Kerala was constructed at Panathady panchayath at Kasaragod district. The project was executed with the technical expertise of the Thane-based Indian Rubber Manufacturers Research Association (IRMRA). The Irrigation Department took the lead role for the execution of the project. The state government first conceptualized the project during the drought in 2017. “The drought a year ago and this year’s devastating floods have stressed the need for an effective water management system. The rubber check dams will be effective against flood control and drought mitigation. It will also be cost-effective as it has high flexibility and durability.

The working principle of a rubber check dam is both simple and ingenious. It consists of a flexible, waterproof membrane, typically made of reinforced rubber or similar materials, that is strategically placed across a stream or river. This membrane acts as a barrier,

temporarily impounding the water and slowing its downstream movement. As the water accumulates behind the dam, Water will be stored by inflating the rubber dam by pumping water into it to create a controlled reservoir, allowing for the gradual release of the excess water at a manageable rate.

One of the key advantages of the rubber check dam lies in its adaptability to varying environmental conditions. Unlike traditional concrete or earthen dams, the rubber structure can flex and conform to changes in water levels, river bed topography, and even seismic activity. This flexibility ensures the integrity of the dam, reducing the risk of catastrophic failures that can have devastating consequences for downstream communities.

# IV Application of Hydroseeding for Stabilizing Airport Runway KIAL, Kannur

KIAL is Kerala's fourth international airport located in Mattannur municipality in Thalassery taluka of Kannur district. The slopes surrounding the airport have loose soil, low organic content, high iron content and low Ph indicating acidic character. Erosion was severe during rainfall events. Formation of rain cuts could be observed which could lead to further erosion of slopes. The slopes are of approx. 1.5H;1V

Hydroseeding is a widely used technique for controlling erosion and promoting vegetation growth on bare or disturbed soil surfaces. It involves a process where a mixture of seed, mulch, fertilizer, and water is sprayed onto the soil surface using specialized equipment. The resulting mixture, often referred to as a "Hydroseed slurry," forms a protective layer that helps prevent erosion,supports plant growth, and eventually establishes a stable and sustainable vegetative cover. Here's how the hydroseeding process works. Hydroseeding offers a cost-effective and efficient solution for controlling erosion and establishing vegetation on a variety of surfaces, including slopes, embankments, construction sites, and disturbed areas. Its ability to quickly establish a protective cover and support plant growth makes it a valuable tool in environmental restoration and land development projects.

To protect the slope, they have used Hydraulically applied Erosion Control products (HECPs)- MacFlex, MacGanics and other agronomic amendments such as AquapHix, Jumpstart and Bioprime. In Phase one, they have selected an area of 400 sqm and seeds are applied on the slope. Agronomic soil tests had been conducted to determine the soil nutrients condition to measure soil's ability to supply essential elements to seeds, to recommend the amendment to improve soil and to ensure appropriate plant species selection. It has been observed that the hydraulically applied erosion control measures have significantly influenced the vegetation growth, which shall act as an erosion control measure and will function exceptionally well. The seed species have been selected based on the soil type present at site, pH, climate, type of planting, availability of local seeds. The quantities of hydraulically applied erosion control materials, soil amendments were finalized before mixing in hydro-seeder along with seeds and water in a two step process. The slurry obtained after mixing had been sprayed over the slope surface and maintenance was done by spraying water over the same to avoid drying of the material. Soon after the application of erosion control measures at site, the applied systems started showing the performance with respect to erosion control of the embankment slope (i.e, vegetation coverage). Germination started within a few weeks and grasses were visible on the treated slope.

# V

# Beehive Fence
## Pakkam, Wayanad

Human-elephant (HEC) conflict is a growing concern in today's crowded world. Human-animal conflict refers to the adverse interactions between humans and wildlife, resulting in negative outcomes for both people and their resources, as well as for animals and their habitats.

Human-animal conflict has emerged as a significant environmental and social challenge in the Indian state of Kerala, a region renowned for its rich biodiversity and dense human population. The increasing encroachment of human activities into natural habitats has led to a heightened frequency of confrontations between wildlife and local communities. This conflict not only threatens the safety of both humans and animals but also poses serious ecological and economic repercussions.

Kerala's landscape is characterized by its lush forests and diverse wildlife, including elephants, tigers, and various venomous snakes. As urbanization progresses and agricultural practices expand, the fragmentation of habitats intensifies, pushing wildlife into closer proximity with human settlements. Elephants, in particular, have been known to raid crops, leading to substantial financial losses for farmers and prompting retaliatory measures that can result in the death of these majestic creatures. Such incidents heighten tensions and contribute to a cycle of violence and revenge.

In addition to agriculture, the proliferation of infrastructure projects, such as roads and resorts, has exacerbated the issue. These developments disrupt migratory routes and breeding grounds, further constraining animal populations and increasing the likelihood of encounters with humans. The resulting confrontations can be both dangerous and deadly, highlighting the urgent need for sustainable development practices that respect the intricate balance of Kerala's ecosystems.

Efforts to mitigate human-animal conflict in Kerala must focus on eco system balance and fostering coexistence and promoting awareness among local communities.

In Wayanad the issue of human animal conflict is in the extremity. The local people especially the tribal people who are dependent on agriculture has severely impacted with this issue. Edible Forest, a start up came with an idea of bee hive fencing in the Pakkam area, near to Kuruva island, which one of the elephants' corridors.

Edible forest dedicated team conducted various researches and they were decided to implement the pilot project in the Pakkam area. Bee hive fencing involves strategically placing beehives along the perimeter of agricultural fields or human settlements. The principle behind this method is twofold: the presence of bees, along with their protective behaviors, acts as a natural barrier. Elephants are known to be cautious of aggressive bee species, and the sound of buzzing bees can evoke a strong flight response in these majestic animals. They have used millifera and Kringodian varieties for the fencing. As such, the fencing effectively discourages elephants from approaching cultivated lands, thereby reducing the potential for crop destruction and minimizing human-wildlife confrontations.The hive is placed in loop for easy hanging and water is placed above the hive to trap ants. Bee attracting plant species like crotalaria and

sunflower were planted near the areas.

This technique not only serves as a deterrent but also promotes a sustainable coexistence between humans and elephants. It encourages the protection of bee populations and fosters a sense of responsibility among local communities regarding conservation efforts. Moreover, the byproducts of beekeeping, such as honey, can provide an additional source of income for residents, enhancing their economic resilience. The dual benefits of conserving biodiversity and supporting local livelihoods render bee hive fencing a compelling solution to the human-elephant conflict in Wayanad. The people residing in the area put high confidence about this idea. They have realized the changes in the past six months. The happily growing vegetables and paddy fields are the visible evidence of the bee hive fence defence. The start up gives special care for involving the communities in the process.

# VI Vembanad Fish Sanctuaries
## Vembanad, Alappuzha

Vembanad lake also known as Punnamada is one of India's largest and longest lake with a length of 96.5 km. The lake is bordered by Alappuzha, Kottayam and Ernakulam districts. The lake is a part of the vembanad-kol wetland system which extends from Alappuzha in the south to Azheekode in the north. A unique characteristic of the lake is the 1,252 meters long Thanneermukkom salt water barrier constructed as part of the Kuttanad development scheme to prevent tidal action and intrusion of salt water into the Kuttanad low lands. This canal divides the lake into two, one with perennial brackish water and the other with freshwater from rivers draining into the lake. Major livelihood activities of the people living on the shores of the lake include agriculture, fishing, and tourism, and because of this fact ecology of the lake is largely affected. Increased fishing from the lake by use of modernized equipments have led to the depletion of several indigenous fish species. As a remedy for this crisis Atree came up with a sustainable community-based project such as clam relaying, fish sanctuary and fish survey programmes.

**Clam Relaying**

Vembanad being India's largest producer of black clams constitute about 60% of the black clam production in India. Black clam scientifically known as *Villorita cyprinoides* is an important fishing resource for the traditional fishing community of vembanad lake. Around 10,000 people are dependent on it and an average of 32000 tons of clam shells are harvested from the Vembanad lake. It is after the construction of Thanneermukkom saltwater barrage in 1970 which led to the formation of perennial freshwater zone in the southern area of Vembanad. Optimum salinity required for black clams' reproduction is 10-12ppt. The irregular operation of the barrage has altered the ecological stability of lake and has resulted in the decrease of fishery and black clam resources. Atree-CERC conducted participatory mapping of natural resources in Vembanad and detected decline in clam resource over the years. They came up with the project proposal for Department of Fisheries, Government of Kerala, CMFRI, WWF, 5 black clam societies (Muhamma, Vechoor, Aryad, Muhamma clam marketing and Kavalam), Samyuktha Vembanad Kayal Samrakshana Samithy. The thicker top layer of clams is removed for facilitating the optimal growth of clams. Through the project they aim to increase the population of black clams in the southern region by relaying baby clams from the northern part and

also ensuring sustainability of clam deposits. The project expects to revive clam deposits in Vembanad by 3-5 years through this process. The project also contributes towards enhancing the livelihood of those depended on clams. The newly deposited zones are declared as no collection zones and later opened for harvest after a stable population is established.

**Vembanad Fish Count**

VFC or Vembanad fish count is an annually practiced fish assessment by local stakeholders and communities. It is very useful in understanding the fishery and ecological trends in Vembanad. It was first initiated in may 2008 and had been continuing ever since. The event had reported over 121 species altogether and at least 60-100 species per count. This activity make use of professional as well as traditional knowledge in identification and monitoring of different species.

**Fish Sanctuary**

The rising unethical fishing practices have forced to look for sustainable fishery resource conservation practices. Fish sanctuary also known as Matsyathavalam are structures created out of bamboo, twigs and leaves. These act as fish shelters providing ideal habitats for the fishes to bread and for young fishes to hide from predators. The community declares the fish sanctuaries as a "nonfishing zone" so that fisher folk community can avoid fishing in these zones. Evaluation of fish sanctuaries have showed in the increase of economically value added fish *Etroplus suratensis* and other small fishes, water snakes and clams. Presence of large number of top predators like otters and cormorants in the sanctuary zone obviously indicate the richness of fishes. So far the SVKSS has established nearly 22 sanctuary in different parts of Vembanad lake which indicates its success of foremost securing livelihood and conservation of fishery resources.

# VII Bio Bunds
## Alappuzha

Kuttanad, a wondrous delta land cradling the shimmering Vembanad Lake, a jewel among India's Ramsar sanctuaries, whispers stories of resilience. Nearly two lakh souls call this watery haven home, their lives woven into the ebb and flow of the tides. Yet, in the dance of seasons, relentless floods arise—nature's fierce embrace—bringing upheaval, displacing dreams, and scarifying the land. These recurrent surges cast a shadow over the hearts of the people.

Conversely, Lower Kuttanad and Kayal Nilams, spreading across approximately 25,744 hectares and nestled 1 to 2 meters below the average sea level, face relentless floods. These low-lying areas suffer from ongoing silt accumulation and diminishing water-carrying capacity in their water bodies. Vembanad Lake, strained beyond its limits, struggles to contain the surging waters from tributary rivers and tidal inflows from the sea. During high tide, when the protective bunds give way, floods pour in, and without adequate drainage, they can linger for months, enveloping the landscape

in a persistent inundation.

In the wake of climate change, the threat of flooding has intensified dramatically in these regions, underscoring the urgent need for effective mitigation strategies. This article explores a proactive approach undertaken to reduce flood risks and safeguard the lives and livelihoods of those living in Lower Kuttanad and Kayal Nilams.

Traditionally, in Kuttanad, the local practice was to perpetually reconstruct the bunds by extracting clay from the water bodies. This method offered two key benefits: it enhanced the water-carrying capacity of the lakes and rivers, and it fortified the bunds themselves. During the era of the feudal system, the abundance of inexpensive labor made it feasible to build and maintain these clay-based bunds with relative ease. However, following land reforms, the rising cost of labor posed a significant challenge. In response, the community, with the support of the state, shifted towards constructing masonry bunds—more durable and resilient structures to better withstand the increasing pressures from floods and encroachments.

Thumpuram project aimed to develop a sustainability-focused intervention for constructing bunds in Kuttanad. This was done with the assistance of IIT Bombay's living lab in Alleppey named CANALPY.

The innovative design focused on building a robust bio-bund using locally sourced materials such as clay, coir fibre, and coconut wood. These natural materials proved to be much more cost-effective than traditional

stone bunds. To enhance the durability and strength of the bio-bund, geotextiles were strategically placed between each layer of clay as reinforcement. Additionally, long coconut stumps and coco logs were positioned along the outer side of the bund to provide extra stability. The construction process demanded substantial manual labor, which was efficiently mobilized through the centrally funded scheme MGNREGA, ensuring community participation and support.

A major benefit of bio-bunds lies in their capacity to preserve the carrying capacity of water bodies by minimizing the depletion of resources from the Western Ghats and the narrow rivers of Kerala. This is particularly crucial for Kuttanad, a region at high risk of floods and soil erosion. By establishing bio-bunds at strategic locations, we can address these challenges effectively, helping to protect the region's water ecosystems and promoting their sustainability for the future.

# VIII Terrace Farming
## Vattavada, Idukki

Vattavada, located in the high ranges of Kerala, is known for its unique terrace farming practices, adapted to its undulating terrain and cool climate. This traditional agricultural system minimizes soil erosion, enhances water retention, and promotes sustainable use of hilly landscapes. As a nature-based solution (NbS), terrace farming in Vattavada aligns with ecosystem-based adaptation strategies by preserving natural contours, promoting biodiversity, and reducing the vulnerability of communities to climate-induced hazards such as landslides and droughts. It stands as a model of how indigenous practices can support both climate resilience and sustainable livelihoods.

Terraces are typically aligned along the natural contours of the hillside to maximize water conservation and minimize soil erosion and the use of native plants and vegetation on terraces to further stabilize soil and enhance biodiversity

# IX Gabion Walls for Road Slope Stabilization
## Ponmudi, Thiruvananthapuram

Ponmudi is a hill station in the Peringamala gramapanchayath of Trivandraum district of Kerala in India. Ponmudi is connected to Trivandrum by a two lane highway (SH2 & SH45). The travel consist of 22 hairpin turns. The maintenance of 1000 km state highway highways and priority roads comes under the responsibility of the Road Maintenance Component(RMC) of world bank aided Kerala State Transport Project(KSTP). The maintenance of 40 km Trivandrum-Ponmudi road was done under the phase 3 of this project. The main thrust area of the project was the protection of the embankment along the river Kayyar. The embankment was at a height of 6 meter from the river bed level. The major factors leading to the destruction of embankment are the varying water level and flash floods with the movement of large boulders and rocks. The steep hills on the opposite side of the embankment also bring large overburden surcharge weight. All of these factors constitute in the destruction and failure of existing conventional rubble masonry which necessitated the requirement of erosion resilient structures.

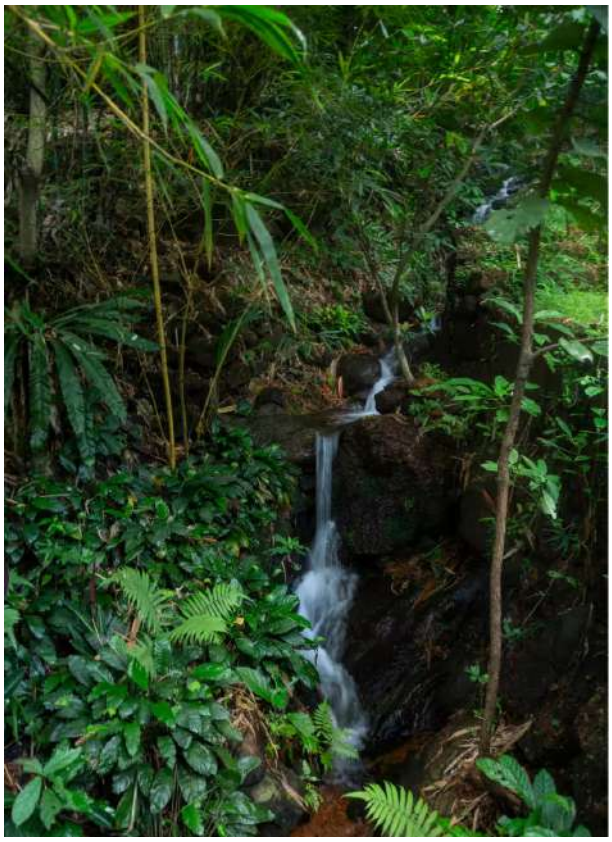
Kerala State Transport Project under the consultation of Maccaferi, ICT LTD and Kerala PWD choose the installation of gabion retaining walls as a solution. A gabion wall is a retaining wall made of stacked stone filled gabions tied together with wire. Gabion walls are usually angled back towards the slope, rather than stacked vertically. Since the foundation of the site was rocky in nature. It was difficult for the excavation of land therefore a concrete footing of minimum 300 mm thickness was provided on the rock stratum and the gabion wall was anchored to this concrete slab. The slab also provided a 6 degree angle which leads to better stability. The permeable nature of gabion wall allowed movement of water through pores reducing the pressure exerted by the water flow. They also support integration with flora and fauna which makes them sustainable and environment friendly. The gabion walls constructed in 2005 has been successful in protecting the embankment and pavements for years.

# X Green Ara: A Living Testament to One Man's Commitment to Nature

## Malappuram

Green Ara is not just a plantation—it is a thriving ecosystem born out of vision, patience, and an unwavering love for nature. Conceived and nurtured by Mr. Musthafa, a 52-year-old environmental enthusiast from Malappuram, Green Ara stands today as a powerful example of how individual effort can restore degraded landscapes and give back to the planet.

Driven by a deep concern for environmental degradation and a desire to contribute meaningfully to nature conservation, Musthafa envisioned transforming barren land into a self-sustaining forest. Determined to remain closely involved in every stage of its growth, he wanted the land to be near his home, enabling daily care and long-term nurturing. It took him nearly ten years of searching to finally identify the right property—a 5.5-acre abandoned laterite mining site in Karipur, once scarred and lifeless.



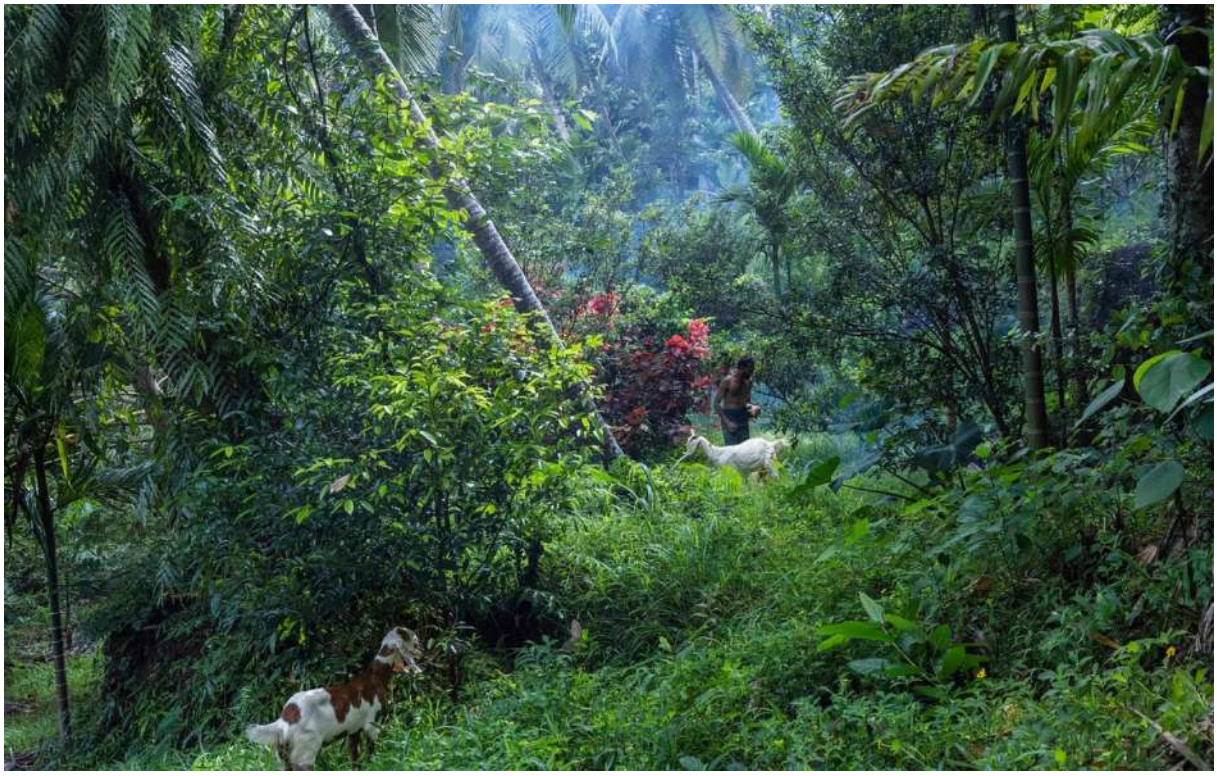
With water as the backbone, the land gradually transformed into a rich mosaic of green life. Today, Green Ara hosts more than 2,000 trees, including:

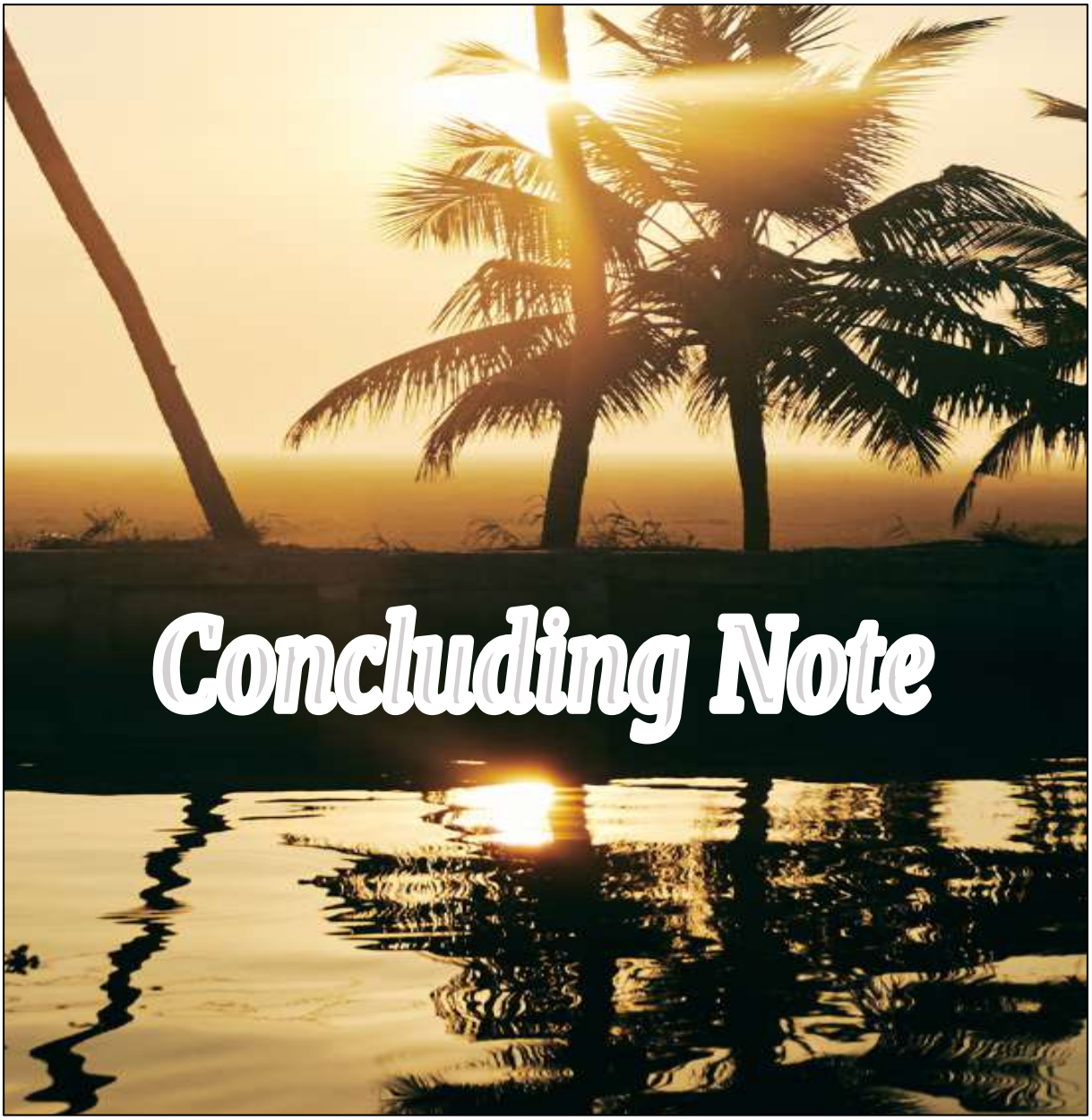
- A dense bamboo forest
- A carefully designed Miyawaki forest
- Hundreds of fruit-bearing trees
- Thousands of tropical evergreen species
- A wide variety of ornamental and medicinal plants

What was once barren mining land has now evolved into a lush, breathing forest that supports birds, insects, and countless other life forms, creating a balanced and resilient ecosystem.

Initially, Green Ara was open to the public, welcoming visitors who wished to experience and learn from the forest. However, due to increasing pollution and the need to protect the fragile ecosystem, access is now restricted and permitted only upon prior request, ensuring the forest remains undisturbed and healthy.

Green Ara stands as a living inspiration—proof that with patience, knowledge, and dedication, even the most degraded landscapes can be restored. Musthafa's journey reminds us that meaningful environmental action does not always require large institutions; sometimes, it begins with one person, one vision, and the courage to let nature lead the way





# Concluding Note

At a time when climate extremes are accelerating and conventional responses are increasingly stretched to their limits, the case studies in this compendium offer a compelling truth: nature itself is one of our most powerful and reliable allies. These experiences move beyond theory to show how living systems—rivers, wetlands, forests, coasts, and soils—can protect lives, secure livelihoods, and restore balance in landscapes under stress.

Each case study tells a story of renewal—of degraded ecosystems brought back to life, of communities reclaiming resilience, and of risk transformed into opportunity. Together, they reveal that Nature-Based Solutions are not soft alternatives to development, but robust, adaptive strategies capable of

delivering protection, prosperity, and ecological integrity simultaneously. Where concrete walls divide, nature connects; where short-term fixes fail, living systems endure.

The lessons captured here demand a shift in mindset. Investing in nature is not a choice between environment and development—it is a decisive investment in long-term safety, economic stability, and social equity. Yet these solutions require patience, stewardship, and governance systems willing to work across sectors and time horizons, guided by science and grounded in local knowledge.

As the impacts of climate change intensify, the question is no longer whether we can afford to adopt Nature-Based Solutions, but whether we can afford not to. This compendium stands as both evidence and invitation—evidence that NbS work, and an invitation to policymakers, practitioners, and communities to reimagine development pathways where resilience is rooted in nature and the future is shaped in partnership with the living world.

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