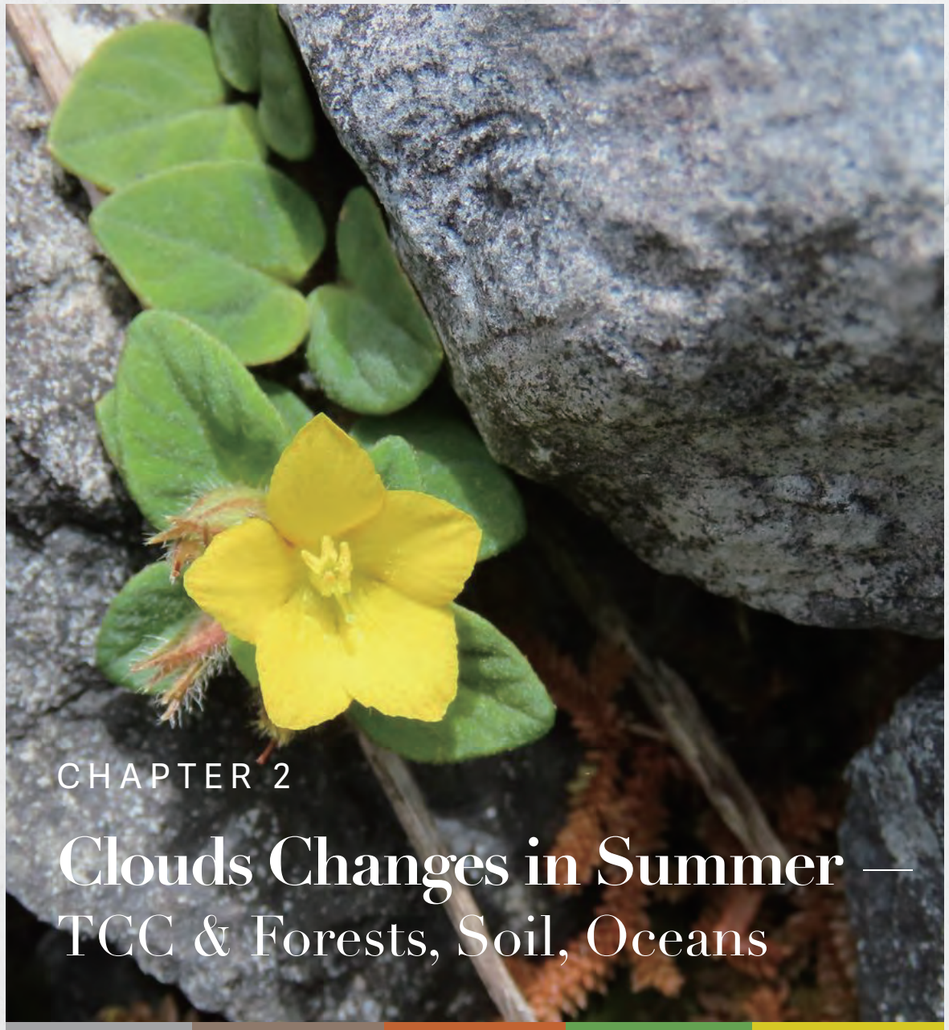


Lysimachia nigropunctata / Baolai Quarry

CHAPTER 2

Clouds Changes in Summer — TCC & Forests, Soil, Oceans

MINERAL GREY

STEMS BROWN

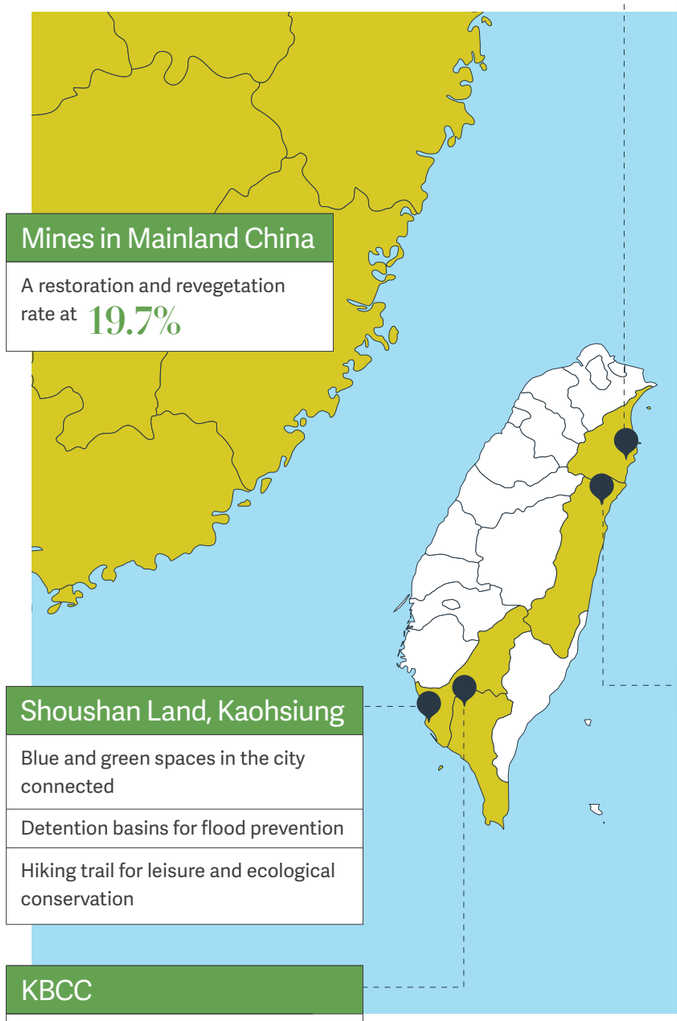
PUBESCENT REDDISH BROWN

LEAVES DUSTY GREEN

FLOWERS YELLOW COROLLA

2.1 _ Forests

2.1.1 _ TCC Forest Map – 2023



Taibaishan Mine, Suao

- Microirrigation system in Taiwan with PV and energy storage combined
- Improved windbreaks for mist interception

13.2 hectares restored and revegetated, with the rate at **61.5%**

1,121 of indigenous species planted

90% of indigenous species maintained

Mines in Mainland China

A restoration and revegetation rate at **19.7%**

Shoushan Land, Kaohsiung

Blue and green spaces in the city connected

Detention basins for flood prevention

Hiking trail for leisure and ecological conservation

KBCC

34,646 taxa
of plants conserved (endangered species included)
| as of March 31, 2024

6,500 medicinal supplies from 62 plant families provided
| as of March 31, 2024

Hoping Mine, Hualien

Low-carbon vertical shaft transport system combined with phased-excavation at hilltop platform

58,368 m³ of runoff rainwater harvested from the mine's vertical shaft

51.7 hectares restored and revegetated at the rate of **49.1%**

24,955 indigenous species planted

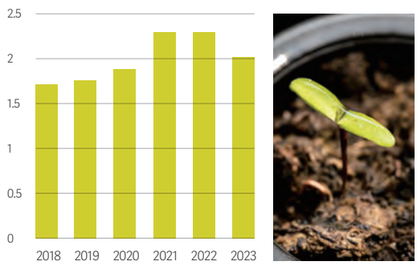
88% of indigenous species maintained

TOC % in the soil of restoration area raised by **1.3 times**
| 3 years of restoration

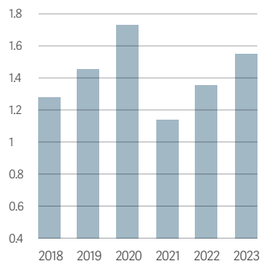
The biodiversity index

the Shannon-Weiner Species Diversity Index adopted (H'), as H' between 2 to 3 indicates a certain level of biodiversity.

Biodiversity Index of Plants



Biodiversity Index of Mammals

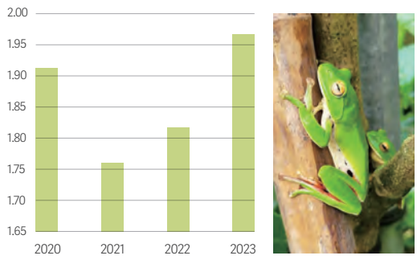


Note: The H' for the mines slightly declined in 2023, possibly due to seasonal dormancy of plants or the fluctuation of species in the natural environment.

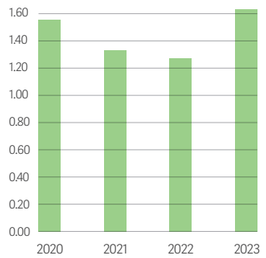
Biodiversity Index of Birds

Biodiversity Index of Butterflies

Biodiversity Index of Amphibians



Biodiversity Index of Reptiles



Note: The index is caculated for the Hoping Mine and the Taibaishan Mine

2.1.2 _ Biodiversity Plan

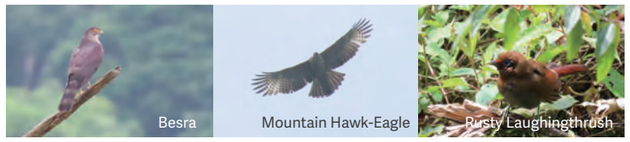
Upholding the principle of restoring while mining, TCC cultivates indigenous species in mines, and leveraging natural succession to promote biodiversity. The flora and fauna in mines are monitored on a regular basis. The biodiversity index of mines is calculated using international methodologies to evaluate the effectiveness of restoration efforts. The ecosystems in the mines are gradually recovering, aiming for the goal of No Net Loss to Net Positive Impact.

With the analysis using the Criterion I and Criterion II in the phase of Locate of TNFD for areas with high nature or species sensitivity and with potential species in the Hoping Mine (Hualien), the Taibaishan Mine (Suao), the Shoushan Land (Kaohsiung), and the Hejiayuan Mine (Anshun, Guizhou), the practices for nature and biodiversity restoration in force as well as the results and future plans are elaborated as follows.

The Hoping Mine — Hualien

Conducted the terrestrial ecological survey of the mine in 1997, passed EIA in 1999, commenced mining in 2003, with ecological monitoring performed quarterly, and implemented the forest restoration and biodiversity plan in 2016.

TNFD Locate	Responses of TCC
Ecosystem Sensitivity (H) The mine is located in the geologically sensitive area and the Environmental Conservation Zone, making it ecologically sensitive.	➧ Rigorously adherence to the red line for the mining area with no operations beyond, as the long-term monitoring results show that nearly 90% of the indigenous plant species in the mine have been maintained ➧ The soil and water conservation plan established upon commencement of mining operations ➧ Berm ditches, drainage ditches, and large silting basins created in the mine in response to the potential landslides and soil erosion caused by heavy rainfall ➧ Physical rock embankments over 2 meters high constructed on slopes to prevent direct runoff due to heavy rainfall ➧ Limestone transported with a vertical shaft system to avoid surface and human disturbances

TNFD Locate	Responses of TCC
Species sensitivity (VH) Prediction was made based on the model of the Ministry of Agriculture for the potential distribution of 9 threatened species, flora and fauna, including Eurasian Jay, Formosan Bulbul, Long-tailed Shrike, Mountain Hawk-Eagle, Lilac Daphne, Beach Morning-Glory, Rubus sumatranus, Depressed Orange, and Heptapleurum ellipticum var. ellipticum	SPECIES INFORMATION ➠ Threatened species observed in the quarterly ecological survey of the mine: including Mountain Hawk-Eagle, Rubus sumatranus, and Depressed Orange ➠ Protected species like Formosan Serow, Crab-eating Mongoose, Formosan Yellow-throated Marten, Black Eagle as well as Small-leaved Distylium, Lycopodium sieboldii Miq., and Taiwan Cow's-Tail Pine observed in the monitoring report, besides the list of potentially threatened species  Besra Mountain Hawk-Eagle Rusty Laughingthrush MEASURES ➠ Ecological ponds established as amphibian habitats and source of water for wildlife ➠ Nesting boxes for birds varied in size set up for bird reproduction

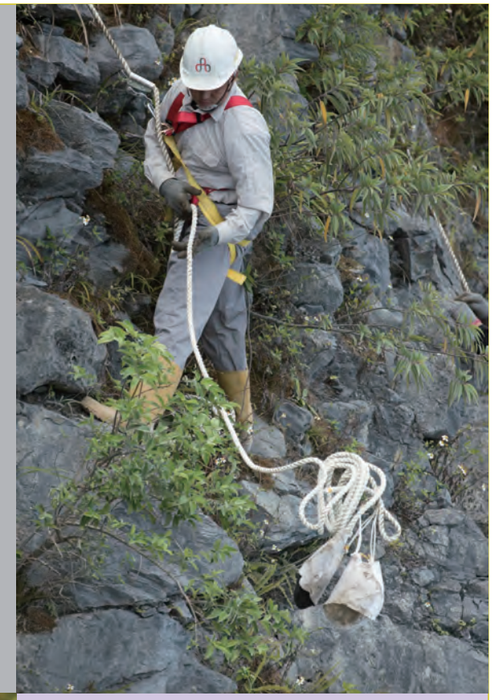
TCC has extensively cultivated indigenous species at the Hoping Mine. In collaboration with TCC-funded KBCC, plants like Yunnan Bletilla, Oriental Chain Fern, and Common Free Ferm, are restored.

In 2023, 24,955 plants were grown for restoration, with large indigenous tree species such as Formosan Alder, Ring-cupped Oak, and Formosan Ash being the majority. These plants are pioneer species in forest succession, capable of adapting to the alpine climate and accelerating soil nitrogen fixation. In addition to plant restoration, ecological monitoring and survey are carried out for the mine quarterly. Besides documenting species listed in the database of the Ministry of Agriculture, dozens of protected species, including Crab-eating Mongoose, Formosan Serow, Mountain Scops Owl, and Crested Serpent Eagle, were observed as well. Since 2022, the humid climate has been leveraged to cultivate ferns. Also, boardwalks connect ecological ponds, enhancing environmental education, where visitors can see butterflies in spring and fireflies in early summer.


Luciola cerata in Hoping Plant Pit 1

Yunnan Bletilla

Yunnan Bletilla is a rare orchid species endemic to Taiwan and native to the Hoping Mine of TCC in Hualien, which thrives on rocky slopes kissed by the sun. To restore the original ecological landscape to the mine, the mine restoration personnel of TCC replanted Yunnan Bletilla seedlings on the rock walls. Under the professional guidance of KBCC, the restoration efforts were conducted using ropes throughout a challenging process. In 2020, TCC partnered with KBCC to promote the restoration of the indigenous Yunnan Bletilla, with the aim for it to flourish once again at the Hoping Mine.



KBCC first employed the aseptic seeding technology to cultivate approximately 2,000 seedlings, which were then transferred to pots for cultivation in the nursery of the Hoping Mine for at least 6 months to adapt to the local climate. Then, in October 2020, 300 Yunnan Bletilla seedlings in good condition were selected for manual replantation back onto the rock walls of their native habitat on the principle of replantation for every five meters of mining.
TCC will continue to work with KBCC to cultivate seedlings and select suitable locations for transplantation and restoration, expanding the population and area of Yunnan Bletilla to restore the mine to its original ecological landscape.

The Taibaishan Mine — Yilan

Passed EIA in 2003, with ecological monitoring conducted every 6 months, and initiated the ecosystem restoration project in 2017.

TNFD Locate	Responses of TCC
Ecosystem Sensitivity (H) The Taibaishan Mine is located in the geologically sensitive area and the Environmental Conservation Zone, making it ecologically sensitive. Also, the strong winds for years at the Taibaishan Mine, and the karst topography, present harsh conditions for restoration.	• Rigorously adherence to the red line for the mining area with no operations beyond, as the long-term monitoring results show that nearly 90% of the indigenous plant species in the mine have been maintained • The soil and water conservation plan established, with protective netting installed on slopes to prevent soil erosion • The first-of-its-kind microirrigation system integrated with PV and energy storage; rainwater harvesting ponds • Windbreak set up to protect restored plants and enhance ecological resilience • Enhanced plant resilience with nurseries and acclimatization facility established down the mountain for replantation of flora back to the mine upon maturity
Species sensitivity (M) Prediction was made based on the model of the Ministry of Agriculture for the potential distribution of 2 threatened species, such as Rubus sumatranus and Small-leaved Distylium.	SPECIES INFORMATION • Ecological survey of the mine carried out semiannually, with no potential distribution of threatened species found • Protected species like Formosan Serow, Crested Goshawk, Crested Serpent Eagle, Lycopodium sieboldii Miq., and Taiwan Cow's-Tail Pine observed in the monitoring report, besides the list of potentially threatened species  Formosan Serow | Lycopodium sieboldii Miq. | Taiwan Cow's-Tail Pine MEASURES • Food sources for mammals, with crops such as pumpkin, sweet potato, potato, yam, taro, and chayote interplanted, as temporary distraction to keep animals from gnawing on saplings

The Taibaishan Mine faces strong winds and water scarcity due to its location and karst topography. Since 2017, TCC and Professor Ji-Wei Huang from National Ilan University have used innovative methods for restoration, including Taiwan's first microirrigation system with PV and energy storage, windbreaks, and rainwater harvesting ponds.

Initial efforts included microclimate studies and soil improvement with mushroom compost. Indigenous species were selected for restoration. The Suao Plant repurposed an old tennis court for acclimatizing seedlings. By 2023, 1,121 trees, mainly wind-resistant and drought-tolerant species, such as Subcostate Crape Myrtle and Autumn Maple Tree, were planted. An increased wildlife activity has been observed. 5 taxa of medium to large mammals, 24 taxa of birds, and 9 taxa of amphibians were detected by infrared thermal imaging cameras in 2023. Among the protected mammals, Formosan Serow is the most frequently observed species, while bird species, such as Crested Serpent Eagle, Crested Goshawk, White-tailed Blue Robin, and Green-backed Tit, have also been observed.

The Shoushan Land — Kaohsiung

Ceased mining in 1992 and became the Chaishan Flood Detention Park in 2017.

Source: Shu-Qi Yang and Keng-Yu Ku from the Landscape Architecture Department of TungHai University

TNFD Locate	Responses of TCC
Ecosystem Sensitivity (H) **Species Sensitivity (VH)** Part of the land of the Shoushan Land is located in the geologically sensitive area and the urban planning area, making it ecologically sensitive. Also, prediction was made based on the model of the Ministry of Agriculture for the potential distribution of 18 threatened species.	SPECIES INFORMATION ➟ Ecological surveys conducted before and after the transition into a flood detention park in 2013 and 2017, with the potential distribution of 1 threatened species found: Fan Palm ➟ Protected species like Crested Serpent Eagle, Taiwan Hwamei, and Brown Shrike observed in the ecological survey, besides the list of potentially threatened species ➟ An increasing species diversity of birds, fish, and aquatic insect species, gradually forming an ecosystem and a complete food chain MEASURES ➟ Mining ceased and restoration initiated in 1992 ➟ Detention basins established to mitigate flood and connect blue/green spaces in the city ➟ Hiking trails created for recreation and eco-tours ➟ Assessment for working with the Kaohsiung Wild Bird Society to continue the bird survey

At the Shoushan Land, the concept of in-situ conservation is adopted to plant indigenous plants and bring back indigenous animal species like Formosan rock macaque, along with diverse species. In recent years, Shoushan Land has undergone environmental improvements, creating the Chaishan Flood Detention Park and the Chaishan Hiking Boardwalk. Aside from being a recreational spot for Kaohsiung citizens, it offers an ecological corridor connecting the urban blue and green spaces like the Love River and Chaishan. Flooding issues in low-lying areas has been improved through the collaboration between TCC and the Kaohsiung City Government, which involved the construction of flood prevention facilities like detention basins, open channels, and pumping stations at the park, with a total flood detention capacity of 65,000 metric tons. The entire flood control project is based on disaster prevention, with the goal of transforming Kaohsiung into a livable city that puts people at the core. In addition to solving the flooding problem, the area of green spaces has been significantly increased by design to mitigate the heat island effect.

The Hejiayuan Mine — Anshun, Guizhou

Acquired the mining right in 2009 and passed the National Green Mine assessment of Mainland China in 2021.

The Hejiayuan Mine, Anshun, continues to green the mine environment and boost resource utilization efficiency, saving energy and reducing carbon emissions. It has passed the on-site review of Green Mine in a row from 2021 to 2023. In addition to revegetation works, ecological farms, ecological ponds, and employee leisure facilities have been built in the mine to enrich the ecological environment of the area. In 2023, about 0.4 hectare of area was revegetated, and 4,500 plants were planted, with cumulative 6 hectares of area revegetated.

Biodiversity Risk Assessment	Responses of TCC
Potential Distribution of the Species on the List of Three Values An analysis of the Hejiayuan Mine, Anshun, using the BIA tool recommended by the TNFD, reveals the potential distribution of 11 species listed in the List of Terrestrial Wild Animals of Significant Ecological, Scientific, or Social Value (The List of Three Values), including Black-throated Tit, Grey-capped Greenfinch, Oriental Magpie Robin, White-browed Laughingthrush, White Wagtail, Green-backed Tit, Sparrow, Daurian Redstart, Pallas's Leaf Warbler, Brown-breasted Bulbul, and Collared Finchbill.	MEASURES ➟ Ongoing attention to the mine ecology by the Anshun Plant, although species listed in the List of Three Values are not species protected by the law in Mainland China ➟ A land reclamation plan formulated, and retain topsoil from mining for temporary slope protection before backfilling for revegetation after mining ➟ Accumulation of revegetation experience, identifying plants fit for the local environment and extensive planting, such as False Acacia, Willow, Chinese Coriaria, Diverse-leaved Creeper, and Shamrock ➟ Nitrogen-fixing plants grown, and use of chemical fertilizers avoided, to restore the physical and chemical properties of soil AREA OF IMPROVEMENT ➟ A lack of species monitoring report; environmental and ecological survey of the mine required

2.1.3 _ Carbon Sink Survey & Findings

High Forest Coverage in Mines with A Growing Density

Following international conservation trends such as Nature Positive and NbS, TCC collaborated with Associate Professor Chyi-Rong Chiou's team from the School of Forestry and Resource Conservation, NTU, at the end of 2023 to conduct a survey on forest carbon sink in the Hoping Mine. By collecting metrics from the natural forest in the mine, TCC aims to establish the standards of NNL for restoration areas.

The project started with analyzing land use changes in mines, creating a matrix of land use changes since mining began, examining area changes and trends of forests, mining areas, and restoration areas in different periods.

Results show high-density forests covered 646.76 hectares (63.08%) in 2002, increasing to 788.58 hectares (76.92%) in 2022. Medium-density forests have decreased yearly due to conversion to high-density forests. Low-density forests increased slightly in 2015, then decreased annually. Bare land and grassland areas also declined, gradually returning to forest. Mine restoration areas have risen, with a 213% increase in 2022 compared to 2002.

The Carbon Stock of Natural Forests in Mines Higher than That of Asia Tropical Rainforests

After analyzing the past and present land use of mines, TCC started the survey of natural forest carbon sinks of mines. Due to the steep terrain, convenience sampling was adopted, randomly selecting areas easier to reach at varied altitudes as sample areas. The survey team set up 40 sample plots in the natural forests and restoration areas in the mines, among which 10 were selected for an expanded monitoring of plant growth to analyze carbon sink.

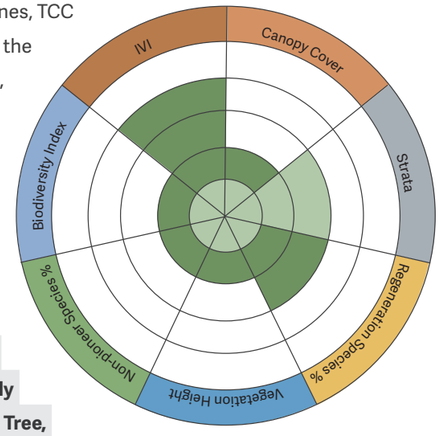
The preliminary analysis results show that the carbon stock of the Jinchang Quarry in Hoping Mine is about 123.21 tons per hectare, which is nearly twice that of Daan Forest Park and also higher than the average of 121 tons per hectare of the tropical rainforests in Asia.

REGION	CARBON STOCK (ton C/ha)
The natural forest in the Hoping Mine	123.21
Daan Forest Park[1]	39.49-65.84
Experimental forest in Liugui[2]	153.7
Tropical rainforest in Asia[2]	121
Tropical rainforest in Brazil, South America	137- 200

Reference
1: Lin, K., Duh, C., Hsu, C., & Huang, C. (2006). Aboveground Carbon Accumulation of Subtropical Natural Broadleaf Forests in the Liukuei Experimental Forest of Southern Taiwan.
2: Lin, Y. (2022). Carbon Sinks Potential of Urban Trees in Daan Park.

The Recovery Wheel Assessment System Introduced, Assessing Restoration Progresses with 7 Indicators

In addition to the survey of natural forest's carbon stock in the mines, TCC has introduced the "Recovery Wheel" assessment system by the Society for Ecological Restoration (SER). 7 localized indicators, i.e., canopy cover, non-pioneer species %, strata, vegetation height, regeneration species %, biodiversity index, and Important Value Index of Indigenous Species (IVI), were set based on survey results. With the indicators of natural forests in mines as a benchmark, the recovery status of restoration area is assessed.



13 years restoration area has shown grown in all indicators except strata compared to one year restoration

According to the analysis results, compared with the new restoration area at 1,020m, the canopy cover of the restoration area at 1,160 m after 13 years of restoration increased by nearly 50%. Non-pioneer species like Acuminate-leaf Eurya, Milk Fig Tree, and Largeflower Deutzia are observed. The growth percentage is nearly 20%. The IVI increased by 1.5 times, and the biodiversity index has risen from 0.93 to 1.75, indicating a significant restoration result.

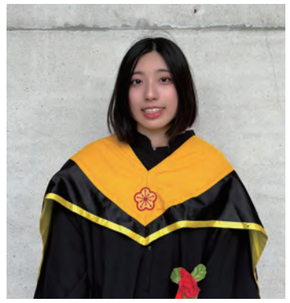
MINE ELEVATION	1,020 M (1 YEAR OF RESTORATION)	1,160 M (13 YEARS OF RESTORATION)
Canopy Cover The vegetation coverage in the sample plot (%)	**37%**	**83%**
Strata The vegetation composition in the sample plot is visually assessed to evaluate the strata structure. The more strata there are, the more conducive it is to the coexistence of different species in the same habitat, thereby promoting biodiversity.	**Two layers** (floor stratum; shrubs)	**Two layers** (floor stratum; shrubs)
Non-pioneer Species % Classify the shade tolerance of different species into level I to V and calculate the percentage of species with a shade tolerance level of III or above. The abundance of non-pioneer species symbolizes the length of forest succession. The more non-pioneer species there are, the more mature the succession is.	**10%**	**29%**
Vegetation Height The average height of vegetation with a DBH ≥ 5cm	**1.87 meters**	**6 meters**
Regeneration Species % It is calculated as the percentage of species with a DBH ≤5cm in the sample plot to the total number of species. A higher regeneration species percentage indicates that the sample plot is mainly composed of seedlings, with fewer large trees present.	**100%**	**71%**
Biodiversity Index Shannon-Weiner Species Diversity Index adopted	**0.93**	**1.75**
IVI The average coverage and frequency of indigenous species are calculated. A higher IVI indicates a greater number of indigenous species in the sample plot.	**65%**	**98.7%**

Reference: Yi-Hsin Rao (2024). Applying quantitative indicators to evaluate ecological restoration results in mining areas - A Case Study of Taiwan Cement Hoping Mining Area

Restoration Areas on the Path to Natural Forests

TCC will continue monitoring the 7 indicators to assess the performances of the restoration areas. The interim report shows the restoration area at 1020 m is mainly composed of Griffith's Ash, Tall Fleabane, and Summatra Fleabane, and the area at 1160 m is mainly Miscanthus sinensis var. glaber, Tuberous Sword Fern, and Large-flower Deutzia. A higher proportion of shade-tolerant species, such as Largeflower Deutzia and Acuminate-leaf Eurya, begin to appear and thrive at 1160 m. There are also seedlings of Milk Fig Tree and Chinese Spice Bush. The overall species composition is beginning to change. In the later stage, to increase the tree cover, species with a higher shade tolerance, such as Phoebes and Fagaceae may be considered. These dominant species of natural forests can serve as important references for restoration tree species, with the goal of gradually advancing towards natural forests, from NNL to NPI.

Since working on carbon sink investigation in the Hoping Mine, I have visited the mine nearly 10 times so far. I cannot help but marvel at the rich species composition of the forests in the mine. Although identifying tree species really takes quite an effort, it's also gratifying to see such a complex ecological makeup in this place. Sometimes, we even spot traces of Formosan muntjac and Formosan serow on the ground. I find it is very meaningful to be able to participate in the investigation and record the achievements of conservation effort.



Additionally, when I first saw the restoration area, I was quite taken aback. While mining operations were ongoing, the restoration on the cliffs had turned into an entire small mountain, which was quite astonishing at first glance. Every year, new seedlings are continuously planted, and the restoration has been ongoing for 20 years. It is evident that TCC has invested considerable effort, time, and money into restoration work. By conducting these investigations of the restoration areas, we can also provide specific suggestions on areas for improvement. Hoping that through the results of these surveys, we can contribute to the restoration efforts.

Yi-Hsin Rao, Graduate Student, School of Forestry and Resource Conservation, National Taiwan University

2.2 _ Soil

2.2.1 _ Mine Soil under Microscopes

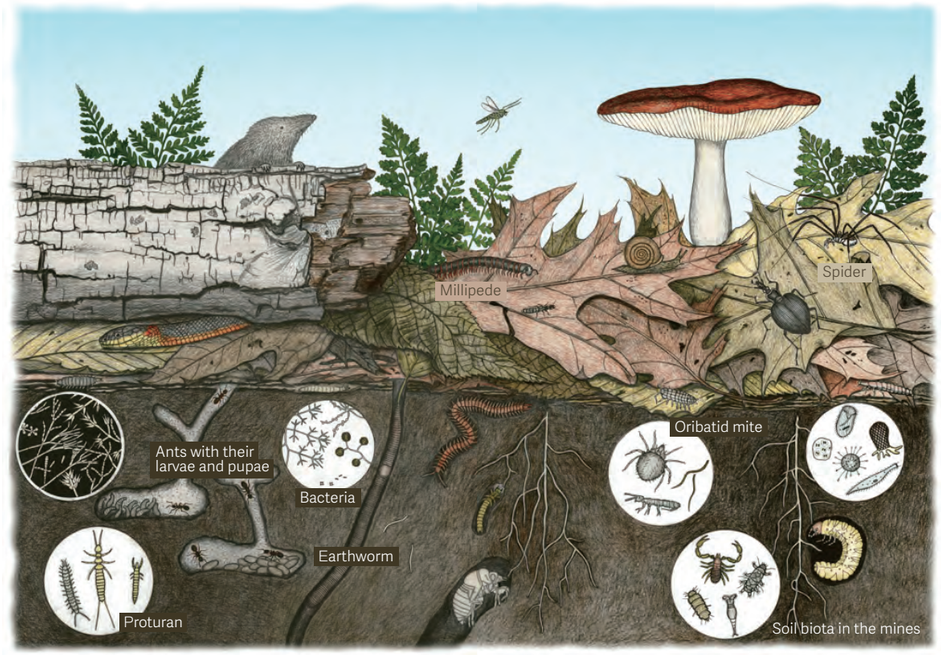
"We believe the lives of all living beings have always been interconnected, coexisted and codependent for survival. In the ecosystem, creatures such as germs, insects, animals and plants rely on one another to survive. Around the world, 95% of food are from the soil and there are 60% of biological species that were discovered within the soil. In a natural environment, one cubic meter of soil is the home to hundreds of billions of bacteria, hundreds of millions of protists, millions of nematodes, hundreds of thousands of mites, as well as insects, spiders, and earthworms."

"Furthermore, soil is the most important carbon sequestration source in the world, which we know little about, nevertheless."

~Nelson An-ping Chang, Chairman of TCC

Soil Invertebrates in the Mines – 2024 Survey Report

In the area at 1160 m that has been under restoration for over 10 years, the total organic carbon (TOC%) in the soil exceeds 5%. The presence of typical soil fauna such as earthworms and springtails indicates that the greening works have indeed restored part of the ecosystem services of soil.



Reference: Life in the Soil: A Guide for Naturalists and Gardeners. By James B. Nardi.

2.2.2 _ Soil Fauna & Survey

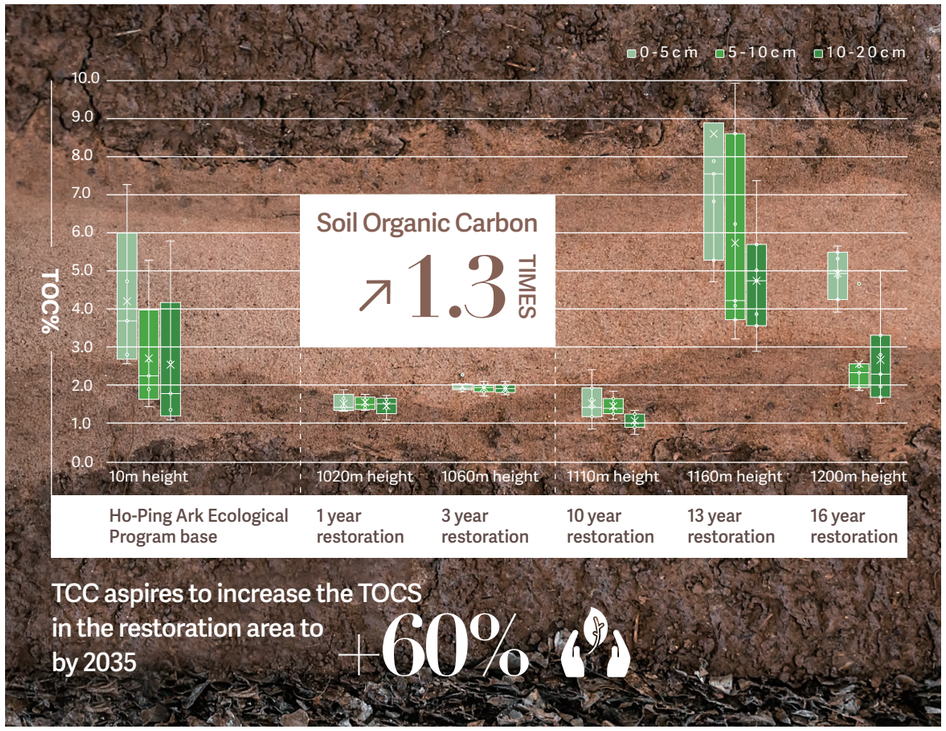
There are more living organisms in 1 teaspoon of healthy soil than there are people on Earth. Over 95% of our food comes from the soil. “Land degradation, desertification and drought are not only arid nation problems. They are global problems.” On World Environment Day 2024, Inger Andersen, Executive Director of UNEP, launched the “Generation Restoration” initiative, calling on states to pay attention to soil issues.

In 2022, TCC launched the globally rare Ho-Ping Ark Ecological Program at the Hoping Mine. Also, in 2023, TCC commenced the soil fauna and carbon sink survey in the mine. Soil fauna account for at least a quarter of all life on Earth (almost all of which are invertebrates) and provide critical solutions to issues in agriculture, environmental protection, climate change adaptation, human health, medicine, and pollution remediation. Soil biodiversity and the ecosystem services it provides are the most important keys to the success of the UN Decade on Ecosystem Restoration (2021-2030) and the Post-2020 Global Biodiversity Framework, announced in 2020, representing effective and truly NbS from the field to the world.

Establishing Base Year Data of Carbon Sink & Biodiversity

The soil survey in the Hoping Mine stemmed from the aim to capture the changes in soil after restoration following mining, hoping to tweak the benefits of restoration in line with soil properties. For over a decade, the mine restoration team has been constantly experimenting various techniques and methods for mine restoration, such as collecting the original soil and then reapplying it as a base for tree planting after mining, or using organic fertilizers to improve soil quality. In 2023, TCC worked with an expert team to investigate the soil carbon sink and biodiversity of the Hoping Plant and the mine, establishing their base year data.

At the project’s start, the expert team engaged in capacity-building training for employees executing BMPs, with an emphasis on sampling techniques. Then, at the Ho-Ping Ark Ecological Program base (10 meters elevation) as well as in the mine restoration areas(1,000-1,200 meters elevation, 1 to 16 years restoration), the project team collected soil samples up to a depth of 20 cm using the fixed-area core method, with 5 sets of samples collected from each sampling point. The samples underwent analysis for physical and chemical properties like soil bulk density, pH value, electrical conductivity, organic matters, total carbon and nitrogen concentrations, as well as the composition of soil fauna and microorganisms.

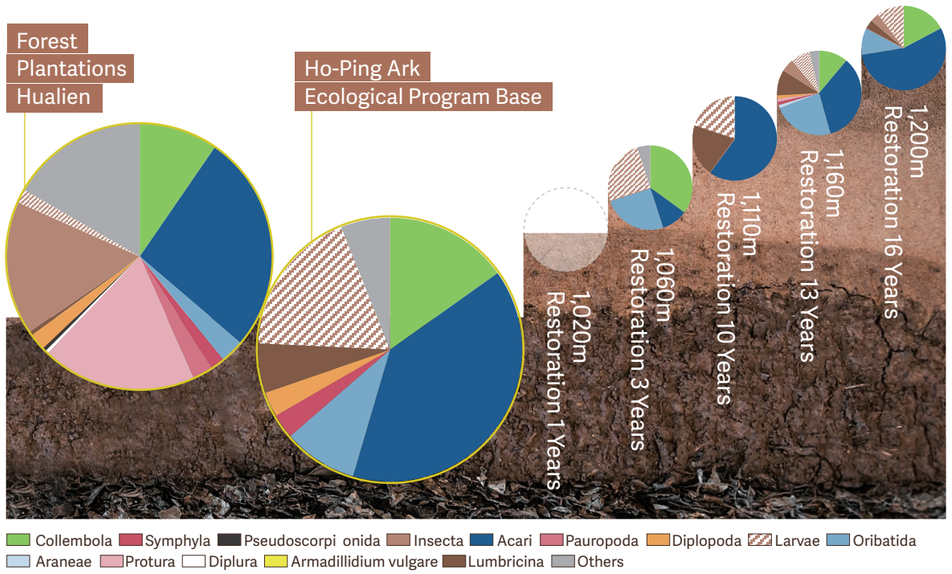


Soil Restoration in 2021-2023 with the TOC% Raised by 1.3 Times

The preliminary survey and analysis results in 2024 revealed that the soil of the Hoping Mine, which has been restored for 16 years starting from different years, has a higher TOC% compared to the urban park environment. In particular, the area that has been restored for 3 years, after topsoil coverage and revegetation, has seen an increase in the TOC% by 1.3 times compared to the latest restoration area, indicating enhancement of soil sequestration after restoration management. In addition to surface soil organic carbon, the project also probes into soil carbon stock. The analysis results show that the total organic carbon stock (TOCS) of the soil in the restoration area in 2023 is 31.2 tons per hectare. Aiming for 49.3 tons of TOCS per hectare in the Ho-Ping Ark Ecological Program base that is without human disturbances, TCC aspires to increase the TOCS in the restoration area to 60% by 2035.

Typical Soil Fauna Observed after 10 Years of Restoration, with a Biodiversity Index Close to That of the Forest Plantations in Hualien

Recent research highlights soil biodiversity as crucial for soil quality. To understand the composition and density of medium-sized invertebrates, sampling was done in secondary forests of the Ho-Ping Ark Ecological Program and 10 lowland forest plantations in Hualien. Safe sampling surveys were also conducted in natural forests near the mine. The 2024 interim report shows that, except for the 1020 m restoration area, where no soil fauna was found, longer restoration periods lead to more diverse soil fauna. The biodiversity index of the 13-year restored area reached 1.903, similar to Hualien's artificial forests. Symphyla, Pauropoda, and springtails were found. These typical soil fauna usually only appear in more complete soil ecosystems, suggesting that after years of restoration, the mine's ecological environment has improved, and the soil ecosystem services are gradually being recovered.



2.2.3 _ Ho-Ping Ark Ecological Program

TCC has been promoting the Ho-Ping Ark Ecological Program since 2022. Led by KBCC CEO and Professor Chia-Wei Li, the program invited the teams led by soil expert Dr. Chiao-Ping Wang and by Associate Professor Chih-Han Chang from the Department of Life Science, NTU to help establish a semi-closed experimental base in the Heping region. Innovative ecosystem modeling and studies, including monitoring changes in the physi-cochemical and biological properties of soil, understanding the interactions between soil and local flora, and the critical significance of soil's ecosystem functions in the material cycles, are carried out, with the aims to understand the role of soil in carbon and nitrogen cycles and accumulate long-term observation data as the foundation for future ecosystem restoration in mines. **Through the experimental ecosystem symbiotic model, the program may prevent ecological collapse and biodiversity loss, in quest of the ark for human survival amidst impacts of climate change.**

In 2023, alien species were removed from the base, skynets were set up, and a water system was deployed, in an attempt to create different micro-environments in the base. In particular, it has planned to introduce Arace-ae plants to the humid and semi-shaded environment in the base's peripheral. Taro, a member of the Araceae family, has been the staple food of the Austronesian people since ancient times and is an indigenous plant. In addition, Araceae plants present medicinal potential, such as promoting nerve repair after brain injury, which may promote human well-being. The program planned to introduce more than 100 taxa of Araceae plants into the ark.

In 2022,
KBCC transplanted 500 orchid plants
to the base and deployed
the water supply facility around.

In 2023,
the base removed alien species
and introduced 970 plants of 108 taxa to actively restore the local ecology, continue to observe the evolution of plants returning to the wild, in search of potential solutions for the human race and the environment.

The program site is approximately 1.45 hectares, located in a secondary forest in the Heping region. The basic site survey has been completed, and pillars and skynets have been installed. Over a hundred Taipower electric poles have been reused.
Increase the habitat heterogeneity utilizing dead branches and fallen woods within the base, observe the decomposition of different woods, measure the microbiota at different decomposition stages, and estimate the overall carbon sequestration.

Japanese Soil Fauna Expert Exchanges with TCC Team

Time: November 2023

Participants: Professor Satoshi Shimano, the soil expert from Japan; the team led by Dr. Chiao-Ping Wang from TFRI; the team led by Associate Professor Chih-Han Chang from the I the Department of Life Science, NTU; the restoration team of the Hoping Mine; the TCC Office of Responsibility and Sustainability

The Hoping Mine restoration team learned soil sampling techniques in early 2023 and expected to improve their abilities to identify and classify soil fauna. Therefore, TCC consulted with Dr. Chiao-Ping Wang and Associate Professor Chih-Han Chang, inviting Professor Satoshi Shimano, a Japanese expert in soil fauna taxonomy, to Taiwan to exchange with the restoration team of the mine.
During the 3-day workshop, Professor Shimano used samples of urban parks and botanical gardens provided by the teams of Dr. Chiao-Ping Wang and of Associate Professor Chih-Han Chang, along with soil samples from the mine, to introduce the teams to the taxonomy and specimen preparation of soil fauna. Employees also invited Professor Shimano to the Hoping Mine to observe the results of mine restoration and to seek advice on soil sampling. Professor Shimano also shared the habits of different soil fauna groups and suggested collection locations for different biomes. Through the 3-day workshop, the restoration team enhanced their soil fauna survey capabilities, hoping to further their soil restoration efforts in the mine.

2.3 _ Oceans

2.3.1 _ The EcoPort You Don't Know

2021-2024 ---------- FUTURE

Hermit Crabs' Home

Shell Exchange Station, planning extended to Hanben Ocean Station

Fish and Shellfish Survey Project

During the coral survey and transplantation, CITES-listed giant clams were found. Survey will be conducted, records compiled, and distribution maps created to develop future conservation plans.

Constructed Wetland Project

Little Tern Restoration Project

At the southern beach of the Heping River estuary, the Hoping Power Plant protects little tern nesting sites by blocking vehicle access, reducing disturbances to egg-laying and chick-rearing. This area is planned for little tern habitat education projects, making it ideal for conservation.

Hoping EoPort, part of the TCC 3-in-1 Park of EcoPort, Power Plant, and Cement Plant, originally featured a sandbar coastline. To preserve the eastern coastline, it was designed with inward excavation, making it Taiwan's only inward-dredged port. This design prioritizes environmental considerations, creating a habitat for corals and marine life.

The cross-industry symbiotic model of "3-in-1 Park" integrated the Hoping EcoPort, Hoping Cement Plant, and Hoping Power Plant, becoming a zero-waste, low-carbon production park rare seen in the world. Strict environmental controls are in force at the Hoping EcoPort.

The water quality at the Hoping EcoPort is Class-A Water certified by the Ocean Conservation Administration (OCA), which is equivalent to the waters of the Penghu Islands.

Certification of the Port Environmental Review System of EcoPorts (PERS) for the 3rd time in 2023

the APSN Green Port Award System(GPAS) certification

In the fish survey

a total of 207 species of 39 families of fish
were recorded across four seasons

In the shellfish survey

660 shellfish of 10 species from 8 families
were recorded across four seasons

IN 2023

+713 corals
newly transplanted

1,001 corals
restored at the Hoping EcoPort to date

An overall **rehabilitation rate** close to **90%**

2.3.2 _ The Coral Restoration & Rehabilitation

Corals cover only 0.2% of the ocean but provide a home for a quarter of marine life. TCC values coral restoration. Traces of coral were observed in Hoping EcoPort ten years ago. In 2020, Hoping EcoPort initiated a coral species identification survey and found coral fragments on the shallow-water dolosse in the port. It was inferred that this might be due to the lack of stable substrate in the growth area. Therefore, in 2021, TCC partnered with the Eco-Angel Environment Conservation Association. Combined with TCC's core business in cement, the Bio Cube Coral Creation Project was executed to expand the coral restoration area in the port.

Bio Cube Coral Creation Project

TCC collaborated with the Eco-Angel Environment Conservation Association in 2021 to deploy bio cubes at Wharf N2 with relatively small impact from wind and waves in the port. Utilizing the core industrial technology of TCC and its low-carbon cement as the base material, coral fragments broken off due to natural factors or port waves are transplanted to bio cubes. In addition to attachment opportunities for corals, the microporous nature of cement material also supports algae, serving as a food source for other marine life and enriching the marine ecosystem.

Coral Planting Project with Grating Plates

In 2023, the restoration team expanded the coral creation scope. By establishing elevated grating plates at the Wharfs S1, S3, S4, and N1 in the port, it provides a more stable base than the revetment, preventing coral from dying from silt coverage. By January 2024, all coral habitat creation works were completed, with cumulative 1,001 corals transplanted. The survival rate of coral seedlings reached 80% (some corals were eliminated due to competition for living space), with the restoration area expanded to 4 times. The elevated coral habitats are conducive to observing and documenting restoration results. Hoping EcoPort will also assess the possibility of allowing the public to participate in coral planting, encouraging people to engage in marine conservation issues.

After years of restoration efforts, the bio cubes' "inhabitants" have tripled, with 25 Acropora species dominating 38% of the area. Coral identification on grating plates is expected to conclude by 2024. Although restoration with coral fragments is of asexual reproduction, the project team reconstructed the home of corals, enabling corals to reproduce sexually. Working with the National Dong Hwa University, the Hoping EcoPort keeps tabs on the coral spawning in the port and observes coral growth quarterly.


Dendronephthya sp.

Sister Coral

Ying-Ling Chen, Secretary-General, Eco-Angel Environment Conservation Association

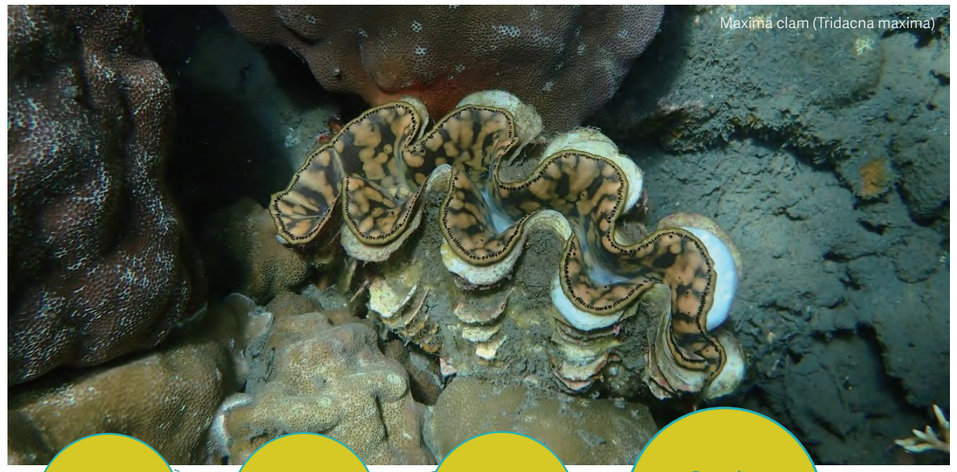
From the perspective of Earth's evolutionary history, climate change is a normal phenomenon.
The environment is constantly shifting, and all creatures are continuously growing.
Only through change can there be sustainability.

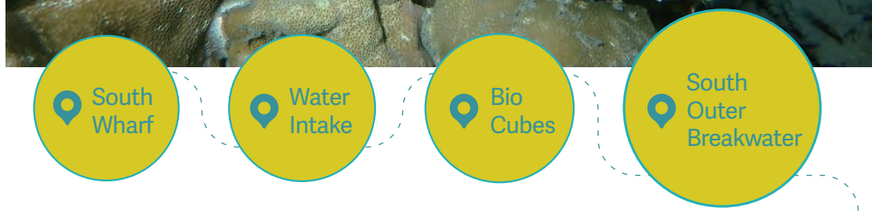
Situated amidst these changes, humans often feel compelled to take action, but the resulting impact is often beyond their control.
Having planted various corals, however, I would ask myself: What is the purpose of this endeavor?
To expect the world to remain as it was seems impossible!

However, I believe that when habitats are abundant, the mountains, forests, and oceans shall continue to nurture all life, including us the human race.
Since we must act, let us move towards the coexistence with life!

2.3.3 _ Survey of Fish & Shellfish

Tridacna (giant clam), the home for Ariel in the animation The Little Mermaid, is the largest bivalve mollusk in the world. It is also a crucial environmental indicator, primarily inhabiting coral reefs in clear, sunlit waters. Tridacnae were surprise visitors to the Hoping EcoPort, spotted at the section of bio cubes in 2023. To comprehend the ecology of the coral reefs in the port, Hoping EcoPort commissioned a team from TUMT to conduct an ecological survey of the fish and shellfish at the coral hotspots in March 2023. The quarterly ecological survey was carried out for four times in a year.

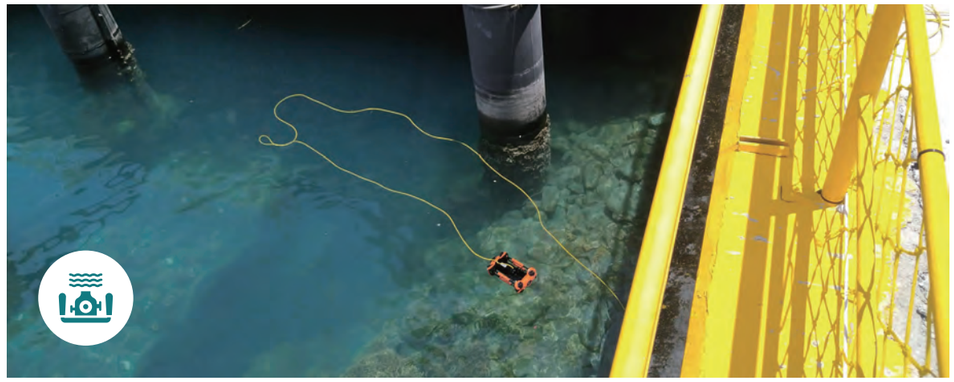

Maxima clam (Tridacna maxima)



Biodiversity Differences among Four Sample Sites

The research team set up four sample spots around the port: South Wharf, Water Intake, Ecological Block, and South Outer Breakwater, each representing different marine environments.

- The South Wharf, inside the port, is most affected by operations.
- The Water Intake, near the Hoping Power Plant, is less affected.
- The Bio Cubes, made of TCC's low-carbon cement, provide a habitat for marine life.
- The South Outer Breakwater, closest to the open sea, is least affected by operations.



The biodiversity Index is Highest at the Bio Cubes Site

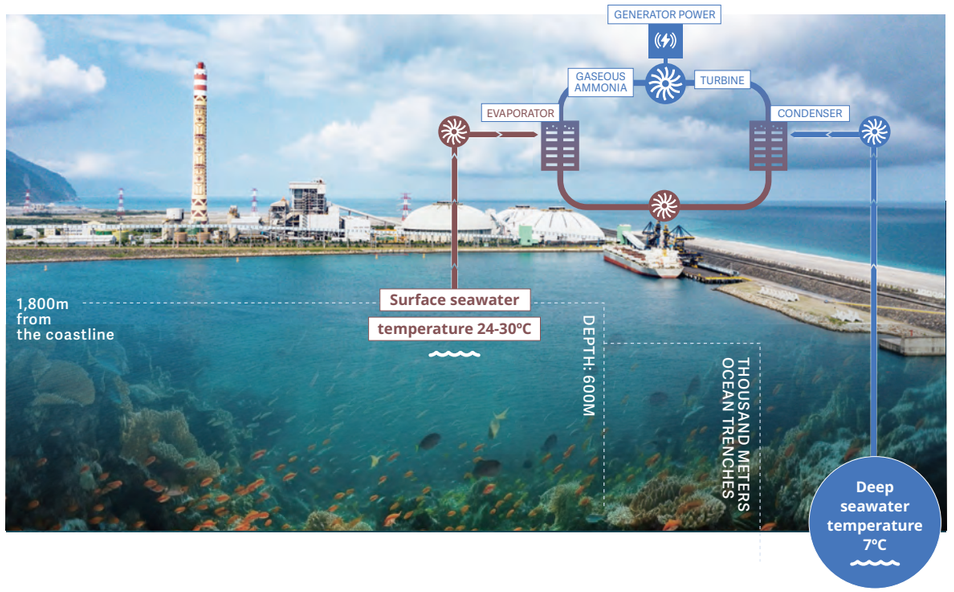
Survey personnel went scuba diving and used underwater visual census (UVC) as primary methods, with underwater cameras aiding species identification. Fish and shellfish were identified at each site, documenting species distribution and numbers. Results showed the South Wharf had the lowest biodiversity due to frequent cargo activities and ship berthing. The other three sites had similar species numbers, with the Bio Cubes showing the highest biodiversity index and most shellfish, indicating that the coral habitat restoration has successfully attracted more "residents" to settle in the Hoping EcoPort.

	FISH	SHELLFISH	Biodiversity index
South Wharf	1,789 fish of 127 species from 28 families	130 shellfish of 5 species	3.96
Water Intake	2,874 fish of 157 species from 32 families	129 shellfish of 6 species	3.75
Bio Cubes	2,791 fish of 158 species from 34 families	213 shellfish of 8 species	**4.03**
South Outer Breakwater	2,977 fish of 164 species from 35 families	188 shellfish of 4 species	4.00

2.3.4 _Development of Marine Resources

OTEC in Taiwan's Waters

Taiwan, rich in marine resources, sees ocean energy as a promising renewable source. Ocean Thermal Energy Conversion (OTEC) is particularly promising, operating continuously unlike solar and wind energy. Eastern Taiwan's unique coastline, with a 600-meter-deep trench just 1.8 km offshore, is ideal for OTEC. TCC and its subsidiary, Hoping Power Plant, are applying for Taiwan's first large-scale OTEC system. If completed, it will be the world's only MW-class OTEC plant, generating 24,000 kWh daily, enough for 2,000 households. The underwater cultural heritage survey is done, and the ecological survey for the EIA is ongoing. The first phase aims for 1-2 MW capacity, with grid connection by 2028.



Byproduct of Power Generation: Mineral-rich Deep Seawater

Deep seawater, untouched by sunlight, is rich in minerals and is the most nutrient-rich and pure water source on Earth. After being extracted for OTEC and discharged back to the ocean, it can drive the circulation of precious marine minerals and trace elements like magnesium, zinc, selenium, and germanium, vitalizing the food chain. Thanks to its purity, deep seawater can also be used for premium fish and lobster aquaculture. Furthermore, since its osmotic pressure is similar to human body fluids, deep seawater is easily absorbed and utilized, with applications in drinking water and skincare products. The value-added applications of deep seawater will be assessed and developed following a stable OTEC operation.