Final Project Report(to be submitted by 15th September 2022)

Instructions:

- Document length: maximum 10 pages, excluding this cover page and the lastpage on project tags.
- We welcome the submission of Annexes (i.e. bachelor or master thesis, references, species lists, maps, drawings, pictures) to further HeidelbergCement's understanding and future use of your findings, however they will not be reviewed by the Jury, and we kindly ask for these to be sent separately to the National Coordinators.
- Please use the attached template for species data collected during the project and submit with the project report.
- Word/PDF Final Report files must be less than 10 MB.
- If you choose to submit your final report in your local language, you are required to also upload your final report in English if you wish to take part in the international competition.
- To be validated, your file must be uploaded to the Quarry Life Award website before **15th September** 2022 (midnight, Central European Time). To do so, please log in, click on 'My account'/ 'My Final report'.
- In case of questions, please liaise with your national coordinator.
- You should not publish additional private information in your final report (e.g.: address, day of birth, email-address, phone number), just complete the categories we ask for below under "Contestant profile".

The final reports should comprise the following elements:

For research stream projects:

- Abstract (0,5 page)
- Introduction :
  - For projects that are building upon a previous project, write a summary of actions that were already completed in the previous project.
  - Project objectives
- Methods: a detailed description of the methods used during the project is required.
- Results: the results of the project should be outlined and distinguished from the discussion.
- Discussion:
  - Results should be analyzed and discussed with reference to region/country taking into account other publications.
  - Outline the added value of the project for science and for the quarry / company.
  - Recommendations and guidance for future project implementation and development on site is requested. Where possible, please mention the ideal timing and estimated costs of implementation.
- Final conclusions: a short summary of results and discussion.

For community stream projects:

- Abstract (0,5 page)

- Introduction
    - For projects that are building upon a previous project, write a summary of actions that were already completed in the previous project.
    - Project objectives
    - A short description of the site and the team members and the targeted audience of the project.
- Actions and activities: a detailed description of planned or implemented actions and outreach activities done to elaborate the project, list of stakeholders involved.
- Discussion:
    - Project teams should discuss the pros and contra and illustrate experiences.
    - Outline the added value of the project for biodiversity, the society and the quarry / company.
- Deliverables: practical implementation and development recommendations of the project are required. Where possible, please mention the ideal timing and estimated costs of implementation.
- Final conclusions: a short summary of the project findings and discussion.

1. Contestant profile

▪ Contestant name:	**Pascal John Matugura**
▪ Contestant occupation:	Researcher
▪ University / Organisation	UDSM
▪ Number of people in your team:	**2**

2. Project overview

Title:	Study of soil seedbanks, aboveground vegetation and species regeneration in the Wazo hill quarry
Contest: (Research/Community)	Research
Quarry name:	Wazo Hill Quarry

Abstract (max 0.5 page)

The restoration program in Wazo Hill quarry has been ongoing with success for over a decade now, however only ex-situ conservation measures are devoted properly. In order to achieve further goals of restoration and biodiversity conservation, it is necessary to complement both ex-situ and in-situ conservation measures in a proper way. This study aimed at investigating intensively the in-situ conservation measures particularly the Soil Seedbanks and their influence on Aboveground Vegetation and Specie Regeneration on the Restored, Unextracted and Self –regenerating regions within the quarry. Nest-quadrant sampling technique was used along pre-established transect lines (6 transects each 0.75km) for Vegetation and Specie Regeneration assessment. Randomly collected soil samples (240 Samples) were collected from three different depths (0-15cm, 16-30cm and 31-45cm respectively) from the restored and unextracted regions. Through Seedling Emergence Method (SEM), the Soil Seedbanks were assessed from the collected soil samples.

The data collected in the field were summarized in Excel and then analyzed using R and SPSS software. Pearson Correlation Coefficient was employed to compare the similarities between the aboveground vegetation, regenerating species and their respective Seedbanks. Paired Sample t-Test was used to compare indices of diversity, evenness and richness between the three regions The soil depth of (0-15cm) had the highest seedling diversity, evenness and richness from both the Restored and Unextracted regions. The study found a high correlation between the Soil Seedbank and both the Aboveground Vegetation and Specie Regeneration. Pearson Correlation coefficient values of ($r= 0.82$ $df=48$ and $p<0.05$ for aboveground vegetation) and ($r=0.76$, $df=48$ and $p<0.05$ for specie regeneration). Germination ability found in the study indicates high potential of regenerating. High level of similarity between the existing species and soil seedbanks confirm the potential to regenerate and also indicate influence of soil seedbanks in determining the vegetation structure. We concluded that if soil seedbanks will be used in an appropriate way,they have a great potential to regenerate thus they will not only restore the past vegetation but they will also conserve the genetic diversity of the quarry.

Text in Arial 10

Final report (max 9 pages)

INTRODUCTION

Soil seedbanks are a form of in-situ conservation of seeds in their natural environment. All viable seeds present in the soil or mixed with soil debris constitute the soil seedbanks and it reflects the cumulative effects of many years of plant and soil management (Ndubaru and Fadayom, 2006). They are a potential source of regeneration and replacement of the current vegetation in future due to the fact that they represent the stock of regeneration potential in many plant assemblages (Elizabeth et al, 2006)

Aboveground vegetation, Specie regeneration and Soil seedbanks have strong positive coupled interrelationship in many ecosystem and they depend on each other to ensure that the genetic diversity of a particular vegetation community exists through succession. The restoration process within the quarry involves two main processes: soil refilling, tree planting and raising. The soil used to refill the area preserves the seedbanks. This study will suggest an appropriate ways of refilling the land by regarding the soil depth with maximum seedbank diversity, richness and evenness so as to offer maximum specie regeneration within the quarry. This will not only increase the restoration rate but also conserve the genetic diversity of this quarry

Objectives of the study

The main objective was to assess the Soil Seedbanks(Underground vegetation), Aboveground vegetation and Specie Regeneration and their interrelations within the quarry.

Specifically the study:

- Determined the soil depth with maximum species diversity, richness and evenness
- Assessed the influence of Soil Seedbanks on both Specie Regeneration and aboveground vegetation
- Determined the Vegetation and Soil Seedbank characteristics of the quarry: diversity, richness and evenness

MATERIALS AND METHODOLOGIES

Description of the study site

Wazo Hill quarry is located in Kinondoni district, Northwest of Dar es salaam region Tanzania, East Africa. It is found between 6°34´South and longitude 39°23´ East

Climate

The climate of the area is controlled by movement of the Inter- Tropical Convergence Zone (ITCZ) between 20°South of the equator (Marchant). The climate is Monsoonal and characterized by high temperatures and humidity in dry and rainy seasons respectively. The average rainfall ranges from (1000- 1900mm) per year (Climatesmps,2009)the rainy season starts from March to June followed by relative cool seasons between June and August and then followed by short rains between September and November thus Bimodal. The average daily temperature ranges between (24°-32°c)

Methodologies

- Vegetation sampling

Vegetation sampling was done to assess the aboveground vegetation and self-regeneration. Vegetation sampling was done to three different communities: restored region, unextracted region and the self regenerating region.

A reconnaissance survey was first carried out to the three vegetation communities. A total of six transects of 0.65km length each were laid out (2 transects in each vegetation community). The distance between the transect lines was 1km. along each transect, six nested quadrants were systematically established after every 100m. Three levels of sampling were employed in the field:

- 25× 20m quadrants for trees
- 5× 2 m quadrants nested in the bigger quadrants for shrubs
- 2× 0.5m quadrants for herb layer, seedlings and grasses

A total of 1.8ha was covered during the sampling process. The collected information included: specie identification and individual trees, shrubs, grasses, herbs and seedlings. Most of the plants were identified to species level in the field when it was possible, whereas unconfirmed species were mounted and taken to the UDSM Herbarium for identification by matching with the herbarium specimens. Relevant Flora Guide Books; Flora of Tropical East Africa (FTEA) and Flora Zambezica (FZ) were used also in species identification within the quarry

- Soil Sampling

Soil sampling was done to two vegetation communities: unextracted and restored regions. Soil samples were randomly collected from three different depth (0-15cm,16-30cm and 31-45cm respectively). A total 240 soil samples were collected from both regions whereby each soil sample weighed 0.75kg thus summing up to 180kg for all the soil samples. The collected soil samples were used to assess the soil seedbanks through the seedling emergence method whereby they were watered once daily and the emerging seedlings were identified and recorded. Identification was done after every 1ten days. After identifying the seedlings, the identified seedlings were uprooted to offer a room for other seedlings to germinate.

Control samples with only sterilized sand were set alongside to detect contamination by wind dispersed agents during the study. The specimen whose identification was difficult, were mounted and taken to the UDSM herbarium for identification. Flora Guide Books were also used in the identifying the seedlings. Seedling assessment stopped when soil samples showed no further changes (became constant)

DATA ANALYSIS

The data collected in the field were summarized in excel and then analyzed using R and SPSS Software. Pearson correlation coefficient(r) was employed to compare (a) similarities between aboveground vegetation and their respective seedbanks (b) similarities between regenerating species abundance and that of soil seedbanks of the natural region. Soil seedbanks of the unextracted region were used under the assumption that the soil seedbanks were responsible on regenerating the self regenerating region. Species diversity of the three vegetation communities and soil seedbanks were calculated basing on Shannon and Wierner Diversity Index (H´) based on the formula

$H' = - \sum(p_i \ln p_i)$ whereby

$P_i = n_i / N$, the number of individuals found in i'th species as a proportion of the total number of individuals in all the species and ln = Natural logarithm. The shannon –wierner diversity index was used under the assumption that each individual species are sampled randomly and that each representative specie was given an equal chance of being included at every sampling point. A paired sample t- test was used to compare indices of diversity, eveness and richness

RESULTS

Overview

In characterizing the species regeneration, soil seedbanks and aboveground vegetation, the study provides description on species composition, diversity indices, species richness and eveness indices and made comparison between existing vegetation , regenerating species and their respective seedbanks. As for germinating soil seedbanks, the study determined soil seedbanks with maximum density and diversity of the emerging seedlings

Aboveground vegetation description

There was a notable difference in plant species composition between the natural and restored regions on basis. The family fabacea was dominant in both restored and unextracted regions(8 and 6 species respectively. A total of 32 species were recorded from the unextracted regions compared to 28 species from the restored region

The common species of both communities were 12 :*Dalbergia melanoxylon,Azadirachta indica, Leucaena leucocephala, Senna siamea, Ricinus communis,Acalpha indica, Grewia forbesii, Lannea stuhlmanii, Pyllantus amarus, Asystacia gangetica,Panicum trichocladum and Flueggea virosa*

Richness (species per plot) and diversity was high on the unextracted region(table 03) while eveness was high on the restored region than in the unextracted region. This is a result of the nature of the plants planted during restoration

Table 01: Summary of species data from unextracted and restored regions

Community	No. of species	No. of families	No. of genera	Density(individuals)
Unextracted region	32	17	26	551
Restored region	28	15	23	365

Table 02: Dominant families and species

Community	Families	Species
Unextracted	Fabaceae and Anacardiaceae	*Sclerocarya birrea, Grewia forbesii, Flueggea virosa and Lannea stuhlmanii*
Restored	Fabaceae and Caesalpiniaceae	*Leucaena leucocephala, Casuarina equisetifolia, Senna siamea and Peltophorum pterocapurm*

Plant species richness and diversity was high in the unextracted regions compared to the restored region, however eveness was high on the restored region compared to the unextracted region. Both diversity, eveness and richness was significant in the two regions within the quarry (table 03)

Table 03: statistical summarry of the aboveground vegetation

Parameter	Unextracted region	Restored region	t-value	DF	P-value	Conclusion
Diversity	2.5± 0.06	2.2± 0.08	0.0385	48	0.0385	**
Richness	14± 1.0	11± 1.0	2.402	48	0.0364	**
Eveness	0.59± 0.014	0.65± 0.01	2.431	48	0.0329	**

** significant

Specie Regeneration

The self regenerating region was esserntially dominated by seedlings and saplings rather than poles and trees. A total of 14 species were recorded from ten families. Twelve families out of them were present in the unextracted region while only 6 sprcies were common to the restored region.

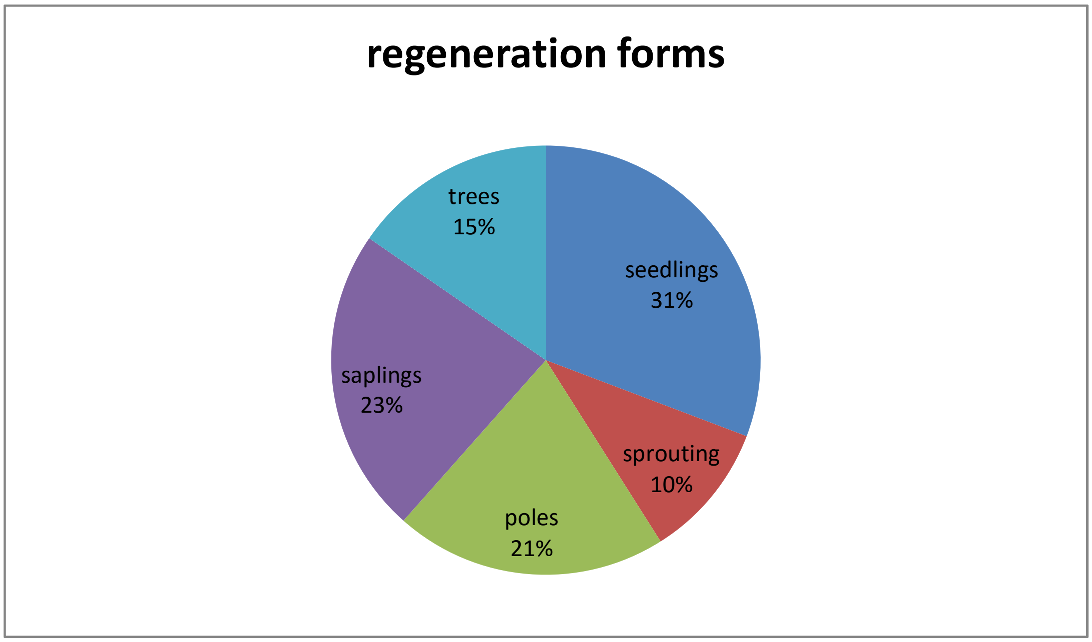
Form	Species number	Dominant species
Seedlings	12	*Leucaena leucocephala*(42%)), *Azadirachta indica (28%)* and *Ricinus communis*(12%)
Saplings	9	*Leucaena leucocephala(*38%), *Azadirachta indica (*32%) and *F aidherbia albida(*14%)
Poles	7	*Leucaena leucocephala(36%), Azadirachta indica(32%)* and *Albizia sp(15%)*
Trees	5	*Leucaena leucocephala(*29%),*Azadirachta indica*(25%) and *Senna siamea(17%)*
Sprouts	4	*Leucaena leucocephala (47%), Azadirachta indica(25%)* and *Senna siamea(17%)*

Table 04: Table of dominant species with their respective regeneration percentage in the self regenerating region

The plots that were close to the restored region had significant number of trees compared to other plots in this region. This could be an attribute of dispersion or the active component of the seedbanks in this area.

Parameter	Self- regenerating region
Diversity	1.5 ± 0.06

Richness	6 ± 1.0
Eveness	0.38 ± 0.01



Pie char 01: Pie chart showing the regeneration proportion wirthin the self regenerating region

Soil Seedbanks

The germinating seedbanks like the the existing vegetation was characterized in terms of species composition, diversity, richness and eveness so that the comparison with rthe existing vegetation could be made

A total of 28 species emerged from the seedbanks of the unextracted region while 23 species emerged from the seedbanks of the restored region. Generally, the seedbanks was characterized by species which are common to all sites. Out of these, only five species(4 from the restored region and 1 from unextracted region) represented species not in the existing vegetation. The depth of 0-15 had the highest values in terms of richness, diversity and eveness from both regionsthe species which were not identified on the existing vegetation of the restored region were: *Adanonsia digitata, Dalbergia vaccinifolia, ocium basillicum* and *Cyanthilium cinerum* while those from the unextracted region was *Psidium guajava*

Soil depth	Species number	Diversity	Richness	Eveness
0-15cm	13	2.836± 0.07	12 ± 1.0	0.69 ± 0.014

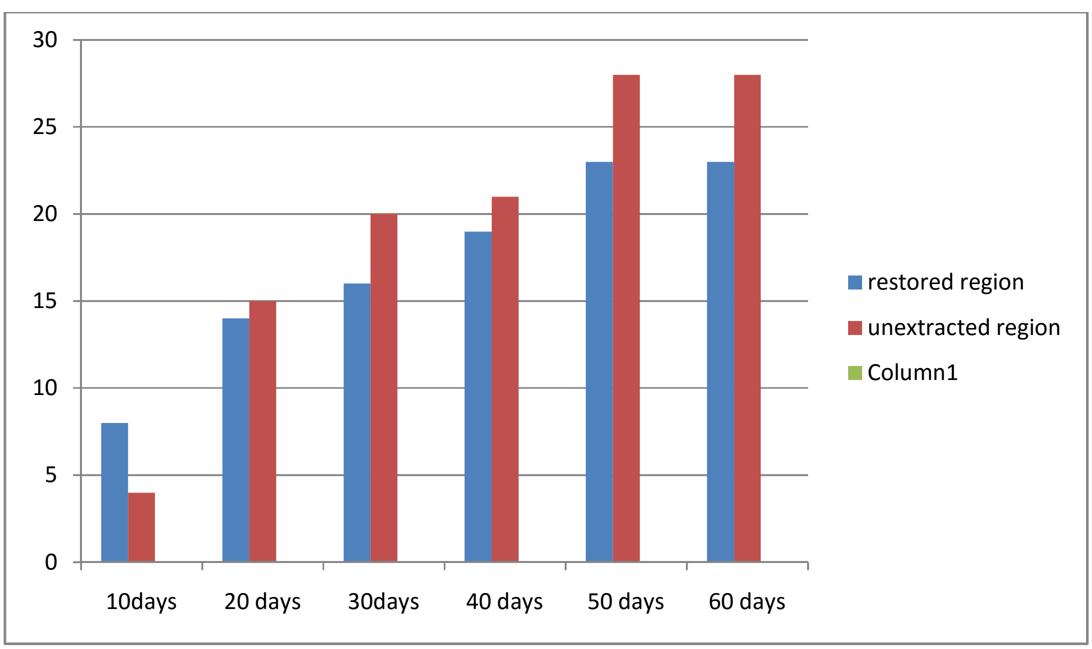
16-30cm	7	1.138 ± 0.05	5 ± 1.0	0.48 ± 0.01
31-45cm	3	0.463 ± 0.039	3 ± 1.0	0.3 ± 0.015

Table 05: statistical summary of the seedbanks of the restored region

Soil depth	Diversity	Richness	Eveness	Number of species
0-15cm	2.753 ± 0.07	14 ± 1.0	0.62 ± 0.015	17
16-30cm	1.052 ± 0.05	7 ± 1.0	0.45 ± 0.01	8
31-45cm	0.328 ± 0.04	4 ± 1.0	0.25 ± 0.01	3

Table 06: stastical summary of the seedbanks of the unextracted region

Unlike the aboveground vegetation, in seedbanks species diversity was higher in the restored region than in the unextracted region. This is an attribute of the persistent seedbanks that were found in the seedbanks since refilling, dispersion and restoration techniques. Number of species recorded became showed no futher changes after 40 days during the research period



Graph 02: A graph showing number of days with the respective number of emerging species recorded from the restored and unextracted regions

Comparison between the abovegrond vegetation, species regeneration with their respective seedbanks

Soil seedbanks of the natural region were used for comparison with specie regeneration under the assumption that, the regenerating species are attributed by the prescence of seedbanks within the region.

Pearson correlation coefficient (r) revealed a significant positive influence on both specie regeneration and aboveground vegetation. The values for pearson correlation coefficient(r) were (0.82 Df 48) for aboveground vegetation correlation and (r= 0.74 Df 34) for regenerating species correlation with soil seedbanks respectively. This indicates a positive correlation between the soil seedbanks and both aboveground vegetation and specie regeneration.

Discussion

Restoration may be achieved through natural regeneration from coppicing, soil seedbanks or artificial planting. Restoration through natural seedbanks may be relatively cheaper and reliable compared to other methods (Mansourian et al, 2005) According to Faist et al. 2013 the soil seedbanks serves as reserviors for future plant communities and when diverse and abundant, they can buffer the vegetation communities against environmental fluctuations(Bernhaudt and Ulbel, 1995).

Generally the species composition of the germinating seedbank was characterized by species which are common to both aboveground vegetation and regenerating species. Within the the quarry, only five species represented species that were present on the soil seedbanks but absent on their respective aboveground vegetation (4 from the restored and 1 from the unextracted). The existence of high level of common species to the studied regions indicate that the seedbanks has conserved the genetic diversity of the area. Genetic diversity conservation is the desirable wish of every biodiversity conservationist. The soil depth of 0-15cm had the highest values of diversity, richness and eveness. This means that the **' active componet'** of the soil seedbanks within the quarry is found within that depth. This is mainly a result of the extraction activities within the area. Before extraction, the top soil is usually removed randomly to a depth of more than 20meters and kept for refilling the land after extraction. Mixing the soil of depth more than 20m, indicates that the soil within the depth of 0-15cm is likely to be mixed inappropiately within the whole soil.. This action leads to the loss of alot of seedbanks thus forming the **inactive component** the soilseedbank that could be used to regenerate the area and conserve the genetic diversity. In addition to that the soil used in refilling the extracted area is preserved for a **long time** before the refilling process. Alot of **preserved soil heaps** used for refilling were observed during the study and they were found to have stayed for a long time period. The impact of preserving the soil for a long time before refilling is losing the soilseedbanks that have short life duration, only the seedbanks that are persistent for a long time duration will be active. This will lead to **genetic erosion(loss of genes)** within the quarry.

The ecological characteristics of aboveground vegetation based on diversity indices have been reported on various studies (Kent and Coker 1992, Magurran 2004). Kent and Coker pointed out that shannon diversity indices in most African Coastal forest ecosystem ranges between 1.5 and 3.5, in our study, the diversity indices of bothe regions did not dwell far from that(Table 03). This indicates that the aboveground vegetation is still ecologically rich and diverse. Eveness was higher on the restored region than in the unextracted region (table 03) due to the selective plantation of trees during restoration. The aboveground vegetation is also characterized by many common species. Prescence of many common species within the quarry indicates that at some stage this was **one continous forest** which has been **fragmented** as a cosequence of the mining activities within the area. This indicates that the restorastion program within the quarry should further focus on conserving the genetic diversity of the area also so as to prevent **habitat fragmentation**, a phenomena that is against all biodiversity conservationists . Appropiate use of insitu conservation measures of biodiversity conservation will allow the conservation of genetic diversity within the quarry. The restoration program within the quarry should not only focus on restoring the area, but it should also focus on conserving the genetic diversity of the area. However, the statistical indices of the regions within the quarry show that both diversity, richness and eveness are significant. This is an indication that the soil seedbanks within the area have conserved the genetic diversity of the area since the restoration program within the quarry is based on species that are not native to the area.

The mechanisms through which plant species recover from many forms of disturbances have been discussed by a number of authors (Chidumayo and Frost 1996). Highest numbers of both seedlings and saplings within the self regenerating region indicates that there are no big problems of survivorship of young trees within the quarry. This is a pays a good goahead of implying the seedbanks as one of the major way of restoring the land, however the self regenerating region is highly attributed to human disturbances due to its closeness to human settlements. Despite of this region being fragile, the near by villagers still utilize plants from this region. They use several plants for firewood collection, grazing of animals escpecially cows and goats and many other activities., therefore alot attention should also be paid by the company to this area. A good reference from the study is that the plots that were far from the human settlement had trees and shrubs. The closer you get to the human settlements the fewer the trees. Prescence of sprouts also indicates that the region is also enroached to this area. This region is very fragile hence alot of conservation effoerts should be cordinated by the company

Conclusion and reccomendations

Reccommendations

Since restoration and regeneration, is the key to coastal forests conservation , there is a high need of initiating in situ conservation measures appropriateley. From the results obtained in the study, we recommend that

(a) The soil depth of 0-15cm should be used as the topsoil layer during soil refilling followed by 16-30cm and 31-45cm due to the findings of the research that revealed that the reccommended soil depth contained maximum active components of the soil seedbanks within the wazo hill quarry
(b) The soil used to refill the region should not be preserved for long time period. By doing so,even the seedbanks with short life span will germinate thus **preventing genetic loss** within the region
(c) Futhermore, the planted trees after soil refilling should correlate with the native species of the area, this will prevent **habitat fragmentation** that is likely to occur within the quarry if further actions won't be taken
(d) To achieve further goals of restoration, other means of insitu conservation not only on vegetation but also animal species should be implemented intensively. This is due to the fact that , in order to achieve a community with high genetic intergrity, it is compulsory to complement both the ex situ and insitu conservation measures. This will not only conserve the genetic intergrity but the quarry will be a hotspot for various researchers and biodiversity conservationists
(e) Alot of cordinated conservation efforts should be put on the self regenerating region due to the fact that this region is more fragile than the other two regions (unextracted and restored). If possible the nearby villagers should be strictly prohibited from entering on this region so as to allow the propagation of the available species

We hereby conclude that, soil seedbanks have a great role to pay on both specie regeneration and aboveground vegetation. Proper use of the available soilseedbanks within the quarry will lead to a vegetation community that is full of diverse species. Appropiate use of seedbanks will increase the rate of restoration and allow self regeneration if much attention and efforts are paid. Futhermore insitu conservation measures should be put into further considerations so as to achieve further results on the restoration process

Acknowledgements

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To be kept and filled in at the end of your report

Project tags (select all appropriate): This will be use to classify your project in the project archive (that is also available online)	
Project focus: ☐Beyond quarry borders ☐Biodiversity management ☐Cooperation programmes ☐Connecting with local communities ☐Education and Raising awareness ☐Invasive species ☐Landscape management ☐Pollination ☐Rehabilitation& habitat research vScientific research vSoil management ☐Species research ☐Student class project ☐Urban ecology ☐Water management Flora: vTrees & shrubs ☐Ferns ☐Flowering plants ☐Fungi ☐Mosses and liverworts Fauna: ☐Amphibians ☐Birds ☐Insects ☐Fish ☐Mammals ☐Reptiles ☐Other invertebrates ☐Other insects ☐Other species	Habitat: ☐Artificial / cultivated land ☐Cave I ☐Grassland ☐Human settlement ☐Open areas of rocky grounds ☐Recreational areas ☐Sandy and rocky habitat vScrees ☐Shrub & groves ☐Soil ☐Wander biotopes ☐Water bodies (flowing, standing) ☐Wetland ☐Woodland Stakeholders: vAuthorities ☐Local community ☐NGOs ☐Schools ☐Universities