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Community Based Ecological Restoration of Changa Manga Forest, Punjab, Pakistan.

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Master's in Ecology

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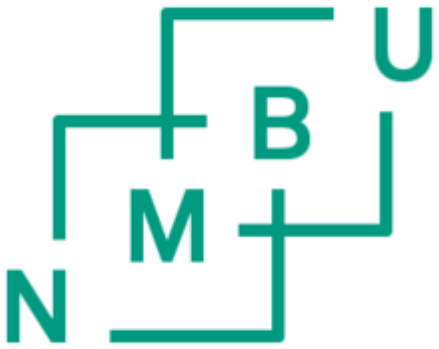

A thesis submitted in partial fulfillment of the requirements for the degree of Master's in Ecology

By

Muhammad Ahmad

Department of Ecology and Natural Resource Management

Ås, Norway

November, 2016

DEDICATION

I,

Humbly dedicate this research work to Almighty ALLAH, The most Merciful and Beneficial. And To My Beloved Parents Who always supported me with Prayers and Affection.

DECLARATION

I,

Muhammad Ahmad

Hereby declare that this thesis titled;

"Community Based Ecological Restoration of Changa Manga Forest, Punjab, Pakistan"

is a result of my own research findings and investigations. This work has not been previously printed, published and submitted in any university or research institute.

Signature.....

Date.....

ACKNOWLEDGEMENTS

First of all, I am grateful to almighty **ALLAH,** who has given to me abilities and strengths to do work on this and submit this thesis. I also offer special praise for our **HOLLY PROPHET MUHAMMAD** (Peace Be upon Him) who is an ocean of knowledge and forever a torch of guidance for mankind as a whole.

Words are limited to express heartiest gratitude to my Supervisor and Mentor **Professor Dr. Jonathan Edward Colman** and **Dr. Diress Tsegaye Alemu** (Research Fellow at UiO) for their constructive teaching and suggestions related my research and thesis. They tolerated my mistakes and guided me persistently to complete this research work with affection.

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Muhammad Ahmad

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Abbreviations

FAO: Food and Agriculture Organization.

IPCC: Inter Governmental Panel for Climate Change.

SER: Society for Ecological Restoration.

WWF: Worldwide Fund for Nature.

REDD: Reducing emissions from Deforestation and Degradation.

ACE: Anti-Corruption Establishment (Pakistan).

Abstract

Restoration ecology emerged as a separate field in ecology, and recently gained substantial attention due to global environmental changes and increased anthropogenic activities. The present research highlights the importance of ecological restoration of a 128 years old plantation named Changa Manga Forest in Pakistan. During the past few decades, this forest has undergone increased degradation through mismanagement, fires, illegal removal of trees and more, with almost 70% degradation compared to its original state at the time of partition of Pakistan (1947). Plantations play a significant role in the ecology and economy of countries like Pakistan, where forests and trees already are scarce and make up only about 4% of the total land area. I aimed to describe and characterize weather available tree/shrub species, their coverage and size could be used as a descriptive indicator of the state of a forest as either "intact" or "degraded". In this study, the Changa Manga forest was investigated for signs of degradation, measured in terms of tree/shrub species count, density/cover and height. A total of five randomly selected regions were sampled through quadrat sampling in predefined "intact" and "degraded" habitats. I found significant differences ($p \leq 0.001$) between intact and degraded habitats for all plant attributes (i.e., species count, density, diameter and height) studied. I found significantly higher values for intact than degraded habitat, indicating that degradation is a threat to the Changa Manga forest. Of the total 8 tree species recorded in the sampled plots, Eucalyptus (*Eucalyptus microthyeca*) and Shisham *(Dalbergia sissoo*) were found the most dominant, but both were rare in degraded habitats. These two plant species as such can be used as an indicator of degradation. The mean density of Eucalyptus in the intact habitat was significantly higher (16.68 individuals per 625m^2) compared to degraded habitats (2.160 individuals per 625m^2), indicating the severity of degradation. I also conducted qualatative interviews to gain insight into ongoing causes of degredation. During the last few decades, there have been many events of massive degradation of the forest in which the government officials were found guilty in some reports. The interview program provided a 94% response rate, highlighting the causes and some remedies for degradation of Changa Manga. Un-prescribed fire, water scarcity, corruption, lack of funds and improper management were found to be the main drivers of degradation. For the future ecological restoration and sustainability of this green resource, proper management, strict laws, increased community awareness, and proper ecological monitoring of restoration activities will be needed.

1. Introduction

Forest and plantations play a significant role in the maintenance of global ecological balance, temperatures and environmental sustainability (FAO 2014). Forest resources are a good source of ecological and economic benefits for a country. Data about the conservation and working plan of forest is most often not available and is a major limitation in controlling deforestation. However, the fact is that the rate of forest degradation is accelerating worldwide, despite increased ecological awareness among the society. The anthropogenic activities worldwide are reshaping the earth in different aspects, especially in environmental terms. Increasing temperatures and changing environment are accelerating degradation, desertification, food and water scarcity and ecosystem exploitation (IPCC 2014). Many natural ecosystems are being converted into agricultural lands, urban developments, or other uses leading to degradation and fragmentation, all contributing to a loss of biodiversity in these areas (Brook et al, 2008). Deforestation could be generally regarded as the conversion of a forest into a land for agricultural or industrial development (van Kooten & Bulte, 2001). There are also many other causes such as poor seed dispersal (White et al, 2004), un-prescribed fires, mining and construction, political instability and corruption, and exotic plant invasions. Degraded or deforested sites have certain characteristics like hydrological instability, eroded soils, very low biological diversity and limited primary productivity.

In the event of such significant destruction in natural habitat in a country, a plantation can be used as a form for ecological restoration measures. A plantation is a human made forests. Plantations are also a tool for enhancing and developing connectivity across landscapes (Brockerhoff et al, 2008). Plantations comprise approximately 7% of the forested land globally. Plantations also play an important role not only as an alternate habitat, but they can also provide economic, social and environmental benefits. Although plantations may be artificial and unable to provide suitable habitat for some specific species, they do change the permeability of the given landscape and allow many species to move across more easily (Taylor et al, 1993). In many countries, plantations are also a source of wood supply for industrial or domestic use. For wood production and other ecological services, plantations are increasing globally (FAO, 2010). Some of the non-industrial plantations are used as foraging or fuel wood, soil retention against erosion and water conservation, wind protection, biodiversity conservation, to combat desertification or as a result of restoration programs. The increasing demand for lumber might lead to the establishment of more plantations (Kole et al, 2012).

In developing countries, such as Pakistan, where resources are limited or depleted, plantations have a very significant role in the ecology and economy. Trees are an important part of the hydrological cycle, so they also effect climate related changes and energy fluxes within the global ecosystems that we are facing today (Pielke et al, 2011). Many countries worldwide, and especially within Asia, are increasing their focus on the restoration of aging plantations at different sites after the awareness about the importance of such plantations. In most of the tropical regions worldwide, native tree species are being planted as a method to restore the lands (Rodrigues et al, 2011), including in many plantations. It is important to choose the right species, such as endemic species, good nursery stock, site preparation, planting techniques, weed control, and, less frequently, fertilizer inputs in order to get good ecological restoration results. Once healthy plantations have been planted at a site, later other restoration techniques may become more important, depending on the requirements of the restoration plan. The Food and Agriculture Organization is also helping developing countries to develop and manage forest plantations according to ecologically sustainable forest management rules and practices, considering the environmental, social, biological and economic factors.

With respect to global climate change and increasing desertification and degradation of landscapes, the maintenance and restoration of vegetation cover and diversity is a very important strategy. The restoration of species composition in an ecosystem is important and could be implemented relatively easily (Ruiz-jaen & Aide, 2005). Presently, restoration ecology is emerging as a young and developing science working towards the restoration of degraded ecosystems (Alexander, 2013). "Ecological restoration is the process of assisting the recovery of an Ecosystem that has been degraded, damaged, or destroyed" (Society for Ecological Restoration Science and Policy Working Group 2002). However, a major drawback of ecological restoration today is that the results of most ecological efforts and projects of restoration are not easily accessible to others researchers and experts and many projects go unmonitored post-restoration (Bernhardt et al, 2005).

To set the goals for ecological restoration, it is required to consider what will be easy and good for global environment change (Hobbs, 2007). However, at a local scale, it is imperative to identify simple and inexpensive methods to identify and determine the degree of degradation, and ways to both avoid and restore eventual degraded sites. Human activities have caused huge damage to natural and artificial ecosystems in recent years, especially in underdeveloped countries.

Pakistan is already very scarce in forest and plantations, with a total forest cover of approximately 4.8%, which is quite low according to global standard for a country. Changa Manga is an ecologically and historically very important forest for Pakistan, but the forest has been degraded and deforested during the past few decades.

I aimed to find simple and inexpensive ways to identify degradation within a biological context and through the human perspective. This will be a pioneer study in the field of restoration ecology for Changa Manga, as no other institution is giving focus on the field of restoration ecology for this forest. Although certain work plans by officials are made but very less have been properly implemented in the past.

The main purpose of the study was to highlight the degradation level and the causes of deforestation of Changa Manga by using both interviews and ecological survey techniques. Qualitative and quantitative methods were used to collect data for this study. To collect the quantitative data, I used quadrat sampling method, while for the qualitative study, I conducted interviews from both public and relevant government officials. This will provide preliminary data that can be further used towards the issues of the forest's conservation and restoration.

The objectives of the study were:

- To investigate and document tree species composition and their height and size as a measure of degradation and compare this between intact and degraded habitats.
- To identify the main causes of degradation in the Changa Manga forests using an interview survey among the people of that area and governmental officials, including also questions about the possible restoration of the forest.
- To give some strategical suggestions based on the study for ecological restoration and conservation of Changa Manga.

2.0 Changa Manga Forest in Pakistan: Historical Perspective

The Changa Manga forest is located 70 km away from Lahore within the boundaries of the District Kasur and is one of the oldest man made forest in the world. The entire forest area covers almost 48.6 square kilometers. The plantation started in 1888 when British were ruling over the India/Pakistan subcontinent. At that time, there were steam engines used for the rail locomotives. From 1886 to 1936, Shisham tree was commonly planted in order to fulfil fuel and timber needs. Although this forest is strictly a plantation, it is generally known as Changa Manga Forest (Park). The reason for the name "Changa Manga" has different theories. Some think Changa Manga were two brothers, but these are traditional stories and presently unconfirmed. The average yearly temperature for the area is 24 °C and average rainfall around 14 inches annually. There is a special canal dug in the original years of the plantations to facilitate irrigation of the entire area (Appendix 2). The main canal is further divided into sub canals and channels throughout the plantation to circulate water and irrigate the plantation. A vulture conservation project (Gilbert et al, 2006) funded by WWF Pakistan is presently ongoing in the plantation near C site (Figure 1).

Plantations in this region of the world can have both positive ecological and environmental effects. They also provide some economic benefits for the community including forage for livestock, and production food items such as honey, silk or sericulture, baskets, fruits and vegetables and a source of medicinal plants. Families of workers also live in the plantation in different blocks. There are an estimated 2000 workers there, including Divisional forest officers, conservators, block officers, range officers etc. Ecologically, the Changa Manga is also important because of the increase carrying capacity for livestock, soil protection (from erosion), reclamation of saline, water logged arid soils, positive interactions among the local populations, and act as carbon sequestration.

The most common species planted in the Changa Manga include *Dalbargia sissoo* (Shisham) *Acacia nilotica (*Kikar), *Morus alba (*White mulberry), *Eucalyptus microtheca* (Sufeda), and *Saccharum bengalense* (Kana). The total area under irrigation now constitutes 23.54% of the forest area, of which 0.72% is within the total geographical area of the Punjab. Presently, there are many issues including policy and legislative, institutional, financial, technological and ecological that affect the plantations and leads to extreme degradation (minimal vegetation and desertification), particularly in the study area (i.e. Changa Manga, Forest. Punjab, Pakistan).

Figure 1: (Google Earth imagery date 26.07.2004) south-western part of Changa Manga.

Figure 2: (Google Earth, Imagery date: 29.11.2013) south-western part of Changa Manga.

The level of degradation has increased substantially over the last 10-15 years (Fig. 1 and 2). Images from 2004 on google earth (Fig. 1) illustrate how the landscape looked then and could help in restoration of the degraded sites. In 2004, the plantation looks in quite better state than in 2013 (Fig. 2). The invading towns and population is also a factor contributing to degradation of this forest. Very few studies and little to no work has been done towards the conservation of this plantation. There is therefore a vital need to highlight the issue of its restoration on national and international levels.

3.0 Methodology

The study consisted of two parts; biological field data and interview questionnaire. The main objective of the study was to find simple and inexpensive ways to assess the impacts of degradation levels within the Changa Manga Forest and the interviews supplements ecological interpretations.

Description of study site

The study site is a plantation located 60 km away from Lahore within the Kasur District at Latitude 31º 05`01.9" N and Longitudes 73º 59`45.1"E (Figure 3). The total area is approximately 12510 ha. It is connected to the Karachi to Lahore railway line. It is also transected by a highway. Central Bari doab Canal also serves as its main source of irrigation, and other crops in the surroundings. Changa Manga was awarded with the title of National Park in 1960.

The soil of the region is characterized by dark brown color, high porosity and silty loam texture. The pH value ranges from 7.7 to 8.0. The study site has a fragmented landscape with relatively low tree cover in a matrix of different tree species. The average weather for the area is 38 °C from March to September and an average of 4 °C from October to February. Eucalyptus and Shisham are the key species in the area, however, Bamboo is also grown alternatively for economic purposes. The forest has been divided into different regions or blocks and a road intersects the plantation (Fig. 4). Every block has a small population of workers living therein.

At the time of independence of Pakistan in 1947, the following areas were reserved as irrigated plantations:

Table 1: Present list of plantations in Pakistan.

Name of Plantation	*Area (hacters)*	*Planted Year*
Changa Manga	5065	1866
Chichawatni	4665	1912
Khanewal	7692	1914
Daphar	2920	1918

Figure 3: Geographical Location of Changa Manga Forest, Punjab, Pakistan (Google Earth).

Rainfall is maximum in the monsoon season in August every year. The average monthly rainfall is 324 mm recorded by regional metrological Centre. The humidity in the air of the region varies from 21% to 91% throughout the year, as there are four seasons in Pakistan. The monsoon season is August and September when there is rain with heavy showers.

The Changa Manga forest also has a recreational park for tourist, a guesthouse and a tram, as well as small huts for renting. The tram was established in 1921, with the sole purpose of transferring firewood from forest to sale depot in the past, but now it is just used for tourists. Its original length was 16 miles, but the length of the present track is just 2.5 miles.

Collection of Field Data

The ecological data was collected in two field visits in 2015 (i.e. in March and September) in the Changa Manga Forest using quadrat sampling method. Quadrat sampling is a commonly used method for estimating the abundance, density and other ecological characteristics of plants and other organisms in a specific area (Lawson, 2006).

Using Google Earth Map, five regions (i.e. named as A, B, C, & D) were selected randomly within the Changa Manga Forest (Fig. 4). In each region, 10 quadrats were established (i.e., 5 quadrats in "intact" habitat and the remaining 5 in the "degraded" habitat). A total of 50 quadrats were used for the five regions. I used a quadrat size of 625 m^2 (i.e., 25 m x 25 m). In each quadrat, I counted trees and shrubs of different species and the data was then summarized as the number, average height (m) and diameter (ft) of the trees and shrubs in each quadrat.

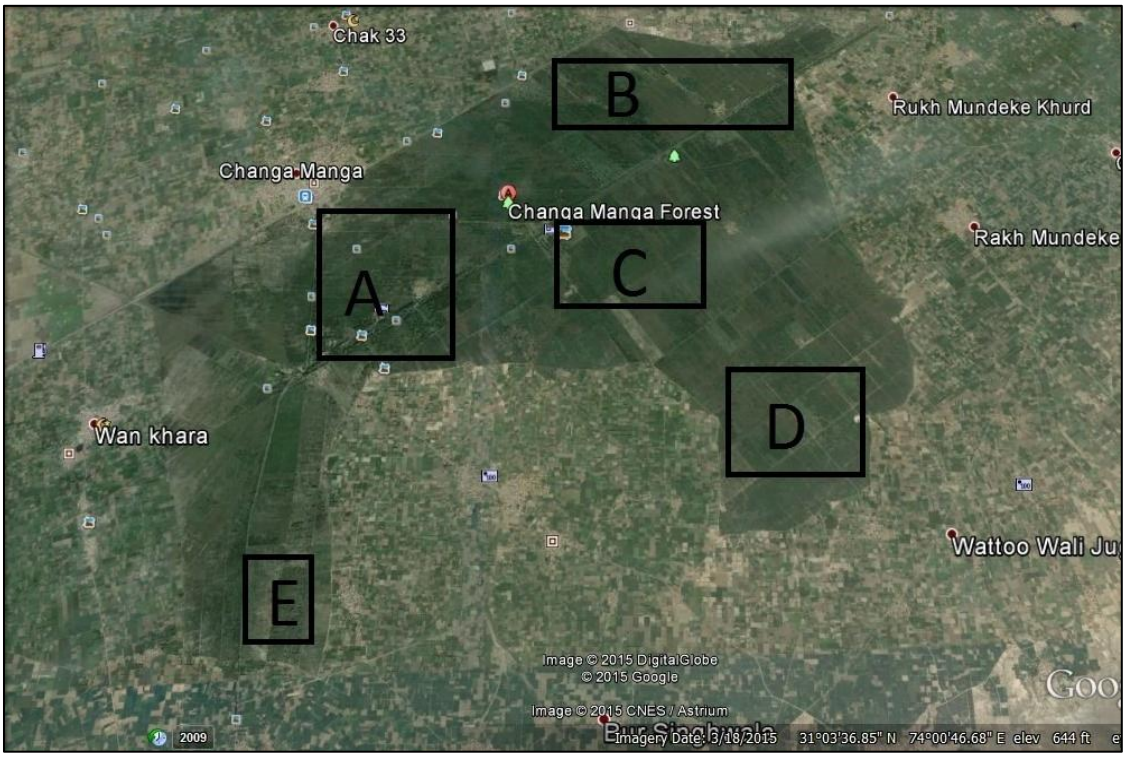

Figure 4: A satellite image depicts the regions (A, B, C, D, E) where the field data was sampled in the degraded and intact habitat (Google Earth).

Qualitative Study

To retrieve information about the degradation level and performance of the plantation, I interviewed various stakeholders of the plantation (i.e., local people, officials from both governmental and non-governmental organizations).

I interviewed 75 people in the District Kasur where the Changa Manga Forest is located. In March 2015, I interviewed local farmers and the workers to the related governmental officials of restoration for Changa Manga Forest in three areas. The questionnaires focused on history,

degradation level, conservation efforts, monitoring and evaluation schemes, etc. The interviews also included ecological issues (Appendix 1). The questionnaire was prepared in English, but it translated into Urdu.

Statistical Analysis

I used "Statistix`8.1" software for the analysis of the ecological data related to species count, and tree/shrub height and diameter. I compared the intact and degraded habitat for each of the response variables listed here and presented in tabular and graphical forms whenever necessary to highlight the differences.

The interviews were transcribed before being organized into types of responses and respondents. A qualitative approach in restoration provides insight into the interaction between a society and the environment. The inclusion of the native people and their recognition of the resources is also an emerging strategy to accelerate the process of restoration (Godden & Cowell 2016). The qualitative research portion was conducted in this work in order to get insight into reasons for and challenges towards the ecological restoration of Changa Manga plantation.

The three different areas were selected by the author (near Changa Manga, Kasur city and Lahore), where face to face interviews were done with people from different ages, occupation and educational levels.

4.0 Results:

Biodiversity:

A total of eight different species of trees and shrubs were found in the sampled quadrats (Table 2).

Table 2 : List of tree and shrub species identified in the Changa Manga forest, 2015.

No.	Scientific Name	Common Name
1	*Melia azedarach*	Bakain
2	*Eucalyptus microtheca*	Eucalyptus or safeda
3	*Dalbergia sissoo*	Shisham or North Indian rosewood
4	*Morus Alba*	Melbury
5	*Salsola foetida*	Lani
6	*Calotropis procera*	Ak
7	*Acacia jacquemontii*	Kikar or kikri
8	*Acacia farnesiana*	Walaiti kikar

As major parts of the plantation have been degraded, less biodiversity was observed, and most biodiversity was found in the intact habitats only. Although there are captive species of birds, I observed some animals in the recreational park. During my fieldwork, there were just a few jackal, wild boars, few common sparrows and some wild cats observed in the Changa Manga Forest. As the degradation level increases, the loss of biodiversity is obvious. For example, one of the respondents highlighted during the interview that "the number of common sparrow is declining in the forest during the last decade due to loss of trees and over-hunting".

Table 3: Mean height, density and diameter for all species studied irrespective of site, Changa Manga Forest, 2015.

Species ***Scientific Names***	**Count** **Ind. per 625m^2**	**Height (m)**	**Diameter (ft)**
Eucalyptus microtheca	21.87	2.93	1.42
Dalbergia sissoo	7.14	1.80	0.87
Acacia jacquemontii	5.96	1.32	0.47
Calotropis procera	5.38	0.96	0.30
Morus Alba	2.89	1.08	0.27
Salsola foetida	2.58	0.55	0.12
Acacia farnesiana	2.42	0.69	0.16
Melia azedarach	0.78	0.52	0.14

Plant Density

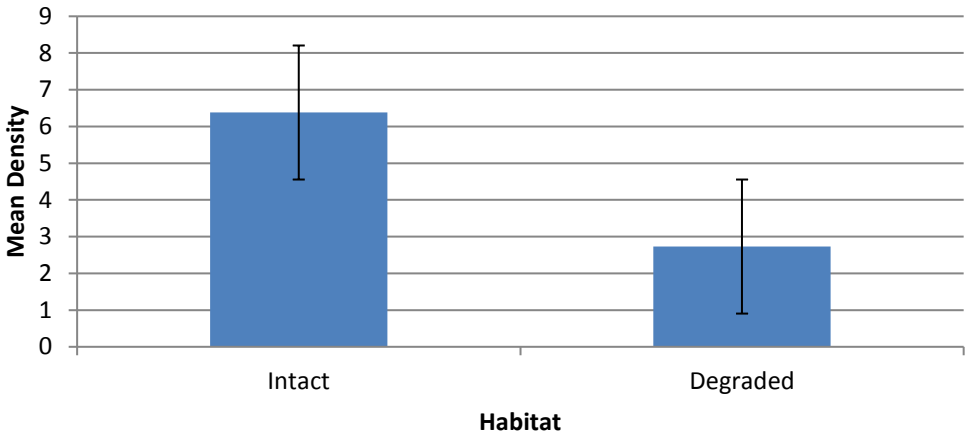

Figure 5: Mean tree density (individual per 625m^2) among the intact and degraded habitats.

In general, intact sites had significantly higher density of plant species than the degraded areas (i.e. for regions) in the Change Manga forest (Fig. 5, $F=9.15$, $P < 0.001$). Intact areas had a mean density of 6.380 (individuals per 625 m^2) while the degraded area had a lower mean density of 2.730.

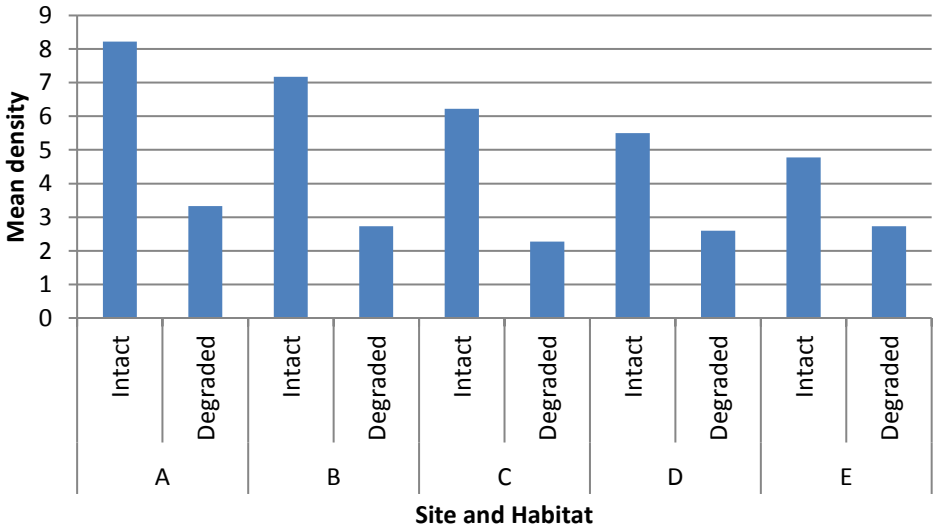

Figure 6: Mean tree density (individual per 625m^2) among all five regions.

Figure 6 shows the relationship of mean density and habitat type (i.e., intact and degraded habitats) in each site. The difference in the density of the plant species was large in Site A and B compared to other sites. Figure 6 shows the highest density in intact habitats of region A, while the lowest tree density was observed in region C for the degraded habitats.

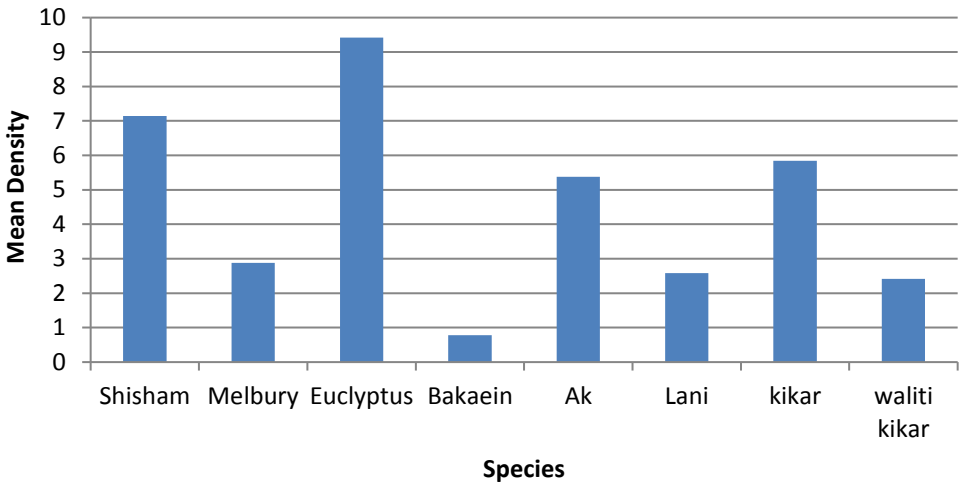

Figure 7: Tree density (individual per 625m^2) for each plant species.

I found eight different plant species: Shisham, Melbury, Eucalyptus, Bakaein, AK, Lani, Kikar and waliti kikar (Table 2). Figure 7 depicts the overall mean density of each plant species. The Eucalyptus density was high (9.4), followed by Shisham (7.1), kikar (5.9), and Ak (5.4). The rest of the species had a mean density of < 3.

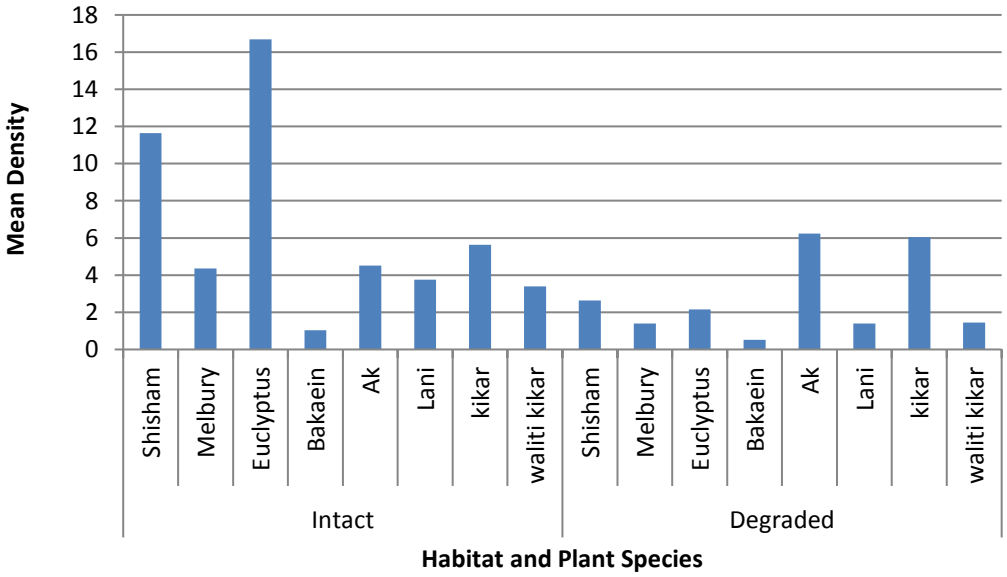

Figure 8: Mean density of different species in the intact and degraded habitats.

Figure 8 describes the distribution of all the eight plant species among the intact and degraded habitats. It also gives a comparison of each plant species in both habitats. There is a huge difference

of plant specie density between the two habitats. For instance, Eucalyptus had a mean density of 16.68 and 2.16 in the intact and degraded habitas, respectively.

Ak had unexpectedly higher plant density 6.24 in the degraded region as compared to intact habitat at 4.52. There was simililar increase in plant density of kikar in degraded habitat with 6.04 as compared to the intact habitat, where it was 5.64 indiviuals per 625 m^2. There was little diffrence observed between the plant density of Bakaein in the both habitats.

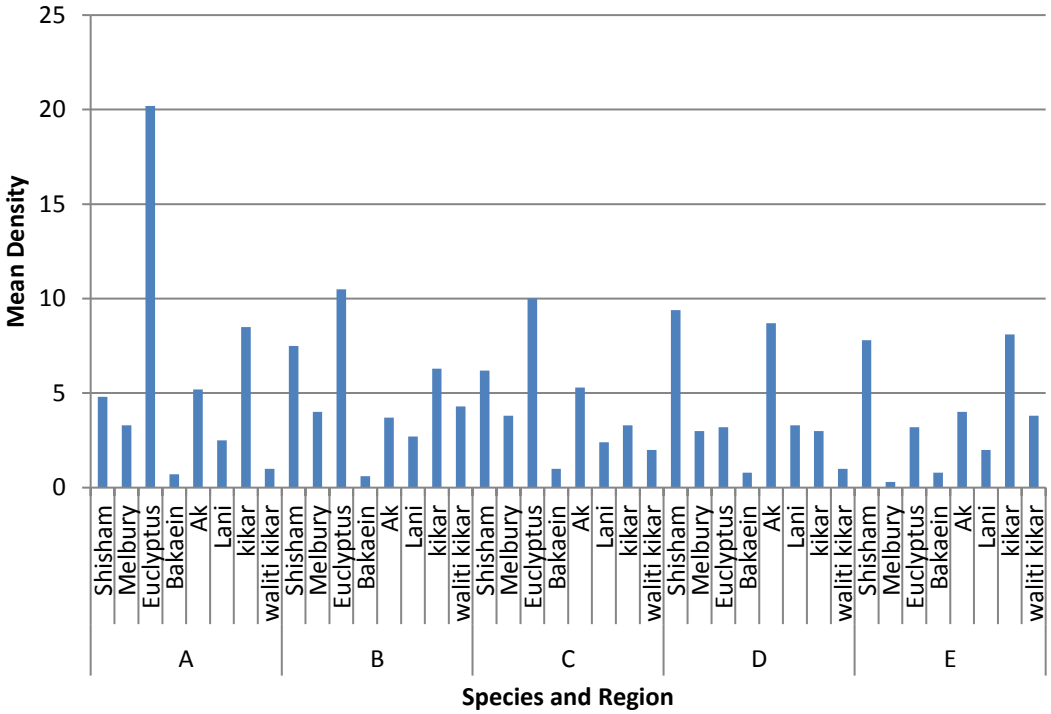

Figure 9: Mean density (individual per 625 m^2) of each species in each site.

Figure 9 and Table 3 shows the distribution of each species in each site or region. Eucalyptus was abundant in the site A, while the lowest amount of Eucalyptus was in site E. Melbury in Site E had the lowest density. Among all the species, *Eucalyptus sps* has the highest density.

Tree Diameter

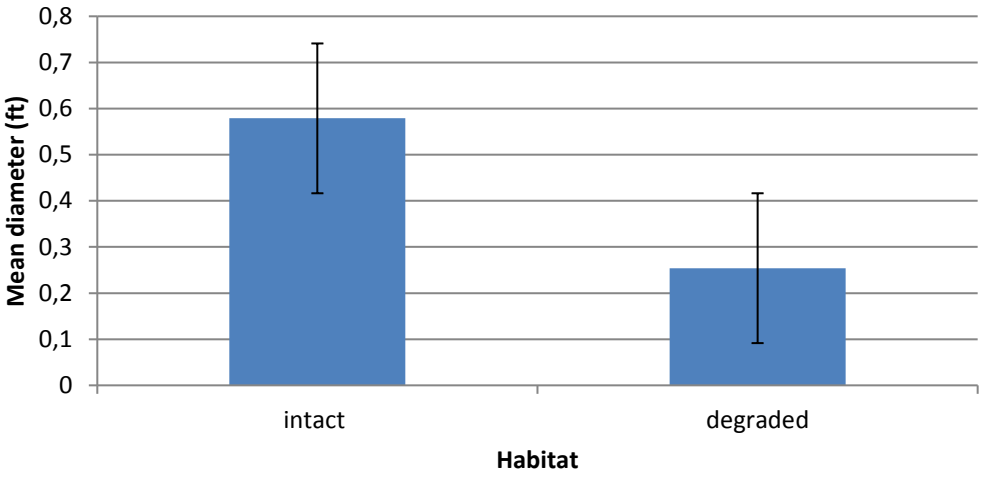

Figure 10: The difference in diameters (ft) of plant species found in both habitats.

Figure 10 shows that intact habitats had a significantly larger stem diameter compared to degraded habitats ($F= 14.76$, $P < 0.001$). There was also a large difference in the diameter of trees for the different species recorded (Table 3).

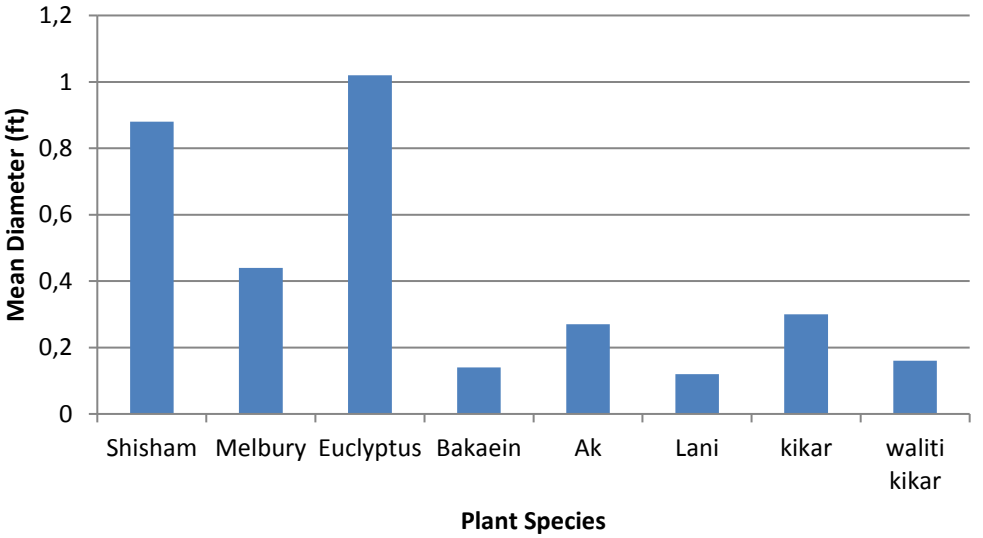

Figure 11: Mean tree diameter density according to the eight different species studied.

As the Eucalyptus species is more common with good height, its diameter was also larger compared to the other plant species in the study area (Figure 11, Table 3). The diameters of Ak and Lani are small because these are shrub plant forms.

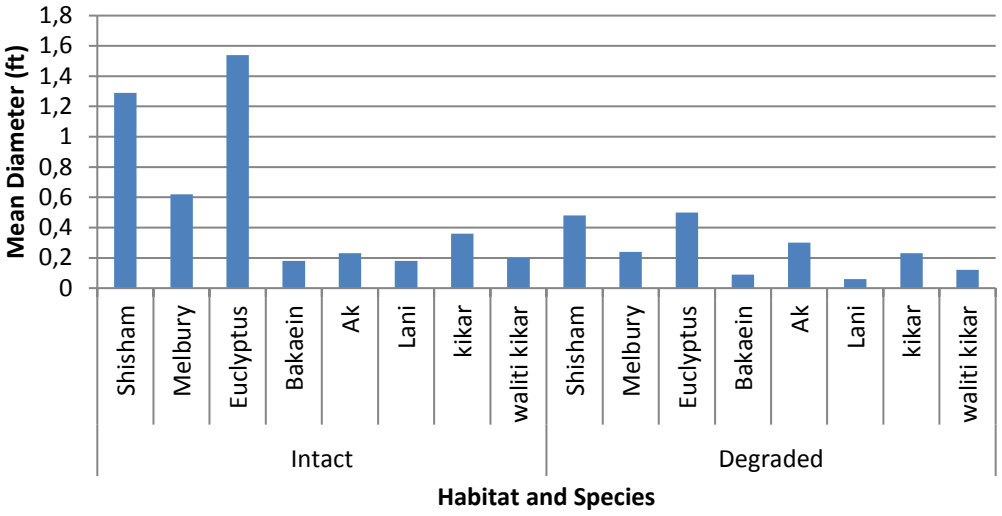

Figure 12: Mean diameter of each species in intact and degraded habitats.

Figure 12 shows that the diameter of the Shisham and Eucalyptus present in the intact habitats were larger than the degraded habitat, while in the degraded habitat all plants have small diameter, including the Eucalyptus and Shisham species. However, the diameter of Ak and Lani almost remains the same as these are shrubs.

Tree height

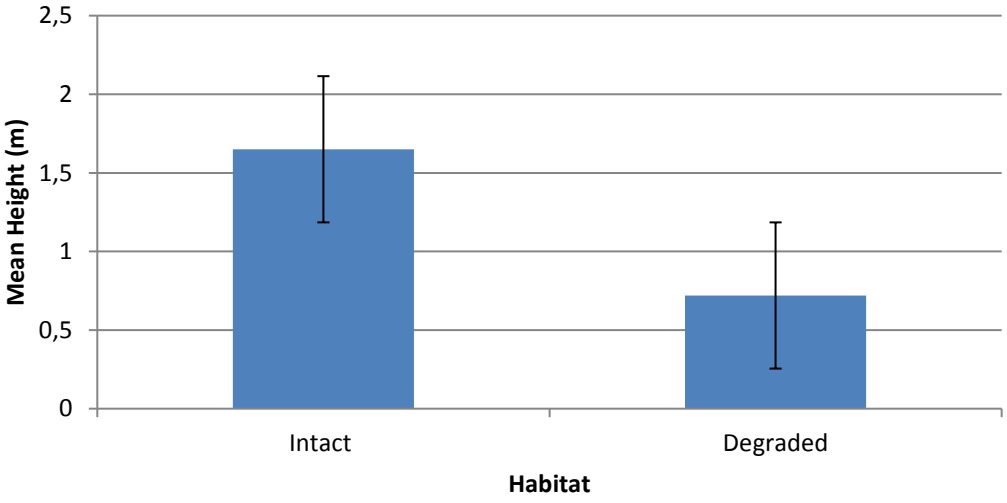

Figure 13: Mean tree height in the degraded and intact habitats. The vertical line indicates the standard error.

Figure 13 clearly shows that there is a significant difference of height in the intact and degraded habitat ($F = 8.18$, $P < 0.001$) similar to the diameter and species count. Trees in the intact habitat

were taller than the degraded regions. The approximate difference among the mean height of degraded and intact habitats is 59%.

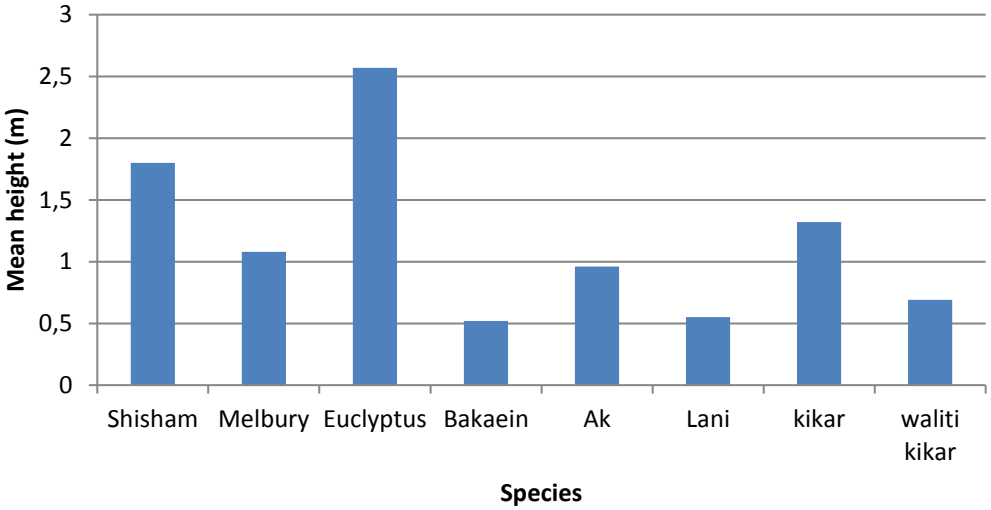

Figure 14: The relation between species and height (m).

Figure 14 and Table 3 shows a clear difference between the heights of each species. Eucalyptus was the highest species studied, while the Shisham was the second highest, although a few individuals sometimes exceed the height of Eucalyptus.

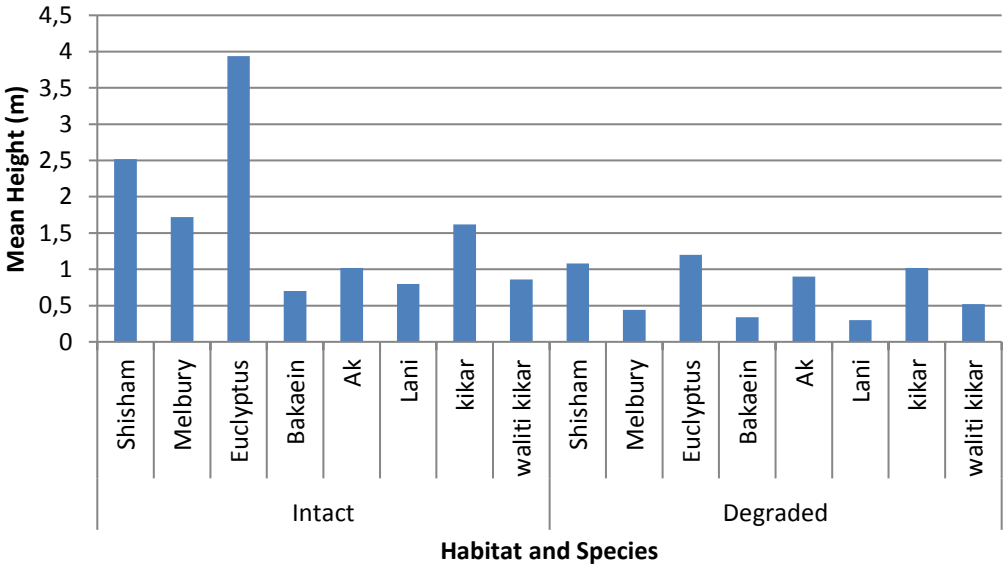

Figure 15: Tree height (m) of each species in intact and degraded habitats.

Figure 15 and Table 3 shows the difference in height of each species found in the intact and degraded habitats. In intact habitats, the height of Eucalyptus and Shisham was high as compared to heights in degraded regions. As a whole, the height of species found in degraded habitats is less due to the fact that many plants were newly planted or they were struggling to grow at all as a result of pressures from humans and livestock**.**

Causes of Changa Manga Degradation:

A questionnaire based interview was used. A total of **(N=75)** people belonging to different ages and occupational levels were approached with a response rate of around **94%.**

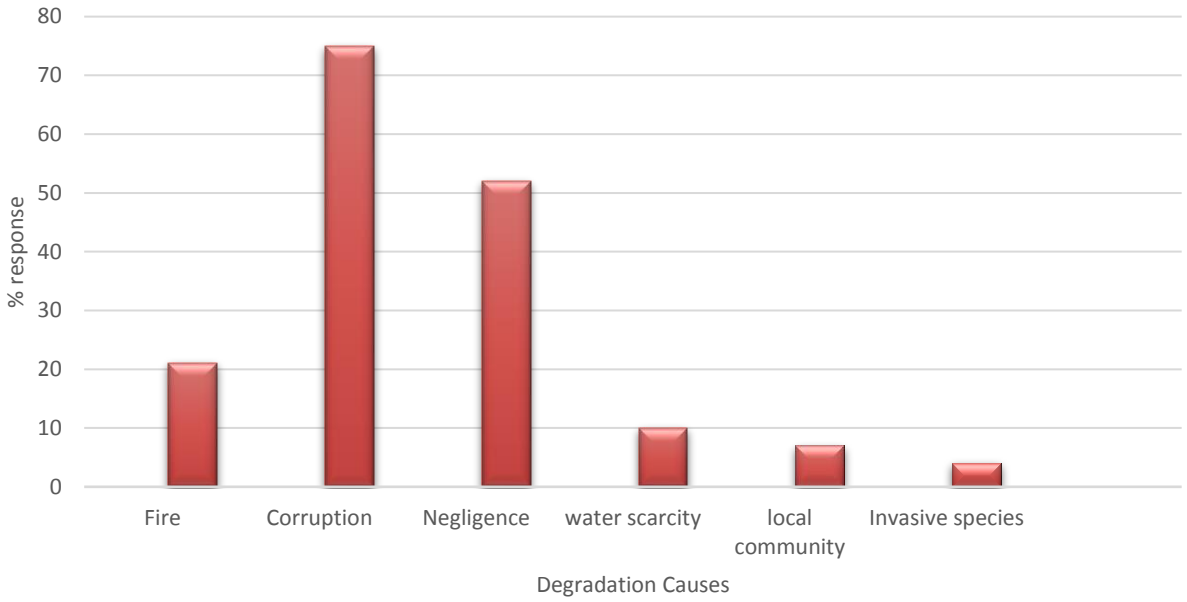

Figure 16: Percentage responses for reasons for degradation of the Changa Manga forest by the respondents.

The interview results in Figure 16 highlights the main causes of degradation of Changa Manga by the respondents, According to this study, corruption is the leading cause of the degradation of Changa Manga forest. The negligence of the relevant officers is also another big cause in the eyes of the local people. Fire and water scarcity were also perceived as partially responsible, but not nearly as much as the corruption and negligence with more than 50%. Invasive species was also considered a threat towards ecological restoration, but in Pakistan, people have little concern with the invasive species.

Local community perception

Table 4: Demographics of respondents.

Variables	(n)= No. of Respondents	Percentages
Age, years		
10-30	24	34%
30-50	36	51%
50-70	10	15%
Ethnicity		
Pakistani, Asian	70	100%
Geographical Location		
Around Changa Manga	45	64%
Kasur city	20	28%
Lahore	5	7%
Educational Level		
Middle class or Matric	11	16%
Bachelors	49	70%
Master's	8	11%
Basic Education	2	3%

For the question about the history of the Changa Manga, **93% (n=65)** interviewed knew about the general history and explained that it is a forest named for the two thieves, and that the main purpose for the plantation was for fueling steam engines for the British regime in that era. However, no one was sure about the age and date of the creation of the plantation:

A Teacher aged 47 said:

"Changa manga as I know is a planted forest, planted in the British regime to get their fuel engines running, so that's why it was build and it was named after two brothers Changa and Manga who used to live there and do robbery".

A rickshaw driver aged 35 when asked about history said:

"I am not sure why it was planted but I just know that it is named after two brothers Changa and Manga."

I also asked whether there any other such massive plantations in Pakistan. The majority, **89% (n=62),** were unknown about the fact, and some of them just considered it as a natural forest, and just a few were aware about similar plantations in Pakistan.

A Farmer aged 35 said:

"No, I don't have any idea about such forest, this Chang Manga is the biggest and people come from the whole country and foreign tourist come here."

The reply of a student visitor aged 21 was:

"Yes, although it is the biggest plantation in Pakistan but there are two more in Pakistan, one is in Chichi-watni and one is in Khanewal District".

Table 5: Responses regarding Changa Manga deforestation and its ecological restoration.

Some of the Questions regarding Changa Manga	n out of total(N=70)	Percentage (%)
History of Changa Manga plantation		
• **Know somewhat** • **Know nothing**	65 05	93% 07%
Idea about some other plantation like Changa Manga	8	11%
Changa Manga Should be protected and conserved	68	0.97%
Plantations are generally **Good** **Bad** **Don't know**	 70 0 0	 100% 0 0
Strategies regarding restoration and its Conservation **Monitoring and evaluation** **Proper usage of funds** **NGOs** **Fencing** **Recreational park**	 60 30 4 25 47	 85% 43% 0.5% 35% 67%

The third question in the interview was whether they considered Changa Manga comparable to a natural forest. Pakistan has approximately 4% forested areas, which is quite low. Some of the people were not clear about the difference between a natural and planted forest, but most of them answered 'yes' that they consider Changa Manga as important as a natural forest.

The Assistant Divisional forest officer aged 45 said,

"Yes, it is as much important as the natural forest especially in our country like Pakistan which is already less in a lack of forests and there is more need of such plantations in Pakistan."

Most of the people interviewed when asked about the availability of forests in Pakistan, did not know. Only 10% of them were aware that there is only 4% forest area in Pakistan, although many replied that there should be more forests planted by the government.

For the question regarding factors responsible for the degradation of Change Manga, about **75% (n=53)** replied that government officials are involved in the corruption and cutting of trees from the forest. **52% (n=37)** suggested that the deforestation and degradation of Changa Manga was caused by negligence of the government. Fire, water scarcity and local community were also considered factors responsible for degradation by 21%, 1% and 0.7% respectively, of the people interviewed. On the other hand, when the Sub Divisional Officer was interview, his response was: *"We are facing many problems like lack of funding for restoration of plantations and poor water supply and fires which are the main reasons for the degradation of this plantation".*

While the reply of a local business man aged 57 was,
"The Negligence of Government and the corrupted officers appointed here are the main reasons for the decline and degradation of this useful Plantation".

Almost all the people replied with **100%** positive response rate for the question that there should be more plantations like Chang Manga. This positive response might be because in the Punjab region, there is very less forest and plant density and people like such natural things. Many responded that:
"The trees and plantations are good for us and our children as they provide oxygen to us and act as buffers for air pollution".

About the responsibility of the government, the general idea of the respondents was that the government should take serious action against the people involved in wood stealing and should have a proper check and balance about the progress and projects going on there. They should also provide funding for the plantation to be restored to its original state. On the question of the recreational project, a lawyer aged 35 said:
"The government should at least or nonetheless allow certain NGOs to start the restoration project on this recreational site."

When asked whether they consider the people living there responsible for the degradation of this plantation, around **7% (n=7)** consider the local community partially responsible, while others did not think like that. An old man said:

"You can't blame the government officers, the people of the communities living there are also responsible as they don't take actions, there should be local persons added into the monitoring of the whole plantation along with the forest officers so that a proper check and balance is made out for it"

However, a block officer aged 45 said this:

"Fire and Leasing is the source of degradation, not the forest officers working here. Also the lack of funds is a major cause".

According to my observation, the community is actually responsible along with the corrupt officials. I came to know during this study that entire patches of trees had been stolen and sold on the black market, and no one is there to monitor or evaluate this. The people residing there and working there have very low salaries and are obliged to get trees cut from Changa Manga forest and sell it into market in order to get money. When I asked a young boy who was carrying a bundle of small wood, his reply was:

"We have not stolen this wood but because we work here in the forest and this is a reward for our work or a salary. The government sometimes not give the salaries on time so we have to rely on this."

This clearly indicates the level and one of the factor responsible for the degradation of this plantation.

There is a recreational park in the forest. When asked about this, most said that if the government will allow a theme park, there will be more tourists coming here. Obviously, it will give good economic benefit to the government also. About the proper strategy for the corruption, **85% (n= 60)** of the respondents proposed proper monitoring and evaluation. A senior citizen aged 59 said:

"The government should recruit educated and honest officers and should have a governing board for this plantation in which local educated citizens should be involved so that there should be a proper check and balance."

About 64% (n= 45) said that the Changa Manga forest should be given preference as an important natural resource. Otherwise, Pakistan will lose this precious resource and that will not be ecologically good for the next generations and local biodiversity. The suggestion of a student was: "*The government shouldn't only work for its improvement but other such plantations should be planted, as it is a need of Pakistan Now*."

As the Divisional forest officer suggestions was:

"It's a cultural, natural and ecological habitat, we are working hard for its stability and sustainability so it should be recognized by the other institutes and NGOs and organizations working on conservation and restoration ecology in order to save it and invest here for the wellbeing of next generations of Pakistan."

5.0 Discussion

This study highlights the importance of restoration and afforestation of the Changa Manga forest considering an overall 55.5% reduction in tree/shrub density of the degraded habitat relative to the intact forest. A total of eight different species of plants were identified in the Changa Manga forest, of which Eucalyptus species had the highest density. Shisham, kikar and AK have almost similar densities, as an average, but not compatible to Eucalyptus. Eucalyptus species are considered important in Pakistan due to their physical and environmental tolerance. The Eucalyptus Plantations are also increasing worldwide especially in Ethiopia (Bekele, 2011). In Brazil, Eucalyptus comprises about 62.7% of the total plantation area (Brockeroff et al, 2013). Eucalyptus is mostly selected for plantations purpose due to its adaptability and fast growth. Although this might appear unnatural, the existence of trees/vegetation in an otherwise arid landscape has multiple values as mentioned below.

My results clearly show that the degradation has occurred in various regions at various times in the past (See Fig 1, 2). "The annual degradation rates of forest are likely to increase further and could become double in the next decade" (Myers, 1992). My interviews supported the biological data, but also provided important insight into *local* causes of degradation. About 94% of the respondents reported the importance of this plantation, but have observed increased degradation in recent decades. They however suggested reforestation as a pathway in mitigating destruction and introducing restoration strategies for the plantation in the future. Plantations can act as successional catalysts, not only in degraded areas such as the region surrounding Changa Manga, but also in other parts of the world. It has been documented for many cases, particularly in South Africa, that plantations have contributed a lot to the regeneration or expansion of native forest (Geldenhys, 1993). Ecological restoration often emphasizes that the lost species recolonize by themselves in a natural way (Lipsey & Child, 2007). However, where the degradation is extreme and succession is in an arrested form, restoration will need more local emphasis and methods. It is therefore crucial and beneficial for the successful conservation and restoration of degraded landscapes to identify the main causes of degradation and understand the life styles of the people in order to facilitate their participation (Meli et al., 2014). Based on this study, several factors are involved in the Degradation of Changa Manga, including water scarcity, fire, negligence and corruption by forest officers. Benyas et al. (2008) also regarded fire, grazing and water scarcity as a human disturbance and their removal is necessary in order get good results of restoration efforts.

The encroachment of settlers (i.e. two communities) is also a reason for the destruction of the western region of Changa Manga. In most of the tropical areas, deforestation is often from legal and illegal logging, large colonization and urbanization schemes to get rid of poverty, and industrial expansions for paper and other industries (Hansen et al, 2008). There are reports in the past about this cause of degradation and that some officers have been involved in the selling of timber wood illegally. In one of the reports (Express tribune, 2012), 27 persons including officers were reported in illegal pilferage of wood by Anti-corruption establishment (ACE), Pakistan. Cutting of the trees for fuel or other purposes also cause degradation of plantations (Putz et al, 2001), as was the case for the boy recorded in this study. Land is leased to the local agriculture producers and farmers to get revenue, which has caused a severe destruction of the plantation. Misuse of the funds given by the government or foreign organizations, and negligence of the government due to politics or personal use, is also a major reason in the decline of this forest.

Tourist's activities also threaten the sustainability of this forest. As the recreational park, Changa Manga is visited by a large proportion of the local tourists. Their activities cause destruction to the plantation through illegal hunting of birds, over trampling, etc.

All these problems need strategies to restore the Changa Manga forest. For success, specific management objectives are required based upon the successes and failures of previous practices elsewhere (Section7: SER, 2004). The level and type of degradation effects determines what needs to be done (Skutsch & McCall, 2010). Fig 17 provides some ecological solutions based on the causes of degradation of Change Manga identified in this study.

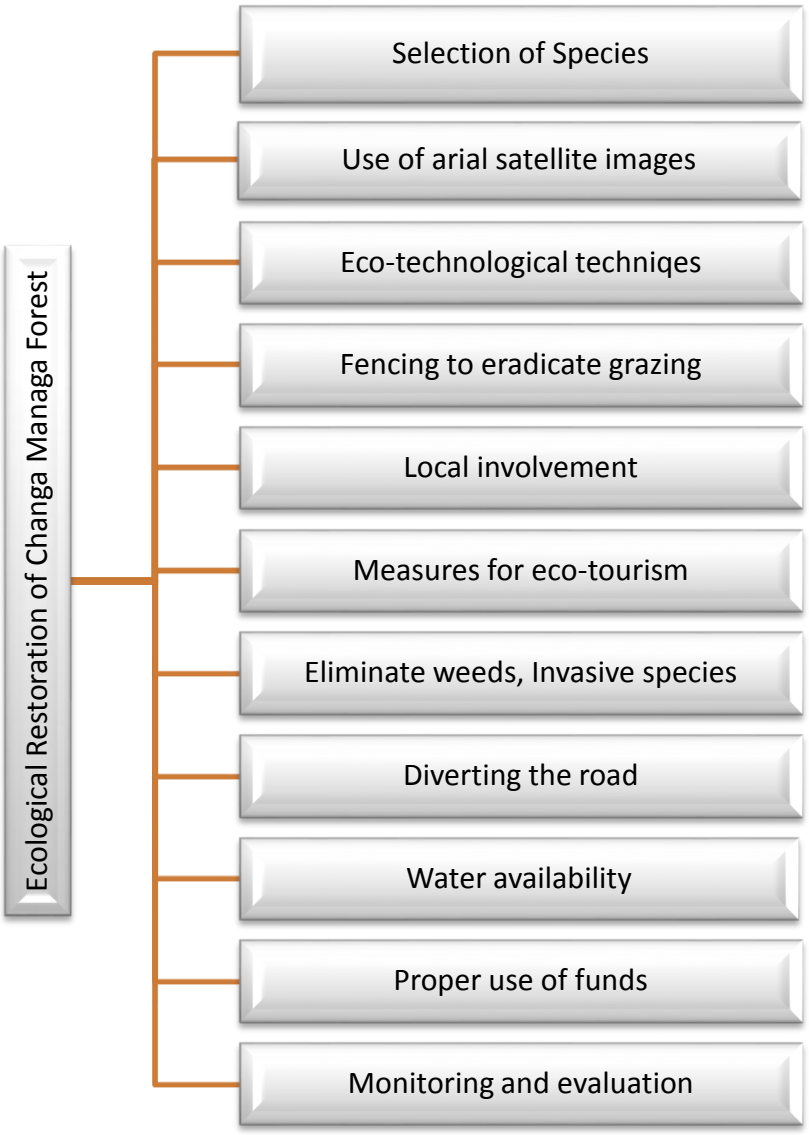

Figure 17: Restoration Model for the Changa Manga Forest.

If degradation is limited, it is not mandatory to apply complex restoration techniques for that site, but when the area to be restored is degraded badly, then there is a need to apply specialized silvi-culture and plantation techniques because in such cases the environmental stress is relatively high (Campoe et al, 2010). The area and location of the protected area is very important to get the proper conservation and restoration (Margules et al, 2000). Moreover, an effective method used for the restoration of plantation is to use 1-2 years old plants, instead of using seeds, as they have shown reduced success (Fuentes et al, 2010). The environmental conditions should also be

considered as they effect success during the first year of restoration (Vallejo et al., 2012). Eucalyptus species are very dominant in this regard, and have been and can continue to be used as a plantation species, accounting for a large portion of approximately 20 million hectares (ha) worldwide (Iglesias-Trabado & wilstermann, 2008). The reason why the eucalyptus species are more popular is their rapid growth rate and re-growing ability and adaptability to the environment (FAO, 1981). The phylogenetic pathways in the restoration sites where human presence is also a factor are quite different as compared to the natural forests (Schweizer et al, 2015).

The selection of local plant species for the purpose of restoration make them better adapted to harsh conditions as they have morphologically and functionally good traits (Bischoff et al., 2010). Mixed species, as described by Kettenring et al. (2014) are regarded as a bet–hedging strategy and can cause delay in selection of a best species composition. According to Gerber (2011), only native species adapted to the climatic conditions of an area should be planted in order to get the restoration of sustainable ecosystems. So, in most of the restoration projects, the young plants used were of local origin (Kiehl et al., 2010).

Fencing or making any kind of boundary for the Changa Manga forest could be a huge support in conservation, as it will also help to minimize the over-grazing effect near local communities and workers with many livestock. Sawtschuk et al. (2010) reported that maritime clifftop vegetation recovered within 16 years because of fencing to remove or keep away grazers. Moreover, fencing would also limit the damage caused by local communities and tourists (F, Appendix 2). Moderate grazing is considered good for regeneration and restoration as it destroys other unrequired vegetation such as some invasive plant species (McEvoy et al, 2006), so some form for management and controlled grazing could be best in Changa Manga.

About 4.2% respondents in the interview study highlighted invasive species as a cause of degradation (Fig. 16). In the early stages of plantation development, there is a need for removing invasive species in order to get better results for the forest restoration. Invasive species also cause such a risk that could compromise the ecological efforts (Alyokhin, 2011). The exotic or invasive species are too disruptive to the ecosystem that if they become abundant they can take over the indigenous plant species (Nunes et al, 2014).

The results here clearly show that local community and the land degradation has a deep interaction. If the degradation of land occurs due to community, i.e. much land used for agriculture or overgrazing, harvesting of wood for private use or for selling, burning, etc. then it causes decline

in forest productivity and directly and indirectly effects peoples' livelihood and income, and hence requires more sustainable restoration management (Derak et al, 2016). Under the declaration of indigenous people rights of United Nation in 2007, it is the rights and land tenure of communities to be given priority and their involvement in the REDD+ funded projects. The human involvement and their activities are a part of ecological restoration, but are mostly ignored (Hallett et al, 2013).

The cultural element is also critical, not only because including societal values increases the public acceptance of restoration and improves its chances of success, but also because almost all lands in this region have been influenced by human presence and their activities. Moreover, climate change and energy scarcity will also limit the possibility for successful restoration (Day et al, 2009). Successful ecological restoration projects can only be achieved by community involvement; transfer of knowledge between policy makers and scientists, administrative organizations; and inclusion of a broad range of restoration experts in the decision-making process (Bernhardt et al, 2007). The Changa Manga forest should no doubt have a recreational park that could be modified to promote eco-tourism, while the activities of tourists and the visitors should be confined in order to avoid degradation.

Global climate change and irregularity in melting ice and availability of water at required seasons is causing the degradation of rivers and canals in Pakistan, especially in the summer season when the glaciers in northern area of Pakistan are expected to melt into rivers. Water provides the important soluble nutrients essential for plant metabolism. Moreover, water is essential for transpiration and photosynthesis processes in the plants for their survival. If water availability is scarce, it could result in threats to survival of seedlings and improper germination (Madsen et al, 2012). Although there is a special canal for the irrigation of Changa Manga, most of the time throughout the year there is less availability of water especially in the winter season. So, this should be considered in restoration planning. A possible alternate could be the Balloki- Sulemanki link Canal on western side of Changa Manga (Fig 18) for water availability.

Roads have always been considered a major threat to the biodiversity and the biological community, especially if they are passing through an ecologically significant area. As in the case of Changa Manga forest, the Pattoki- Chunian highway intersects the entire plantation (Fig 18). In order to highlight ecological restoration as a major suggestion for the future restoration planning for this forest, diverting the road outside the boundaries of Changa Manga would be extremely beneficial. The removal of roads is not an easy task, as it depends much upon the divergence,

relocation and funding (Loyd et al, 2013). Nevertheless, this would certainly limit future human misuse and overexploitation of the forest.

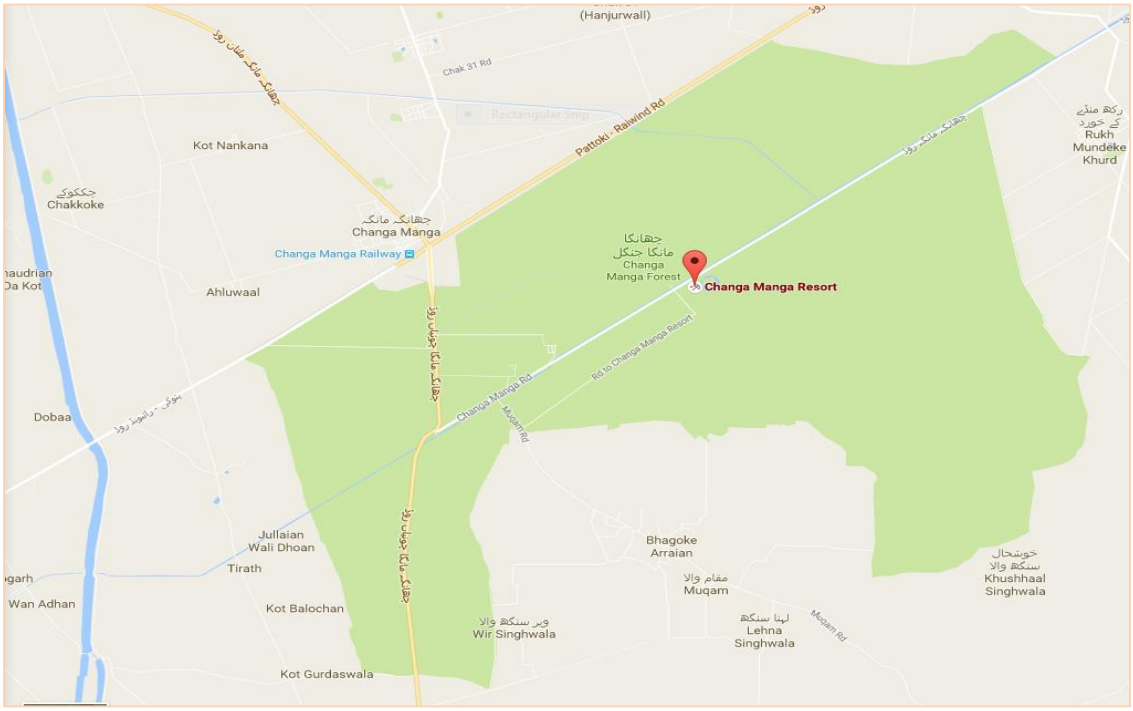

Figure 18: Google map, Changa Manga-Chunian road intersecting the Plantation vertically.

Beside various national projects, the government of Pakistan should also focus on the restoration of this ecological and historical heritage and should allocate funding for its restoration and initiate restoration programs. For funding, certain NGOs could be contacted or REDD could possibly be a good source. Significant work is ongoing towards improved tools for use in monitoring developing country's attachment to their agreed (REDD) targets (Chomitz *et al.*, 2007). My study contributes simple and inexpensive methods for monitoring biological parameters, as well as interviews for additional insight. The involvement of stakeholder has also been reported very essential in ecological restoration projects (Bernhardt et al, 2007). Monitoring plans can help estimate value, resilience and sustainability of the ecosystems (Cury et al, 2005). Although to measure and monitor the stability of an ecosystem is quite complex (Ives & Carpenter, 2007), yet monitoring and evaluation for Changa Manga is very essential. As in the past, I also uncovered many reports of the illegal lodging of the trees in which the officer at divisional and sub divisional level have been involved. With having information about the costs, and spatial dependencies,

decision-making tools can help prioritize restoration activities (Wilson et al, 2011). Moreover, 85% of the respondents in this study suggested monitoring and evaluation as a reliable tool for proper restoration of the Changa Manga forest. My biological data also identified the present state of this forest and what to do in the future in light of either more degradation or hopefully, restoration.

6.0 Conclusion

The Changa Manga Forest is no doubt an artificial green resource, but it is in a state of ecological disturbance and continuous degradation. The findings from both the ecological sampling and the interviews highlights the present and future threats this forest is facing. Lack of attention by the local community, the negligence of government officials and water scarcity were found the main causes of destruction to this major plantation in Pakistan. Pakistan will lose this important ecological resource forever in coming years if immediate appropriate management actions are not in place to reduce, reverse and restore degraded areas. In the future, I suggest in-depth studies of the Changa Manga forest, focusing on restoration and conservation using modern ecological techniques. By this way, in the future, the Changa Manga forest can gain an ecological sustainable state if managers use restoration as the mainstream policy solution to both improve ecosystem services and to make ecological resilience against the perceived environmental change documented in this study.

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Appendix 1

Interview:

Community based Ecological Restoration of Changa Manga Forest, District kasur, Punjab, Pakistan.

General information:

Name:……. Age:…….....

Occupation:…… Education:……

- What you know about the history of largest plantation in Pakistan, change manga forest?
- Is there any such massive plantation in Pakistan in your mind?
- Do you consider changa manga as comparable to a Natural resource as it is an artificially implanted forest?
- What are the major factors responsible for degradation of such a planted forest like change manga?
  (Corrupt officials, water scarcity, fire etc.)
- In Pakistan there is already very scarcity of forests which is only 3-4 %, the minimum standard in a country should be 25, do you consider this forest should be protected in such a situation?
- Do you consider there should be more forests like change manga be planted?
- What are the responsibilities of the government to save it from destruction as already about 70 percent has been partially degraded?
- In your opinion if a project for its ecological restoration will be launched will it be helpful in restoration of this plantation.
- What are your views about the role of plantation and trees: is that good or bad?
  Your arguments……?
- Do you consider local community is also responsible for the restoration and destruction of such a heritage?
- If the recreational park in the forest should be given focus will it be helpful economically or ecologically for govt.?

- There are hundreds of thousands of people around the world which visit from all over the world here, if it will be restored, will it be helpful in attracting more tourists?
- As there are many reports about the negligence of the officials, so what strategy should be made for avoiding such criminal tree cut there?
- Any other suggestions regarding Ecological restoration of Changa Manga?

Appendix 2

Figures from the field visits and collection of biological data.

A. Irrigation canal for Changa Manga.

B. Newly planted Eucalyptus for restoration.

C. Kana shrub useful but catches fire.

D. Kikar in the partially degraded area.

E. Eucalyptus growing from root cut.

F. Interview with a worker at site B.

G. Degraded habitat of site A.

H. Intact habitat of site A.

I. New kana arising from root cut.

J. Fire and tree cut.

K. A sub canal for the irrigation of plantation.

L. Forest boundary (R) private land (L).

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