IDENTIFICATION OF SUITABLE PLANT SPECIES FOR VEGETATION RESTORATION AT MANTHALI

A Dissertation Submitted to Partial Fulfillment of the Requirements for the Master's Degree in Botany

Department of Botany

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RECOMMENDATION LETTER

This is certified that the dissertation work entitled **"Identification of suitable plant species for vegetation restoration at Manthali"** submitted by" **Sunita Poudel "** has been carried out under our supervision. To the best of our knowledge, this research has not been submitted for any other degree, anywhere else. We therefore, recommend this dissertation work to be accepted as a partial fulfillment of Masters' degree in Botany from Amrit Campus, Tribhuvan University Kathmandu, Nepal.

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DECLARATION

I, hereby declare that the dissertation work entitled " **Identification of suitable plant species for vegetation restoration at Manthali "** is carried out by myself and has not been submitted elsewhere for any other academic degree. All the sources of information have been specifically acknowledged by reference wherever adopted from other sources.

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LETTER OF APPROVAL

The dissertation work entitled **" Identification of suitable plant species for vegetation restoration at Manthali "** submitted by **Sunita Poudel** has been accepted for the examination and submitted to the Amrit Campus, Tribhuvan University for the partial fulfillment of the requirements for Masters' degree in Botany (Ecology).

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CERTIFICATE OF ACCEPTANCE

This dissertation work entitled **"Identification of suitable plant species for vegetation restoration at Manthali"** submitted by **Sunita Poudel** has been examined and accepted for partial fulfillment of the requirements of Masters' degree in Botany (Ecology).

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ABBREVIATIONS AND ACRONYMS

U S	:	United States
RGR	:	Relative Growth Rate
SLA	:	Specific Leaf Area
NAR	:	Net Assimilation Rate
LMR	:	Leaf Mass Ratio
et al.	:	and others
IUCN	:	International Union for Conservation of Nature
pH	:	Potential of Hydrogen
KATH	:	National Herbarium and Plant laboratories
D	:	Density
R.D.	:	Relative Density
F	:	Frequency
R.F	:	Relative Frequency
C.	:	Coverage
R.C.	:	Relative Coverage
ANOVA	:	Analysis of Variance
SPSS	:	Statistical Package for Social Science
masl	:	metres above sea level
spp.	:	species

ABSTRACT

The present study aims to find out the suitable native plant species for restoration of degraded lands in and around Manthali. For the selection of the suitable species, the study was carried out in the mountain from 450 masl to 819 masl in Khurkot of Manthali. Thirty quadrats were laid and to observe frequency, density and coverage of plant species present there and ultimately IVI was calculated. Eight plant species – 3 trees like *Acacia catechu*, A*egle marmelos* and *Annona squamosa;* 3 shrubs like *Rhus parviflora, Cipadessa baccifera* and *Abrus precatorius (*woody climber*)*, and 2 herbs like *Uraria lagopodiodes* and *Polypogon monospeliensis* were considered for the detail study on the basis of their high IVI values. Using the protocol of Diaz *et al.*, 2004, fourteen traits (growth form, life-span, phenology, Raunkiaer's life-form, canopy height, stem density, mean ramet distance, leaf size, specific leaf area, leaf thickness, seed mass, propogules mass, seed shape and nitrogen fixation) were observed in those eight species. Based on these traits, through this protocol, the plants were again categorized into five syndrome i.e. establishment syndrome, dispersal syndrome, biomass producing syndrome, persistence syndrome and effect on environment syndrome. Plants which fall under the best establisher were *Annona squamosa*, *Abrus precatorius, Uraria lagopodiodes* and *Polypogon monospeliensis*. Plants with best dispersal ability were *Acacia catechu*, *Rhus parviflora, Uraria lagopodiodes* and *Polypogon monospeliensis*. The plants with best biomass syndrome were *Aegle marmelos* and *Rhus parviflora*. The plants with best persistence were *Acacia catechu*, *Annona squamosa* and *Abrus precatorius*. The plants which effect the environment were *Aegle marmelos* and *Abrus precatorius*. From this study *Annona squamosa* and *Abrus precatorius* can be suggested as candidate species for early succession. Similarly, *Aegle marmelos, Acacia catechu*, *Annona squamosa, Rhus parviflora* and *Abrus precatorius* can be suggested to plant in areas with bushy land which are in the phase of secondary succession.

Keywords: restoration, succession, plant traits, trait syndromes

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1. Introduction

1.1 Background

Land degradation is a major challenge in Nepal and a lot of degraded land is available within the community forests in the Mid-hills which are being aimed to be utilized for ecological restoration as well as supporting livelihoods of the local people (Jha *et al*. 2016). Restoration, in its strict sense, can be defined as the process by which a disturbed site is restored to a pre-disturbance state, with similar environmental conditions, ecosystem structure and species complement (Laurin, 2012). Ecological restoration has the potential to reverse land degradation, increase the resilience of biodiversity, and deliver important ecosystem services (Dorner, 2002). Ecological restoration is very slow process to recover degraded land naturally and if appropriate measures are not applied then, land may even deteriorate (Dorner, 2002). Ecological restoration accelerates this process through a series of active intervention towards the ecological goal (Dorner, 2002).

The restoration process involves different steps: physical reconstruction, reestablishment of hydrologic conditions, chemical modifications and biological manipulations (Tordoff *et al*. 2000).One type of biological modification is through re-vegetation, where plants are used to form cover over the disturbed area(Laurin, 2012)**.**Re-vegetation attempts to restore ecosystem functions and increasing species diversity through the establishment of plant communities (Laurin, 2012).

There is certain process for restoration of the site with appropriate native species. Initially, one should choose appropriate candidate plant species, then should prepare site (by decreasing or removing invasive plant species, by knowing about soil and making it suitable for plantation) and finally caring of the site (Dorner, 2002).

Soil is one of the prime component in the process of restoration. Soil is a natural body occurring on the surface of the Earth that is medium for plant growth and whose characteristics have resulted from integrated effect of climate and living matter (Gupta, 2000). Soils are complex mixture of minerals, water, air, organic matter and countless organisms. Soil is one of the most important factors that can influence plant survival on the site (Dorner, 2002).Soil organic matter is the fraction of the soil that consists of plant or animal tissue in various stages of breakdown. (Baldock and Nelson, 2000). Soils with high organic matter content are capable of supporting greater vegetation diversity and enhancing soil biodiversity (Laban *et al*., 2018).

Hydrogen ion concentration in the soil is called soil pH and is influenced by chemical reactions between soil components and water. Mc Cauley *et al.*(2017) stated that soil pH is a measure of a soil solution's acidity and alkalinity that affects nutrient solubility and availability in the soil. Soil electrical conductivity (EC) is a measure of the amount of salts in soil (Adviento-Borbe *et al.*, 2006). It is an important indicator of soil health (Adviento-Borbe *et al.,* 2006). In areas with high amounts of rainfall, soluble salts from minerals and rocks are flushed below the root zone, eventually into deep groundwater systems or into streams that transport salts to the ocean (Adviento-Borbe *et al.,* 2006). Conversely, in arid areas or in areas where less rainfall occurs or saline irrigation water is used, soluble salts are more likely to accumulate and remain near the soil surface, resulting in high electrical conductivity (Adviento-Borbe *et al.,* 2006). Marx *et al*., (1999) reported that the clay-textured soil is highly conductive while sandy soils are poor conductors. Farahani *et al*., (2005) found that electrical conductivity of soil correlated negatively with sand content, and positively with silt and clay.

For ecological restoration, it is better to use native plant species than exotic ones. A native (indigenous) species is one that occurs in a particular region, ecosystem, and habitat without direct or indirect human actions (Richards, 1998). Native species survived and repeatedly reproduced under the vagaries of unstable climates, predation, disease, herbivory, competition, and all the other limitations and stresses imposed by an environment over multiple generations of continuous genetic editing and sorting (Brown *et al*., 1979). It is better to choose native plant for restoration because of various advantages of native plant species. Some of the advantages as given by Dorner, (2002) are

- add beauty to the landscape and preserve our natural heritage
- provide food and habitat for native wildlife
- serve as an important genetic resource for future food crops or other plant-derived products
- help to slow down the spread of fire by staying green for long time

- decrease the amount of water needed for landscape maintenance
- require very little long-term maintenance if they are properly planted and established
- produce long root systems to hold soil in place
- protect water quality by controlling soil erosion and moderating floods and droughts

Functional plant traits are well-defined characteristics (McGill *et al.* 2006) that relate to plant species' patterns of establishment, growth, and resource allocation and that evolved in response to abiotic environmental conditions and interactions with other species (Reich *et al.* 2003). Thus, functional plant traits are those that strongly influence a plant's performance (McGill *et al.* 2006). Plant functional traits are the features (morphological, physiological, phenological) that represent ecological strategies and determine how plants respond to environmental factors, affect other trophic levels and influence ecosystem properties. Variation in plant functional traits and trait syndromes has proven useful for tackling many important ecological questions at a range of scales, giving rise to a demand for standardized ways to measure ecologically meaningful plant traits.

A total of sixteen traits were collected to closely mirror essential traits measured in other global studies (Diaz *et al.* 2004). Existing protocols were usually followed for their measurement (Cornelissen *et al.* 2003; Diaz *et al.* 2004), occasionally with slight modifications. The fourteen traits are growth form, life-span, phenology, Raunkiaer’s life-form, canopy height, stem density, mean ramet distance, leaf size, specific leaf area, leaf thickness, seed mass, propagule mass, seed shape and nitrogen fixation (Laurin, 2012).

1.1.1 Plant functional traits

Plant functional traits can be defined as those traits important for determining a species’ response to the environment and/or important for ecosystem functioning (Díaz and Cabido, 1997).

In many cases, restoration works to enhance the process of ecological succession. Restoration studies potentially can provide a wealth of information to improve our understanding of succession (Walker *et al*., 2006). Restoration potentially offers succession practical insights into how communities assemble (Walker *et al*., 2006). When restoring degraded ecosystems we can have a range of different goals, ranging from simple reclamation of the land (e.g., reinstating any vegetation cover), to rehabilitation (reinstating some kind of ecosystem functioning such as nutrient and water cycling or productivity), to the most ambitious which is often called true restoration, where restoration of both the structure and function of the pre-disturbance state is attempted (Harris and Van Diggelen, 2006).

During succession, plants must face four major challenges: 1) dispersal to site, 2) establishment on the substrate, 3) persistence and growth, and 4) reproduction (Weiher *et al*. 1999).

i. Dispersal to site

Dispersal ability of a plant relies on: the number of propagules and seeds produced, seed size, seed shape, dispersal method and seed mass (Pausas and Lavorel 2003; Weiher *et al*., 1999). Many dispersal methods exist and have given rise to a series of names: anemochory (wind-dispersed through accessory structures e.g. pappus), exozoochory (attachment with accessory organs e.g. barb), endozoochory (with edible fruit), myrmecochory (with elaisomes), hydrochory (water dispersal), ballistichory, and unassisted dispersal (Weiher *et al*., 1999).

Plant dispersal has for a long time been recognized as a central issue for understanding species distribution and vegetation patterns (Gleason, 1926). The dispersal capacity of the plant can be determined by estimating seed dispersal distances, either directly in the field (e.g Verkaar *et al.*, 1983) or in experimental systems (e.g. Fischer *et al.*, 1996). Seed characteristics play an important role in the colonization and subsequent persistence of species during succession in disturbed sites and thus may contribute to being able to predict restoration success (Horáčková *et. al*., 2016). Dispersal ability relies on: the number of propagules and seeds produced, seed size, seed shape, dispersal method and seed mass (Pausas and Lavorel, 2003; Weiher *et al.*, 1999).

Seeds are dispersed through various agents like: wind, water, animal etc. (Howe and Smallwood, 1982).Four of the traits relate to dispersal; namely, canopy height, seed mass, propagule mass and seed shape and were included in the dispersal syndrome to discriminate dispersal ability of species (Laurin,2012). Canopy height is also an important determinant of the dispersal ability of a species because increased height enables greater dispersal by vectors such as wind (Cornelissen *et al.* 2003). Propagule mass and seed mass influences the dispersal distance (Laurin, 2012). The production of small seed allows for greater total number of seeds being produced which is another way of increasing the potential success of seed dispersal (Weiher *et al.* 1999; Hendry and Grime, 1993).

ii. Establishment

Several environmental factors influence establishment, including soil moisture and fertility, mineral composition, organic matter content, light, temperature, grazing and competition (Walker and Del Moral, 2003), so establishment is often site specific (Weiher *et al.*,1999). Once a seed has dispersed to a new habitat, it does not mean that it will become established. It must germinate and become established on the substrate. An individual plant is most vulnerable at this establishment stage. It must quickly develop a sufficient root system and an adequate photosynthetic system to be able to survive. Sufficient seed reserves and/or a fast growth rate are essential. Many factors influence establishment such as soil conditions (e.g. nutrient availability, porosity, structure and composition), soil moisture, hydrology, light and temperature (Walker and Del Moral, 2003).

However, species traits related to the germination and early life history strategies also determine establishment potential, including seed mass, phenology, life span, SLA and distance between ramets. Seed mass influences seedling establishment because large seeds have more energy and nutrient reserves allowing seeds to germinate faster and earlier (Gondard *et al.*, 2003).Larger seeds are generally better establishers (Shipley and Peters, 1990).SLA is a surrogate for relative growth rate (RGR), and higher RGR allows for a rapid seedling establishment and maturation (Laurin,2012).In terms of phenology, evergreen species can have an advantage over deciduous species since they can photosynthesize over longer periods and during the margins of the seasons (Cornelissen *et al*.,2003).In terms of life-span, annuals tend to be favored during establishment because they generally have larger seeds, faster germination and a rapid relative growth rate (Grime and Hunt,1975).Species with potential for clonal growth through ramet distances are advantaged during establishment because they can find suitable microsites post-germination (Laurin, 2012).

iii.Biomass producing syndrome

Biomass of a plant is its dry weight after removing all the water content in the living body. The growth of an individual plant, or in other words its biomass, in a given location is related to many different traits. In a new environment, plants must obtain nutrients, deal with competition (intraspecific and interspecific) and tolerate various stresses and disturbances (Weiher *et al.* 1999). To deal with these and modify the environment, biomass plays an important role.

Leaf traits have a direct effect on the ability of a plant to capture resources and produce biomass, including leaf size, SLA, leaf thickness (Laurin, 2012). Non-leaf traits also determine biomass production, including phenology, canopy height and stem density (Laurin, 2012).

In terms of phenology, evergreen species are capable of photosynthesizing over longer periods and these species are capable of extending the period of biomass production to marginal seasons when deciduous species already have lost their leaves (Cornelissen *et al.* 2003).Canopy height is associated with the photosynthetic ability of a species, because taller species can obtain more sunlight enabling greater photosynthetic rates (Cornelissen *et al.* 2003).Lastly, a higher stem density allows a plant to stand upright to access higher light levels, but at a cost of increased biomass allocation to stems. Denser stem live longer and are more durable (Cornelissen *et al.* 2003).

iv. Persistence syndrome

Persistence of a plant occur at individual level in a community. Persistence of an individual plant can only occur if it possesses traits allowing survival and regeneration (Pausas and Lavorel, 2003). Leaf traits (thickness, woodiness) and whole plant traits (height, clonality) are important indicators at this level. Persistence also requires individuals to be able to compete with other individuals, either conspecifics or different species, for nutrients, light and water (Weiher *et al*., 1999). Competition can be defined by two ways: 1) the ability to suppress neighboring plants (competitive effect) and 2) the ability to resist suppression by neighboring plants (competitive response) (Pausas and Lavorel, 2003). Plants utilize many different strategies in the face of competition, including growing at different times of year, utilizing different growth forms, height, extreme emergence times (Weiher *et al*.,1999) and fast growth (Pausas andLavorel,2003). In many disturbed ecosystems, competitive response is commonly measured by shade-tolerance. Shade-tolerance is associated with leaves with high specific leaf area, increased stem density and the production of large sized seeds (Pausas and Lavorel, 2003). Competition can often lead to species composition changes and influence community structure which affect succession (Chapin, 2003).

Key traits that relate to persistence include life span, height, stem density, ramet distance, Raunkiaer's growth form, SLA and phenology (Laurin, 2012). Life-span is the most elementary trait measured in relation to persistence since annuals and biennials are replaced by perennials during succession (Weiher *et al*. 1999).Canopy height also indicates persistence because taller plants out-compete others for light (Cornelissen *et al.*, 2003).Stem density is related to height and hence competitive ability, because denser stems allow plants to grow taller (Laurin, 2012).Raunkiaer's growth form categorizes species by the location of the perennating buds, the area where new growth occurs after unfavorable conditions, in relation to the soil surface (Laurin, 2012).SLA is also included in the persistence syndrome, because plant growth rate is also related to competitive ability (Cornelissen *et al.* 2003). Species with a high SLA have higher RGR and consequently greater competitive ability (Cornelissen *et al.* 2003).In terms of phenology, evergreen species persist longer than deciduous species. Evergreen species can have an advantage over deciduous species since they can photosynthesize over longer periods and during the margins of the seasons (Cornelissen *et al.* 2003).

v. Effect on environment syndrome

The plant species growing in the community effects its surrounding environment as well (Weiher *et al*., 1999; Cornelissen *et al*., 2003). Plant traits like canopy height, ramet distance, life span, and phenology and leaf thickness are the selection criteria for effect on environment syndrome (Laurin, 2012). Canopy height creates the microclimatic condition for understory species. The light, temperature, wind humidity, temperature extremes are influenced by canopy height of plant species

(Westoby, 1998). These microclimatic condition also effect the decomposition environment of the decomposers. The height of plant cover also determines the potential for windbreaks and wind erosion. A second related trait, growth form, also determines how species provide surface cover. More the ramet distance, more is the roots and rhizome network which helps in stabilizing soil (Laurin, 2012). Deciduous species produce litter of higher quality as compared to evergreen species (Chapin *et al*., 1996). Leaf thickness also influences decomposition rate and litter formation. Thick leaves (with higher carbon investment) leads to increased resistance during drought. Perennial plant lives for longer duration so, it has higher effect on environment. Nitrogen fixation can also be an important process in disturbed ecosystems because nitrogen is often limited in these habitats (Chapin, 2003).

1.2 Justification of study

Ramechhap lies in the rain shadow area of Mahabharat hill. Manthali lies within Ramechhap. There is a severe drought condition in Manthali. Rapid urbanization occurred in that area. Due to that, the vegetation of that area is being destroyed. So, there is the need of restoration.

There is certain process for restoration of the site with appropriate native species. Initially one should choose suitable plant species, then should prepare site (by decreasing or removing invasive plant species, by knowing about soil and making it suitable for plantation) and finally caring for the site (Dorner, 2002). So, initially it is very necessary to find which species to plant and how the soil should be treated by finding its characters. Hence in this research, appropriate candidate species and few soil properties like: soil organic matter, soil pH, soil electrical conductivity and soil texture were needed to be identified.

1.3 Research questions

The following research questions will be answered:

- Which native plant species can be used for restoration?

1.4 Hypothesis

Null hypothesis

All native species will qualify for restoration of degraded land of Manthali.

1.5 Objectives

The general objective of this research is:

- To identify suitable plant species for restoration of Manthali.

The specific objectives of this research are:

- To analyze 14 functional traits in native plants of Manthali.
- To identify suitable candidate species for five different syndromes

2. Literature review

2.1 Restoration with native species

Native plant species in any particular area of interest are those which arrived, established, and survived there without direct or indirect human assistance (Randall *et al*., 1997).Slattery *et al*. (2003) stated that native plants naturally occur in the region in which they evolved. Native plants are adapted to local soils and climate conditions, they generally require less watering and fertilizing than non-natives. Lu Y. *et al*., (2017) stated that use of native species in forest restoration has been increasingly recognized as an effective means of restoring ecosystem functions and biodiversity to degraded areas across the world. Natives are often more resistant to insects and disease as well, and so are less likely to need pesticides. Wildlife evolved with plants; therefore, they use native plant communities for food, cover and rearing young. Using native plants helps preserve the balance and beauty of natural ecosystems.

Brown *et al.*, (1999) has shown that native species survived and repeatedly reproduced under the vagaries of unstable climates, predation, disease, herbivory, competition, and all the other limitations and stresses imposed by an environment over multiple generations of continuous genetic editing and sorting. The same study suggests that severely disturbed wild lands can be restored with appropriate native species.

Jha *et al*. (2016) concluded through their research in Dhading, Chautara Dada that it would be wise to select the native or naturalized species for the rehabilitation of degraded sites in the Mid-hills, as sometimes the introduction of exotic species may have pessimistic ecological consequences. The study was conducted in the Chautaradanda Community Forest (27°44’05’’ N and 85°04’60’’ E) of Thakre Village Development Committee of Dhading District in the lower Mid-hills of Central Nepal to test the survival capacity and growth performance of different tree species (native, naturalized as well as exotic) that can be used for the rehabilitation of degraded sites. This study showed that the native species can grow very well on degraded sites. Though, *Pinus patula*, the exotic species, showed the outstanding results, we have to be cautious when recommending it as it is an exotic species and may have a chance to be invasive like in Africa. Native and naturalized species such as *Prunus cerasoides, Choerospondias axillaris* and *Melia azedarach* were found to have performed relatively better. Another exotic species *Robinia pseudoacacia* was not successful in this study, and also not in other parts of Nepal. Therefore, it is recommended to prefer the native or naturalized species for the rehabilitation of degraded sites in the Mid-hills. It would be wise to conduct a preliminary study before planting these species in other parts of the Mid-hills for the rehabilitation of degraded land.

Ryan *et al.*, (2007) in Sacramanto valley of U S shows that restoring native grassland along roadsides can provide a relatively low-maintenance, drought-tolerant and stable perennial vegetative cover with reduced weed growth, as opposed to the high-maintenance invasive annual cover (requiring intensive mowing and herbicide treatments) that dominates most Sacramento Valley roadsides. A survey of long established roadside native-grass plantings in Yolo County showed that once established and protected from disturbance, such plantings can persist with minimal maintenance for more than a decade, retaining a high proportion of native species. The survey also showed that each species of native perennial grass displays a microhabitat preference for particular roadside topographic positions, and that native perennial grass cover is negatively affected by disturbance.

Slattery *et al*., (2003) stated that exotic species have become increasingly significant management problems in parks and reserves and frequently complicate restoration projects. So, native species are the best choice.

2.2 Plant's functional traits

Violle *et al*. (2007) defined functional traits as physiological traits that can influence survival, growth, and fitness of an individual within a given environment. Plant performance can be investigated by plant traits as per Roberts *et al.* (2010).

2.2.1 Growth form

Plant were divided into trees, shrubs, herbs.

2.2.2 Life span

Life span of plants may be annual, biennial or perennial**.** Glover (2003) stated that in comparison to perennial plant, annual plant inefficiently utilizes water and nutrients resulting in degradation of soil and water quality. Classic ecological theory suggests that dominance by annual plants, which live for only one year, is a short transient state that is quickly replaced by perennial plants during ecological succession as given by DeMalach (2018). So, in terms of persistence, perennial plants are more favored than annuals and biennials. Perennial plants effects the environment more because perennial lives longer on the environment than annual and biennial. (Laurin, 2012).

2.2.3 Phenology

Species with longer leaf life span always have a lower photosynthetic rate as per Reich *et al.* (1992). So, Guo *et al*., (2017) suggests that the photosynthetic capacity of deciduous species may be more easily limited by light availability than that of evergreen species. Therefore, evergreen plant species can extend the period of biomass production. Hence, have higher biomass production than deciduous. Since, evergreen plant species can photosynthesize over longer periods and during the margins of the seasons, evergreen have higher persistence also as described by Cornelissen, (2003). Deciduous species are supposed to have better effect on environment than evergreen because deciduous species produce litter of higher quality as compared to evergreen species (Chapin *et al.*, 1996).

2.2.4 Raunkiaer's life-form

Raunkiaer's life-form utilizes the hypothesis that location of perennating buds of plants subjected to similar environmental stress can be used as the index of degree of protection from adverse environmental condition as per Chapman *et al.*, (1981). So,one can predict that chaemeophytes to be most affected in drought condition, hemicryptophytes moderately and how well buds are protected geophytes being least affected, if the buds are well protected.

2.2.5 Distance between ramets

Abrahamson (1980) stated that capacity for horizontal spreading by propagating ramets is likely to affect the spatial distribution at the genet level as well as the population level. Increased ramet distance also gives more potential to produce a network of roots/rhizomes, which again can stabilize the soil (Laurin, 2012) while decreased ramet distance shows it can grow more number of it and persist there.

2.2.6 Canopy height

Dispersal is a key process in the life of plants, determining the persistence of populations and the distribution of species (Nathan and Muller-Landau, 2000).Thomson *et al*., (2017) says that there is positive correlation between plant height and its dispersal distance. This means higher the canopy height, larger the propagules and seeds can be distributed.

Soons *et al*., (2004) stated that taller species presumably release seeds at greater heights than do shorter species, and for wind-dispersed species, greater release heights result in increased dispersal distances. Beyond wind-dispersed species, the relationship between plant height and dispersal distance is largely unknown, although there was a positive relationship between plant height and mean dispersal distance for 41 tropical tree species in the study conducted by Muller-Landau *et al.*, (2008). Canopy height has the great effect on environment as it alter the microclimatic condition of the species living beneath it (Westoby, 1998).

2.2.7 Stem density

Weller (1989) reported a positive relationship between dry biomass per unit volume and stem density, suggesting more efficient carbon packing in communities growing at a higher density. Chave *et al.,* (2005) stated that low wood density species are associated with rapid growth and a resource acquisitive growth strategy, while high wood density species are associated with slow growth and stress resistance.

2.2.8 Leaf size and Specific Leaf Area

As given in article by Weraduwage *et al.* (2015), leaf area growth determines the light interception capacity of a crop and is often used as a surrogate for plant growth in high-throughput phenotyping systems. The relationship between leaf area growth and growth in terms of mass will depend on how carbon is partitioned among new leaf area, leaf mass, root mass, reproduction, and respiration.

Liu *et al*., (2017) defined Specific leaf area (SLA), as the ratio of total leaf area to total leaf dry mass, has been shown one of the leaf traits best reflecting whole plant growth. SLA describes the distribution of leaf biomass relative to leaf area.

According to article of Osone *et al*. (2008),

$$RGR = SLA \times NAR \times LMR$$

where,

RGR=Relative Growth Rate

NAR= Net Assimilation Rate

LMR=Leaf Mass Ratio

This means RGR is directly proportional to SLA or vice-versa.

Wright *et al*., (2004) also states that high SLA is often associated with high values of RGR. Grotkopp *et al.,* (2007) said that optimization of fast seedling growth (high RGR) associated with increased root allocation to survive summer drought. This means it results in higher establishment of plant in the study area.

According to Lambers *et al.* (2004), high SLA appears to be associated with competitive ability of the plants and a low SLA is associated with persistence of the species.

2.2.9 Leaf thickness

High biomass investment in leaf thickness and/or compactness, and in high fiber, lignin, and structural components are associated with resistance to drought, freezing, and chilling (Kao *et al*., 2004). As the areas around Khurkot (the study site) is highly degraded, plant with thicker leaves were found to be surviving there. Leaf thickness also influences decomposition rate and litter formation.

2.2.10 Seed mass and propagule mass

There is strong evidence that surplus resources of larger seeds render young seedlings more resistant to hazards like drought, shade or herbivory during early stage of seed as reviewed by Liesman *et al*.,(2000)and has also been supported by data synthesis of Moles and Westoby (2004). Large seed size is a trait associated with plant species of mature, closed habitats, and is thought to supply an ample nutrient reserve necessary for seedling establishment (Hewitt, 1998).While this relationship has been shown for annuals and short-lived perennials, it is poorly documented for trees (Hewitt, 1998).Morse *et al*. (1985) used the propagules of common milkweed (*Asclepias syriaca* L.) and tested the predictions that decreasing size may increase dispersal ability. Thompson *et al*. (2011), proved that small-seeded species disperse farther than large-seeded species. Though they even proved that canopy height correlate more with dispersal ability compared to seed mass. However, negative correlations between dispersal and establishment are often reported in the literature by Skarpaas (2010).Smaller seeds tend to disperse better but germinate less well, and produce smaller seedlings. It was proposed that small and compact seeds are related to ease of burial (Bekker *et al*., 1998), since small and compact seeds can easily penetrate cracks in the soil or are washed in by rainwater and thus escape post-dispersal predation.

2.2.11 Seed shape

Rounder seed tend to survive longer in the soil to form a seed bank (Thompson *et al.*, 2017) and seeds that persist in the soil seed bank for more than one year are considered to exhibit a bet-hedging adaptation to environmental uncertainty (Venable and Brown, 1988). Elongated or flat shape may be less of an impediment to burial in small seeds than in large seeds (Peco *et al.*, 2003).

2.2.12 Nitrogen fixing ability

Chaer (2011) stated the introduction of leguminous trees able to form symbioses with nodulating N_2-fixing bacteria and arbuscular mycorrhizal fungi constitutes an efficient strategy to accelerate soil reclamation and initiate natural succession. Nitrogen fixing ability effect the environment around it because nitrogen is often found to be limited in disturbed sites (Chapin, 2003).

2.3. Soil properties

Various soil properties like: soil organic matter, soil pH, soil electrical conductivity and soil texture in one or other way influences the establishment and persistence of plant community. Organic matter in soil is the key to soil health (Ebtihal *et al*., 2019). Soil organic matter (SOM) improves many physical, chemical and biological characteristics of the soil, including water holding capacity, cation exchange capacity, pH buffering capacity, and chelating of micronutrients (Ebtihal *et al*., 2019). A loss of SOM can lead to soil erosion, loss of fertility, compaction, and general land degradation (Ebtihal *et al*., 2019). Once soil organic carbon levels fall below 1%, then a wide range of soil properties can be adversely affected (Brian, 2015). In grassland or forest soils may have SOM as high as 4 to 5% (Laban *et al*, 2018). Predicting the overall impact of soil organic matter on productivity is complex because of the wide range of potential effects of soil organic matter (Brian, 2015). In the present study, the SOM ranged from 1.2 to 2.4 % indicating that some areas at higher altitude have slightly degraded soil but possibly can help for the survival of the plants.

In sandy soils, soil organic matter is the most important factor, in clayey soils cation balance can be the most important effect and in loamy soils both cation balance and soil organic matter are important. Under similar climate conditions, the organic matter content in fine textured (clayey) soils is two to four times than that of coarse textured (sandy) soils (Bot and Benites, 2005). In the present study soil condition ranged from sandy to sandy loam, hence the soil organic matter were less.

The "ideal" soil pH is close to neutral, and neutral soils are considered to fall within a range from a slightly acidic pH of 6.5 to slightly alkaline pH of 7.5(Lauchli and Grattan, 2012). It has been determined that most plant nutrients are optimally available to plants within this 6.5 to 7.5 pH range, plus this range of pH is generally very compatible to plant root growth (Lauchli and Grattan, 2012). In strongly acid or highly alkaline soils, the growing conditions for micro-organisms are poor, resulting in low levels of biological oxidation of organic matter (Bot and Benites, 2005). In the present study, soil pH ranged from 6.016 to 7.4, which is within the optimal range. Hence, no adverse effect on the establishment of plant in the study site is expected.

Soil electrical conductivity readings less than 1 dS/m, soil are considered non-saline (Adviento-Borbe *et al.,* 2006) and do not impact most vegetation and soil microbial processes (Adviento-Borbe *et al.,* 2006). Soil electrical conductivity readings greater than 1 dS/m, are considered saline and impact important microbial processes, such as nitrogen cycling, production of nitrous and other N oxide gases, respiration, and decomposition; populations of plant-parasitic nematodes can increase; and increased nitrogen losses (Adviento-Borbe *et al.*, 2006).

Soil salinity considers the most serious environmental risks that have restricted in arid and semiarid regions causing soil degradation and deterioration (Ebtihal *et al*., 2019). Soil salinization especially occurs due to exacerbated natural and human activities at or near the surface including land clearing and excessive irrigation (Ebtihal *et al*., 2019). In the present study, soil electrical conductivity of our study area ranged from 65.792 to 85.912 μS/cm which is equivalent to 0.065 to 0.0859 ds/m and is within the range.

In our study area, few places in low altitude have sandy loam soil and all other have sandy soil. At most places the soil were of compacts nature. Restricted depth of penetration of roots is the primary adverse effect of compaction on the sandy soil (Pumphrey *et al.,* 1980). The plants utilize less volume of soil for moisture and nutrient absorption (Pumphrey *et al.,* 1980). A reduced rate of water infiltration, slower exchange of air between the atmosphere and the soil, and slower air movement within the soil are other possible problems occurring from this condition (Pumphrey *et al.,* 1980).

3. Materials and Methods

3.1 Study area

Manthali is headquarter of Ramechhap district in Janakpur zone of north-western Nepal. It was declared as headquarters of the district in 26th Falgun, 2045 BS because of lack of drinking water and difficult topography of former headquarter of Ramechhap.

Ramechhap has a diversified environment in different ecological zone. Southern area of Ramechhap falls in rain shadow zone of Mahabharat Hill which extends from Roshikhola catchment of Kavrepalanchowk occur lower than southern belt of Mahabharat range (Shrestha *et.al.*, 2015). Ramechhap was announced drought area by District Agriculture Coordination Committee on July 9, 2010.

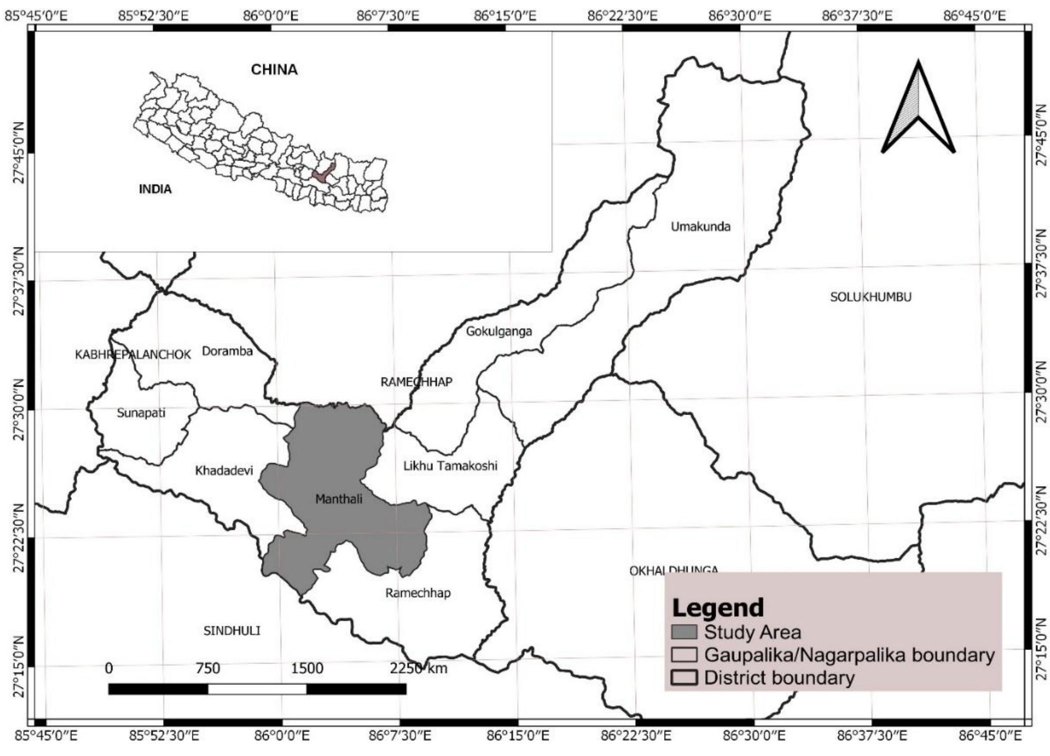


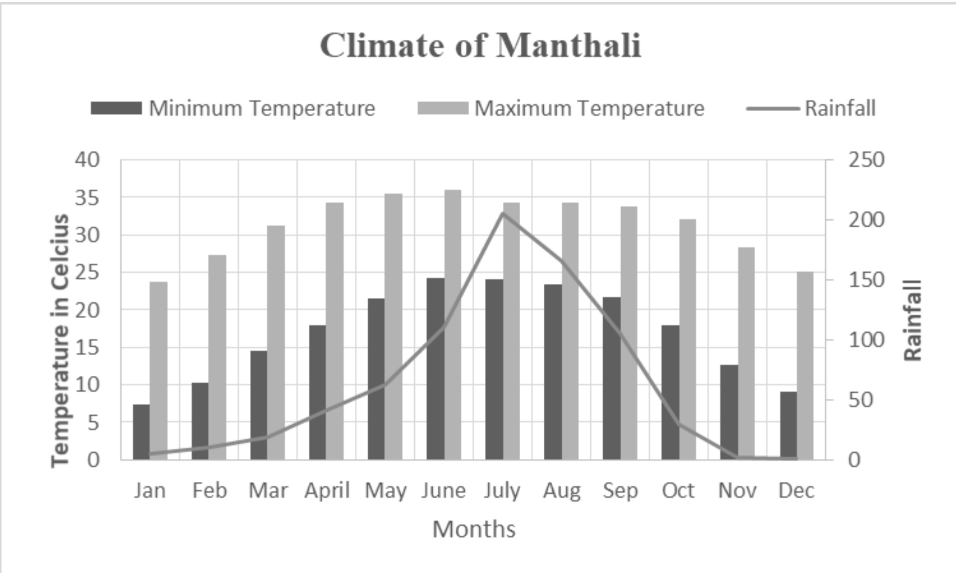
Fig 1: Map of study area

Source: www.google.com.np/maps/

Figure 2**:** Study site with sampling plots

3.1.1 Climate of Manthali

Manthali is the drought-prone area as it is a rain-shadow zone of Mahabharat hill (Shrestha *et. al*., 2015).The climate in Manthali is warm and temperate. The maximum average temperature was observed to be in June. The maximum rainfall was in July itself.



(Source: Department of Hydrology and Meteorology, Babarmahal, Kathmandu, Nepal)

Figure 3: Eight years (2011-2018) AD average monthly temperature and rainfall recorded at Manthali Station

3.2 Methods

Random sampling along the trail were conducted at Khurkot, Manthali, west facing slope, ranging from 462 m to 820 m above sea level. Altogether 30 quadrat of 20×20 m^2 were used for tree species, 60 quadrats of 5×5 m^2were used for shrub species and 60 quadrats of 2×2 m^2 were used for herb species. Frequency, density and coverage of all species present in the quadrat were recorded.

3.2.1 Plant Collection, Herbarium preparation and Identification

The different plant species encountered during the study were identified in the field itself. Herbariums of the unidentified species were prepared and identified by consulting to Godawari, National Herbarium and Plant Laboratories (KATH).

3.2.2 Community structure

The field data was used to calculate frequency, density, coverage and Importance Value Index (IVI) of plant species following the method described by Zobel *et al*., (1987). The formula used for calculation of these attributes are given below:

The number of plants per unit area is called density of the plant species.

$$\text{Density (D)} = \frac{\text{Total no. of species occurred}}{\text{Total no. of quadrat studied} \times \text{Area of quadrat}}$$

Relative density is the density of a species with respect to the total density of all species, and is expressed as,

$$\text{Relative Density (R.D.)} = \frac{\text{Density of individual species}}{\text{Total density of all species}} \times 100\%$$

Frequency is the number of times a plant species occurs in a given number of quadrats.

$$\text{Frequency (F)} = \frac{\text{No. of quadrats in which species occured}}{\text{Total no of qudrats studied}} \times 100\%$$

Relative frequency is frequency of a species in relation to the frequency of all other species, and is expressed as,

$$\text{Relative Frequency (R.F.)} = \frac{\text{Frequency of individual species}}{\text{Total no frequency of all species}} \times 100\%$$

Percentage of ground surface covered by vegetation is called coverage of that area. It is done in terms of 100%

Coverage (C) = Visual Estimation

$$\text{Relative coverage (R.C.)} = \frac{\text{Coverage of individual species}}{\text{Total coverage of all species}} \times 100\%$$

The analysis of the species distribution was conducted by using Importance Value Index (IVI) as introduced by Cottam and Curtis (1956) for comparison of the species dominance. The IVI for a species were calculated as the sum of its relative frequency, relative density, and relative coverage, calculated by using formula,

Importance Value Index (IVI) = R.D. + R.F. +R.C.

3.2.3 Plant trait syndrome

According to Laurin (2012) the various plant traits were noted and candidate plants were selected for various trait syndromes like: i) establishment syndrome, ii) dispersal syndrome, iii) biomass producing syndrome, iv)persistence syndrome and v) effect on environment syndrome. On the basis of different plant traits, the best candidate species were identified for various trait syndromes.

- **i.** Establishment syndrome:For the establishment syndrome- large seed mass, higher SLA, short ramet distance, evergreen phenology and annual life span were the selection criteria.
- **ii.** Dispersal syndrome: For the dispersal syndrome plant traits like: less propagule mass, less seed mass, taller canopy height and round seed shape were the selection criteria.
- **iii.** Biomass producing syndrome: For the biomass producing syndrome plant traits like: less SLA, taller canopy height, high stem density, more leaf thickness, evergreen phenology were selection criteria.
- **iv.** Persistence syndrome: Plant traits like taller canopy height, high stem density, less ramet distance, higher SLA, perennial life span, phanerophytes are selection criteria for persistence syndrome.

v. Effect on environment syndrome: Plants traits like tallest canopy height, large ramet distance, perennial life span, deciduous phenology and high leaf thickness were considered for the selection of candidate species for this syndrome.

3.2.4 Plant traits

Altogether 14 plant traits were collected after the selection of species through sampling as described above.

i. Growth form

Plants were divided into herb, shrub, and trees.

ii. Life-span

Plants were divided into annual, biennial, perennial. Annual plants complete their life cycle in a single year, whereas, biennial plants take two years to complete this cycle (Laurin, 2012). Perennials plants are long-lived, surviving for more than 2 years (Laurin, 2012).

iii.Phenology

Species were divided into evergreen and deciduous. Evergreen is defined as species that have leaves that last longer than one season (Laurin, 2012). Deciduous species avoid losing resources by reabsorbing them before shedding their leaves (Laurin, 2012).

iv. Raunkiaer's growth form

All species were classified into the Raunkiaer's classification scheme , namely: 1) phanerophytes, 2) chamaephytes, 3) hemicryptophytes 4) geophytes and 5) therophytes (Cornelissen et al. 2003) Phanerophytes have resting buds located at least 25 cm above the soil surface and generally include trees and shrubs (Laurin, 2012). Chamaephytes have perennating buds located no higher than 25 cm above the soil surface (Laurin, 2012). Hemicryptophytes have the buds at or on the soil surface (Laurin, 2012). Geophytes, a subgroup of the cryptophytes, have storage below-ground through storage organs (ex. tubers, bulbs) and/or buds (Laurin, 2012). Finally therophytes are annual plant species that do not have storage organs apart from seeds (Laurin, 2012).

v. Distance between ramets

The ramet distances were measured using measuring tape.

vi. Canopy height

Canopy heights were measured using altinometer.

vii. Stem density

It is dry weight of stem per volume (King *et al*., 2006).

viii. Specific Leaf Area (SLA)

Specific leaf area (SLA) is the one-sided area of a fresh leaf, divided by its oven-dry mass (Vile *et. al*., 2005) i.e.

$$\text{Specific Leaf Area (SLA)} = \frac{\text{Leaf Area}}{\text{Dry mass}}$$

Leaf area was calculated using ImageJ and dry mass was calculated by keeping it overnight in oven.

ix. Leaf size

Leaf size was measured through Image J.

x. Leaf thickness

Leaf thickness was calculated using micrometer screw gauge.

xi. Propagule mass

The propagule includes the structures surrounding the seed(s) that aids in their dispersal by vectors such as wind, water or organisms (Laurin, 2012). It is a vegetative structure that can become detached from a plant and give rise to a new plant, e.g. a bud, sucker, or spore. For some wind-pollinated species whole inflorescence were collected. Propagules were collected from matured plant. So, propagules were collected during autumn and monsoon seasons.Propagules were then oven-dried at 80^{o}C for 48 hours (Laurin, 2012). Propagules were bulk weighed from a population then divided by the number of propagules to determine the mean mass of a propagules (Laurin, 2012).

xii. Seed mass

Seeds of the plants were collected. It was then dried at 80^{o}C for 48 hours. They were weighed individually (15 seeds in total for each species per site) or counted and bulk-weighed for smaller seeds (300 seeds) at 0.1 mg precision (Laurin, 2012).

xiii. Nitrogen fixation

Leguminous plants were recorded as nitrogen fixing plants and non-leguminous plants were searched for nitrogen fixation through PLANTS-database (USDA and NRCS, 2011).

xiv. Seed shape

Various shapes of seed were identified and related with seed bank in soil.

3.3. Soil properties

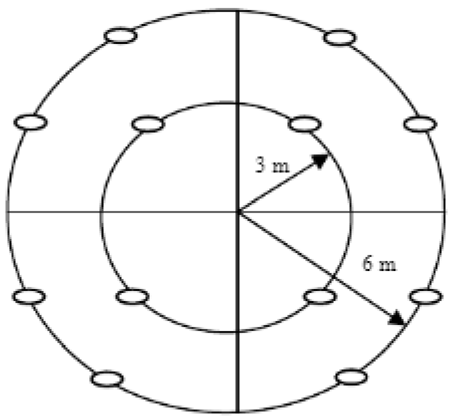
Though for selection of suitable candidate species for restoration, soil parameters were not included by Diaz *et al*. (2004). But, in the present study the soil parameters like: organic matter, pH, electric conductivity and texture were included to understand the soil properties of the study site.

Dorner (2002) states that soils are one of the most important factors that can influence plant survival on the site. A few of the major characteristics of soil and examples of how they can affect plant health and survival as given by Dorner (2002) are listed below.

- texture – affects moisture levels and nutrient exchange
- pH – affects the ability of plants to take up nutrients
- organic matter – affects nutrient and moisture availability
- Compaction– makes it difficult for plant roots to penetrate the soil; affects nutrient cycles & beneficial organisms.

- residual herbicides or pesticides – can affect plants and associated insects

Soil will collected through point sampling. Twelve subsamples from each of sampling plot (west facing slope) will be collected (Maina *et al*., 2015).



(Source: Maina *et al*., 2015)

Figure 4**:** Schematic representation of the twelve soil sampling points which comprised one main sampling point

Soil samples were collected using a sterilised soil auger and mixed thoroughly before obtaining 100 g from this sample.

i. Soil organic carbon

Soil carbon will be calculated through Walkley and Black rapid titration method (Gupta, 2000).

Reagents used:

- Standard 1N potassium dichromate: 49.04 g of AR grade $K_2Cr_2O_7$ (oven dried at 90^0 C) will be dissolved in distilled water and will be made upto 1 litre.
- 0.5 N ferrous ammonium sulphate: 196 g of hydrated crystalline salt will be dissolved in 1 litre of distilled water containing 20 ml of H_2SO_4.

- Diphenylamine indicator: 0.5 g of diphenylamine will be dissolved in a mixture of 20 ml of water and 100 ml of conc. H_2SO_4
- Concentrated sulphuric acid containing 1.25 % silver sulphate
- Ortho-phosphoric acid or sodium fluoride.

Method:

- 1 g soil will be taken in a dry 500 ml conical flask.
- 10 ml of 1N $K_2Cr_2O_7$ will be pipeted and swirled a while.
- The flak will be kept on asbestos sheet. Then, 20 ml H_2SO_4 will be added and swirled again for two to three minutes.
- The flask will be allowed to stand for 30 minutes and then 200 ml distilled water will be added to it.
- 10 ml of phosphoric acid or/and 0.5 g sodium fluoride and 1 ml of diphenylamine indicator will be added to it.
- The contents will be titrated with 0.5 N ferrous ammonium sulphate solution till the color changes from violet blue to green
- Simultaneously, a blank will be run without soil. If more than 7 ml of dichromate solution will be consumed the determination must be repeated with a smaller quantity of (0.25- 0.50) g of soil.

Observation:

Weight of soil taken = S g

Volume of 0.5 N ferrous ammonium sulphate required to neutralize 10 ml of 1N $K_2Cr_2O_7$ i.e. blank titration (Blank reading) = B ml

Volume of 0.5 N ferrous ammonium sulphate needed for titration of sample (reading with soil) = C ml

Difference between volumes of ferrous ammonium = (B=C) ml

Here,

$$\text{Percentage of carbon in soil} = N \frac{B - C}{\text{Weight of soil}} \times 0.003 \times 100$$

Where, N= normality of ferrous ammonium sulphate

There is incomplete oxidation of the organic matter in this procedure. Therefore, the organic carbon obtained by above method will be multiplied by a factor 1.3 based on assumption that there will be 77% recovery.

Organic carbon= organic carbon estimated × 1.3

To determine organic matter content of soil, the organic matter will be multiplied by Van Bemmelen factor of 1.724 because organic matter contains 58% organic carbon.

ii. Soil pH

Soil pH will be measured using pH meter in lab using Sivakugan *et al*., (2011)

- From the soil passing a 2.56 mm sieve, a sample of 35 g will be obtained.
- 30 grams from it will be transferred to 100 ml beaker and 75 ml distilled water will be added to it. The suspension will be stirred for few minutes, then the beaker will be covered with a cover glass and will be allowed to stand for several hours.
- Then, the pH meter will be calibrated placing the electrodes in standard buffer solutions (e.g., pH of 4.0 and 9.2) separately.
- After calibrating, the electrodes will be washed with distilled water and immersed in soil suspension. Two to three readings of pH of soil – suspension with brief stirring between each reading will be taken. These reading should not differ by more than 0.05 pH units.

- The electrodes in the suspension will be removed and washed with distilled water. The calibration of pH meter will be checked using one of the buffer solution. If the instrument is out of adjustment by more than 0.05 pH units, it will be then set to correct adjustment by repeating the above method.

- When not in use, electrodes will be left standing in the beaker of distilled water.

iii. Soil electrical conductivity

Soil electrical conductivity was measured using distilled water and soil in 2:1 ratio with the help of conductivity meter (Gupta *et al*., 2000).

iv. Soil texture

Soil texture class was determined on the basis of the sand, silt and clay percentage by using the USDA textural classification chart (Gupta *et al*., 2000).

3.2.6. Statistical analysis

To understand significant differences among the mean of each plant traits at different growth forms (i.e. herbs, shrubs, trees). Duncan's Multiple Range test was used after One-Way ANOVA using SPSS version with p= 0.5

4. Result

Altogether 16 species were found within the altitude of 450 masl to 819 masl in Khurkot of Manthali (Table 1). Among them, three trees, three shrubs and two herbs with high IVI values were considered for selection of candidate species for restoration for our study. Although *Ageratina adenophora* and *Lantana camara* had high Importance Value Index values in the study area, these species are neglected because they are enlisted as invasive species.

Table 1: Relative frequency (%), relative density (%), relative coverage (%) and IVI of different plant species found in Khurkot, Manthali

S.No.	Name of species	Relative Frequency (%)	Relative Density (%)	Relative Coverage (%)	IVI
Trees					
1.	*Acacia catechu*	41.17	44.44	23.07	108.69
2.	*Aegle marmelos*	23.52	22.22	38.46	84.21
3.	*Annona squamosal*	29.41	27.77	30.76	87.95
4.	*Cladodendron* spp.	5.88	5.55	7.69	19.13
Shrubs					
5.	*Abrus precatorius*	10.51	24.41	10.47	45.39
6.	*Ageratina adenophora*	36.17	27.90	41.09	105.17
7.	*Cipadessa baccifera*	14.89	11.62	2.73	29.26
8.	*Lantana camara*	36.17	33.72	41.09	110.98
9.	*Rhus parviflora*	21.27	11.62	8.21	41.12
Herbs					
10.	*Ageratina* sapling	54.16	3.46	5.12	62.75
11.	*Cynodon dactylon*	4.16	0.22	2.56	6.95
12.	*Polypogon monospeliensis*	25	48.05	20.51	93.56
13.	*Themeda caudate*	16.66	0.865	10.256	27.78
14.	Species A (gramineae)	20.833	1.082	10.25	32.17
15.	Species B (Pteridophyte)	8.33	4.90	15.38	64.62
16.	*Uraria lagopodiodes*	25	5.41	41.02	71.43

On the basis of IVI, plant species having high values were selected for further detail study. Trees like *Acacia catechu*, A*egle marmelos* and *Annona squamosa;*shrubs like*Rhus parviflora, Cipadessa baccifera, Abrus precatorius (*woody climber*),* and herbs like *Uraria lagopodiodes* and *Polypogon monospeliensis* were considered for the detail study. Though the IVI value of *Lantana camara* and *Ageratina adenophora* were recorded very high, but were not considered for detail study because of their invasive nature (Glass, 2004).

For the selection of candidate species the plant traits like Growth form, Life span, Phenology, Raunkiaer's growth form, Distance between ramet , Canopy height, Stem specific density, Leaf area, Specific Leaf Area, Leaf thickness, Propagule mass, Seed mass and Seed shape were observed according to Diaz *et al.*(2004).

a. Plant trait syndromes

i. Establishment syndrome

Plant traits like large seed mass, higher SLA, short ramet distance, evergreen phenology, annual life span are the selection criteria for the establishment syndrome. In the present study, among tree species out of five traits (for establishment syndrome) three traits i.e. larger seed mass, highest SLA and evergreen/semi-deciduous are fulfilled by *Annona squamosa* (Table 2). Hence, *Annona squamosa* can be considered as the best establisher.

Table 2: Different traits (seed mass, Specific Leaf Area, Ramet distance, Phenology, Life span) of establishment syndrome in dominant trees of Khurkot, Manthali (n=3)

Plant's name	**Seed mass (gram)**	**SLA(cm^2/gm)**	**Ramet distance (m)**	**Phenology**	**Life span**
Acacia catechu	0.031± 0.008 A	91.94±3.65 B	4.83± 2.61 A	Deciduous	Perennial
Aegle marmelos	0.058±0.003 B	57.86 ± 4.37 A	5.06 ± 2.89 A	Deciduous	Perennial
Annona squamosa	0.183± 0.001 C	129.29 ± 7.07 C	3.76 ± 0.92 A	Evergreen/Semi-deciduous	Perennial

Same capital letters followed after mean ± Standard deviation in a column do not differ significantly at P=0.05 according to Duncan's Muliple range tests followed after ANOVA.

The shrub *Abrus* had highest seed mass and Specific Leaf Area value. Among herbs, *Polypogon* had lowest ramet distance and annual life span (Table 3). Among shrubs and herbs; *Abrus precatorius*, *Polypogon monspeliensi*s can be considered as good establisher.

Table 3: Different traits (seed mass, Specific Leaf Area, Ramet distance, Phenology, Life span) of establishment syndrome in dominant shrubs and herbs of Khurkot, Manthali (n=5)

Plant's name	**Seed mass (grams)**	**SLA(cm ^{2}/gm)**	**Ramet distance (m)**	**Phenology**	**Life span**
Rhus parviflora	0.0560± 0.002 B	62.82± 4.06 A	2.96± 1.66 B	Evergreen	Perennial
Abrus precatorius	0.151± 0.047 C	184.77±2.41D	2.86 ± 0.70 B	Deciduous	Perennial
Cipadessa baccifera	0.030 ± 0.022 A,B	135.25 ± 2.48 B	3.93 ± 1.45 B	Evergreen	Perennial
Uraria lagopodiodes	0.003 ± 0.0009 A	149.18 ± 9.26 B,C	0.616 ± 0.125 A	Deciduous	Perennial
Polypogon monospeliensis	0.0005 ± 0.0008 A	157.01 ± 20.84 C	0.206 ± 0.055 A	Deciduous	Annual

Same capital letters followed after mean ± Standard deviation in a column do not differ significantly at P=0.05 according to Duncan's Muliple range tests followed after ANOVA

ii. Dispersal syndrome

Plant traits like: less propagule mass, less seed mass, taller canopy height and round seed shape are the selection criteria for dispersal syndrome. In the present study, among tree species out of four traits (for establishment syndrome), three traits i.e. less propagule mass, less seed mass and large canopy height is fulfilled by *Acacia catechu* (Table 4). Hence, *Acacia catechu* can be considered to have best dispersal syndrome.

Table 4: Different traits (propagule mass, seed mass, canopy height, seed shape) of dispersal syndrome in dominant trees of Khurkot, Manthali (n=3)

Plant's name	**Propagule mass (grams)**	**Seed mass (grams)**	**Canopy height(m)**	**Seed shape**
Acacia catechu	0.59 ± 0.05 A	0.031 ± 0.008 A	8.7 ± 1.38 B	Ovate
Aegle marmelos	74.22 ± 4.12 C	0.058 ± 0.003 B	7.64 ± 1.39 B	Oblong
Annona squamosa	34.17 ± 3.66 B	0.183 ± 0.001 C	5.03 ± 0.74 A	Obovoid or elliptic

Same capital letters followed after mean ± Standard deviation in a column do not differ significantly at P=0.05 according to Duncan's Muliple range tests followed after ANOVA.

The shrub *Rhus parviflora* hadless propagule mass and round seed. Hence, can be considered to have best dispersal syndrome. Among the herbs, *Uraria lagopodiodes* and *Polypogon monospeliensis* had higher dispersal capacity as they have lowest propagule and seed mass. Among shrub and herbs; *Rhus parviflora*, *Uraria lagopodiodes* and *Polypogon monospeliensis* are best disperser (Table 5).

Table 5: Different traits (propagule mass, seed mass, canopy height, seed shape) of dispersal syndrome in dominant shrubs and herbs of Khurkot, Manthali (n=5)

Plant's name	**Propagule mass (grams)**	**Seed mass(grams)**	**Canopy height(m)**	**Seed shape**
Rhus parviflora	0.0049 ± 0.0036 A	0.056 ± 0.0026 B	5.47 ± 0.68 C	Round
Abrus precatorius	0.151 ± 0.047 B	0.151 ± 0.047 C	8.55 ± 1.24 D	Oval
Cipadessa baccifera	0.21 ± 0.017 C	0.0302 ± 0.022 AB	1.75 ± 0.47 B	Ovoid
Uraria lagopodiodes	0.0031 ± 0.0009 A	0.0031 ± 0.0009 A	0.06 ± 0.01 A	Kidney-shaped
Polypogon monospeliensis	0.0005 ±0.00008 A	0.0005 ± 0.00008 A	0.05 ± 0.01 A	Oblong

Same capital letters followed after mean ± Standard deviation in a column do not differ significantly at P=0.05 according to Duncan's Multiple range tests followed after ANOVA.

iii. Biomass producing syndrome

Plant traits like: less SLA, taller canopy height, high stem density, more leaf thickness, evergreen phenology are selection criteria for biomass producing syndrome. In the present study among tree species, out of five traits; two traits i.e. lower SLA, higher leaf thickness are fulfilled by *Aegle marmelos* (Table 6). Higher canopy height and higher stem density is fulfilled by *Acacia catechu* (Table 6). Hence, *Aegle marmelos* and *Acacia catechu* are considered to have best biomass producing capacity.

Table 6: Different traits (Specific Leaf Area, canopy height, stem density, leaf thickness and phenology) of biomass producing syndrome in dominant trees of Khurkot, Manthali (n=3)

Plant's name	**SLA(cm^2/gram)**	**Canopy height (m)**	**Stem density (gram/ml)**	**Leaf thickness (mm)**	**Phenology**
Acacia catechu	91.94 ± 3.65 B	8.7 ± 1.38 B	0.87 ± 0.05 C	0.01 ± 0.00 A	Deciduous
Aegle marmelos	57.86 ± 4.37 A	7.64 ± 1.39 B	0.75 ± 0.05 B	0.56 ± 0.10 B	Deciduous
Annona squamosa	129.29 ± 7.07 C	5.03 ± 0.74 A	0.64 ± 0.05 A	0.43 ± 0.13 B	Deciduous

Same capital letters followed after mean ± Standard deviation in a column do not differ significantly at P=0.05 according to Duncan's Muliple range tests followed after ANOVA

Among shrub and herb, out of five traits three traits i.e. less Specific Leaf Area, evergreen phenology and higher leaf thickness is fulfilled by *Rhus parviflora* (Table 7). Hence, *Rhus parviflora* will produce best biomass among shrubs / herbs.

Table 7: Different traits (Specific Leaf Area, canopy height, stem density, leaf thickness and phenology) of biomass producing syndrome in dominant shrub and herb species of Khurkot, Manthali (n=5)

Plant's name	SLA (cm^2/gram)	Canopy height (m)	Stem density(gm/ml)	Leaf thickness(mm)	Phenology
Rhus parviflora	62.82 ± 4.06 A	5.47 ± 0.68 C	0.54 ± 0.005 C	0.61 ± 0.12 C	Evergreen /sub-deciduous
Abrus precatorius	184.77 ± 2.41 D	8.55 ± 1.24 D	1.21 ± 0.005 E	0.07 ± 0.005 A	Deciduous
Cipadessa baccifera	135.25 ± 2.48 B	1.75 ± 0.47 B	0.62 ± 0.003 D	0.0202 ± 0.024 B	Evergreen
Uraria lagopodiodes	149.18 ± 9.26 B,C	0.06 ± 0.01 A	0.02 ± 0.005 B	0.19 ± 0.040 B	Deciduous
Polypogon monospeliensis	157.01 ± 20.84 C	0.05 ± 0.01 A	0.01 ± 0.00 A	0.05 ± 0.02 A	Deciduous

Same capital letters followed after mean ± Standard deviation in a column do not differ significantly at P=0.05 according to Duncan's Muliple range tests followed after ANOVA

iv. Persistence syndrome

Plant traits like: taller canopy height, high stem density, less ramet distance, higher Specific Leaf Area, perennial life span, Phanerophytes are selection criteria for persistence syndrome. In the present study, among tree species, out of five traits, four traits i.e. larger canopy height, higher stem density, phanerophytes growth form and perennial life span is fulfilled by *Acacia catechu*.(Table 8).*Annona squamosa* also fulfill four traits among five i.e. less ramet distance, higher SLA, perennial life span and phanerophytes (Table 8). So, *Acacia catechu* and *Annona squamosa* had best persistence syndrome.

Table 8: Different traits (canopy height, stem density, ramet distance, Specific Leaf Area, Life span, Raunkiaer's growth form) of persistence syndrome in dominant trees of Khurkot, Manthali (n=3)

Plant's name	Canopy height (m)	Stem density (gram/ml)	Ramet distance(m)	SLA(cm^2/gm)	Life span	Raunkiaer's growth form
Acacia catechu	8.7 ± 1.38 B	0.87 ±0.05 C	4.83 ± 2.61 A	91.94 ±3.65 B	Perennial	Phanerophytes
Aegle marmelos	7.64 ±1.39 B	0.75 ±0.05 B	5.06 ± 2.89 A	57.86 ± 4.37 A	Perennial	Phanerophytes
Annona squamosa	5.03 ±0.74 A	0.64 ±0.05 A	3.76 ± 0.92 A	129.29 ± 7.07 C	Perennial	Phanerophytes

Same capital letters followed after mean ± Standard deviation in a column do not differ significantly at P=0.05 according to Duncan's Muliple range tests followed after ANOVA

The shrub *Abrus precatorius* had taller canopy height, higher stem density, higher SLA, perennial life span, phanerophytes growth form (Table 9). So, *Abrus precatorius* is the species having best persistence syndrome.

Table 9: Different traits (canopy height, stem density, ramet distance, Specific Leaf Area, Life span, Raunkiaer's growth form) of persistence syndrome in dominant trees of Khurkot, Manthali (n=5)

Plant's name	Canopy height (m)	Stem density (gm/ml)	Ramet distance (m)	SLA(cm^2/ gm)	Life span	Raunkiaer's growth form
Rhus parviflora	5.74 ±0.68 C	0.54 ± 0.005 C	2.96 ±1.66 B	62.82 ± 4.06 A	Perennial	Phanerophytes
Abrus precatorius	8.55 ±1.24 D	1.21 ± 0.005 E	4.60 ±1.10 B	184.77 ± 2.41 D	Perennial	Phanerophytes
Cipadessa baccifera	1.75 ±0.47 B	0.62 ± 0.003 D	3.93±1.45 B	135.25 ± 2.48 B	Perennial	Phanerophytes
Uraria lagopodiodes	0.06 ±0.01 A	0.02 ± 0.005 B	0.61 ±0.125 A	149.18 ± 9.26 BC	Annual	Chamaephytes
Polypogon monospeliensis	0.05 ±0.01 A	0.01± 0.00 A	0.206 ± 0.055 A	157.01 ± 20.84 C	Annual	Chamaephytes

Same capital letters followed after mean ± Standard deviation in a column do not differ significantly at P=0.05 according to Duncan's Muliple range tests followed after ANOVA

v. Effect on environment syndrome

Plants traits like tallest canopy height, large ramet distance, perennial life span, deciduous phenology and high leaf thickness were considered for the selection of candidate species for this syndrome. In the present study, among tree species out of five traits, four traits i.e. largest ramet distance, largest leaf thickness, perennial life span and deciduous phenology are fulfilled by *Aegle marmelos* (Table 10). Hence, *Aegle marmelos* is the best candidate for the effect on environment.

Table 10: Different traits (canopy height, ramet distance, leaf thickness, life span, and phenology) of effect on the environment syndrome in dominant trees of Khurkot, Manthali (n=3)

Plant's name	**Canopy height (m)**	**Ramet distance (m)**	**Leaf thickness(mm)**	**Life span**	**Phenology**	**Nitrogen fixing capability**
Acacia catechu	8.7 ± 1.38 B	4.83 ± 2.61 A	0.01 ± 0.00 A	Perennial	Deciduous	Yes
Aegle marmelos	7.64 ± 1.39 B	5.06 ± 2.89 A	0.56 ± 0.10 B	Perennial	Deciduous	Not known
Annona squamosa	5.03 ±0.74 A	3.76 ± 0.92 A	0.43 ± 0.13 B	Perennial	Deciduous	Not known

Same capital letters followed after mean ± Standard deviation in a column do not differ significantly at P=0.05 according to Duncan's Muliple range tests followed after ANOVA.

The shrub *Abrus precatorius* had highest canopy height, perennial life span, deciduous phenology and nitrogen fixing ability (Table 11). So among the shrubs, *Abrus precatorius* is the species having best effect on environment syndrome.

Table 11: Different traits (canopy height, ramet distance, leaf thickness, life span, and phenology) of effect on the environment syndrome in dominant shrubs and herbs of Khurkot, Manthali (n=5)

Plant's name	**Canopy height (m)**	**Ramet distance (m)**	**Leaf thickness (mm)**	**Life span**	**Phenology**	**Nitrogen fixing capability**
Rhus parviflora	5.47 ± 0.68C	2.96 ± 1.66 B	0.61 ± 0.12 C	Perennial	Evergreen /Sub-deciduous	Not known
Abrus precatorius	8.55 ± 1.24D	2.86 ± 0.70 B	0.07 ± 0.005 A	Perennial	Deciduous	Yes
Cipadessa baccifera	1.75 ± 0.47B	3.93 ± 1.45 B	0.0202 ± 0.024 B	Perennial	Evergreen	Not known
Uraria lagopodiodes	0.06 ±0.01 A	0.616 ± 0.125 A	0.19 ± 0.040 B	Annual	Deciduous	Yes
Polypogon monospeliensis	0.05 ± 0.01A	0.206 ± 0.055 A	0.05 ± 0.02 A	Annual	Deciduous	Not known

Same capital letters followed after mean ± Standard deviation in a column do not differ significantly at P=0.05 according to Duncan's Muliple range tests followed after ANOVA.

b. Synopsis of all syndromes

At early successional stage, best establisher will be targeted. It can be poor or intermediate disperser.

So, for early succession in the similar area of Manthali, *Annona squamosa* is suitable candidate species among trees and *Abrus precatorius* among herb/ shrub (Table 12).

And, for the land which already has few plant species, plant with ability to produce biomass and persist affect the ecosystem, *Aegle marmelos* can be chosen for better biomass of that area and *Acacia catechu / Annona squamosa* for better persistence of plant species among trees. Among herb/ shrub, *Rhus parviflora* and *Abrus precatorius*can be chosen (Table 12).

Table 12: Name of suitable candidate species of plants obtained from different syndrome for restoration

Growth form	**Establishment syndrome**	**Dispersal syndrome**	**Biomass producing syndrome**	**Persistence syndrome**	**Effect on environment syndrome**
Trees	*Annona squamosa*	*Acacia catechu*	*Aegle marmelos/ Acacia catechu*	*Acacia catechu / Annona squamosa*	*Aegle marmelos*
Shrub /Herb	*Abrus precatorius/ Polypogon monospeliensis*	*Rhus parviflora Uraria lagopodiodes/ Polypogon monospeliensis*	*Rhus parviflora*	*Abrus precatorius*	*Abrus precatorius*

c. Soil

Soil properties like: Soil organic matter, soil pH, soil electrical conductivity, soil texture were also studied in the soil samples collected from the sampling sites. The quadrats located at gorges were having comparatively good vegetation cover. Soil in these plots at gorges were with higher amount of organic matter and sandy loam texture. The quadrats located in the open areas were mostly with poor vegetation cover and the soil in these plots were with less organic matter and sandy texture.

Soil Organic Matter, soil pH, soil electrical conductivity, soil texture is within the range suitable for plant establishment. So, it had no effect on establishment, hence, identification of suitable species for plant species was done.

Table 13: Soil properties

Soil properties	**Mean ± S.D.**	**Range**
Soil organic matter	1.32±0.108 %	1.12 to 2.4
Soil pH	6.708±0.692	6.016 to 7.4
Soil electrical conductivity	75.852±10.06 µS	65.792 to 85.912
Soil texture	Mostly Sandy and few sandy loam	

5. Discussion

Ecological restoration has the potential to improve air quality, reverse forest clearance and desertification, slow biodiversity loss, enhance urban environments and perhaps improve human livelihoods and humanity's relationships within nature (Perring *et al*., 2015).

Our result shows only 16 species from 450 masl to 819 masl. Manthali is a drought-prone area (Shrestha *et al*., 2015). Drought is the most important abiotic factor limiting growth, adversely affect growth of plants (Fathi and Barari, 2016). Drought is the cause of stress in plant growth. There is 50-30% reduction in yield due to low humidity (Ghodsi *et al*., 1998). Drought stress occur in plant due to high evapotranspiration, high intensity of sunlight(Ghodsi *et al*,1998), high temperature in drought causes increased respiration, photosynthesis and enzyme activity in the plant.

Clark *et al*.(2016) in his article suggested that there is declining number of plant species because of drought stress. Drought may have a large immediate effect on ecosystem dynamics (Clark *et al*., 2016). It may also alter community structure as it represents a kind of stress to plants which negatively affects population density and enhances the probability of extinction of less abundant species (White *et al*. 2000).

5.1 Importance Value Index

In the present study three tree species, three shrubs and two herbs were considered on the basis of IVI values for detail study. Laurin (2012) considered native, widespread and frequently distributed species in his study. In the present study, widespread and frequent distribution are selected on the basis of IVI values.

During the study, it was found that *Lantana camara* had highest IVI value. Similar case was found in the research of Kumar *et al*. (2018). In their research, they concluded that invasion of invasive plant species highly reduced the available habitats or niches for the growth of other useful plant species. They directly or indirectly become responsible for the loss of productivity and diversity of species in the invaded areas.

Invasive species should be removed before planting native species (Glass, 2004),. So, even if invasive species have highest IVI, it cannot be selected for restoration. Hence, *Lantana camara* and *Ageretina adenophora* were neglected although they had high IVI value.

Except *Lantana camara* (110.98) and *Ageretina adenophora* (105.17) the species with highest IVI is *Acacia catechu* (108.69) among trees, *Abrus precatorius* (45.39) among shrubs. *Polypogon monospeliensis*(93.96) and *Uraria lagopodiodes*(71.43) had high IVI among herbs.

Acacia catechu demonstrate both the lowest plant water- and osmotic potentials among the indigenous species (Khainga and Mitlohnerb, 2013). They resist drought and soil salinity well, and can thus be found across all of central Myanmar dominating specific forest (Khainga and Mitlohnerb, 2013).This suggests that their resistance to adverse environmental stresses helps improve their ability to dominate the area (Khainga and Mitlohnerb ,2013).

Abrus precatorius L. (Fabaceae) is a woody legume plant that grows in tropical countries and is an invasive weed in other areas (Parsad *et al*., 2015). *Abrus precatorius* is a wild plant that grows best in fairly dry regions at low elevations (Paul *et al.*, 2013). The IVI result of present study also suggested that *Abrus precatorius* grow better in comparison to other shrub species.

The species with higher IVI are *Acacia catechu*, *Aegle marmelos*, *Annona squamosa*, *Rhus parviflora*, *Abrus precatorius*, *Cipadessa baccifera*, *Uraria lagopodiodes*, *Polypogon monospeliensis*.

5.2 Plant trait syndrome

i. Establishment syndrome

Plant traits like: seed mass, Specific Leaf Area, ramet distance, phenology and life span were considered for the establishment syndrome. The present study suggested *Annona squamosa* is best establisher tree because of its larger seed mass, higher SLA and evergreen life span than others. Among shrub, *Abrus precatorius* establish well because it has higher seed mass and Specific Leaf Area values. Among herbs *Polypogon monospeliensis* because of its less ramet distance and annual life span.

Larger seeds are better establisher because the reserve food materials is high which allows seed to germinate earlier and faster (Shipley and Peters, 1990). High SLA is surrogate for high Relative Growth Rate (RGR), and higher RGR allows for a rapid seedling establishment and maturation of seedling (Laurin, 2012). According to Cornelissen *et al*. (2003) evergreen/ semi deciduous plant are better establisher than the deciduous plant because of their high photosynthesizing ability over the margin of seasons. Annual plant establish well than perennial plant because they have larger seed and faster RGR (Grime and Hunt, 1975). Plants with shorter ramet distance are better establisher as they can easily find suitable site for germination (Laurin, 2012).

Several other research also suggest that *Annona squamosa* is better establisher. *Annona squamosa* is drought tolerant species and can establish well in drought-tolerant areas (Verkataratanam and Satyanaranaswamy, 1956). *Annona squamosa* can tolerate wind and dry climates as well as infertile, sandy, and limestone soil so long as it is well-drained (Verkataratanam and Satyanaranaswamy, 1956). Similarly, *Abrus precatorius* has been reported as a wild plant that grows best in fairly dry regions at low elevations (Rajeshwar *et al.,* 2015).

ii. Dispersal syndrome

Plant traits like- propagule mass, seed mass, canopy height and seed shape were considered for dispersal syndrome according to Laurin (2012). Among trees, *Acacia catechu* have best dispersal syndrome because of less propagule and seed mass and large canopy height. Among shrub *Rhus parviflora* has best dispersal capacity because of less propagule mass, less seed mass, canopy height and round seeds. In the case of herbs, plant height was ignored and only two traits i.e. less propagule mass and seed mass were considered and hence the herbs –*Uraria lagopodiodes* and *Polypogon monospeliensis* were good disperser.

Small seeds and propagules are favored for dispersion (Pausas and Lavorel, 2003) because small seeds disperse further than large seeds (Thompson *et al*., 2011). Besides this production of small seeds also allows plant to produce larger number of seeds with the limited resources (Weiher *et al.* 1999). Increased height enables greater dispersal by vectors such as wind (Cornelissen *et al*., 2003) and hence taller plant provide larger dispersal than shorter plant (Soons *et al*., 2004).

Pods dehiscence in *Acacia catechu* is not long after ripening and commence falling in January (Hashmat *et al*.,2013) The seeds get damaged by insects exclusively (Hashmat *et al*.,2013) .The wind- dispersed seeds germinate with the onset of rains (Hashmat *et al*.,2013). *Acacia catechu* is one of the very few species which grows well in the degraded lands. Hence this species attain the best among the trees for dispersal syndrome and this could be very useful for the community plantations in Nepal (Jha and Mandal, 2019), especially in the degraded land.

iii. Biomass producing syndrome

Plant traits like: SLA, canopy height, stem density, leaf thickness and phenology were considered for biomass producing syndrome (Laurin, 2012).In the present study *Aegle marmelos* has higher biomass producing capacity among trees because of lower SLA and more leaf thickness. *Acacia catechu* also has higher biomass producing capacity because of higher canopy height and higher stem density. In the present study, *Rhus parvifora* is capable of producing high biomass among herb/shrub because it has less SLA, evergreen phenology and higher leaf thickness.

Plant with low Specific Leaf Area (SLA) has high biomass because SLA is inversely proportional to the dry weight. Tall plants have higher biomass because they get more sunlight and enabling them for more photosynthesis (Cornelissen, 2003). Besides this higher stem density in *Aegle marmelos* allowed it to stand upright to access higher light levels. More the leaf thickness, higher is the biomass. Evergreen species produce large biomass because they have longer period of light availability, whereas it is limited in deciduous as they fall down (Cornelissen, 2003).

iv. Persistence syndrome

Plant traits like: higher SLA, perennial life span, taller canopy height, high stem density, less ramet distance and phanerophyte life span are considered for persistence syndrome. In the present study *Acacia catechu* has best persistence syndrome among trees because of its highest stem density and tallest canopy height, phanerophyte life form and perennial life form. *Annona squamosa* has best persistence syndrome because of less ramet distance, higher SLA, perennial life span and phanerophyte life form. As *Acacia* has highest stem density, it could attain height and became tall. Larger the canopy height, higher is the persistence syndrome because it will outcompete all other species which do not receive proper sunlight (Cornelissen, 2003). Higher the stem density, higher is the persistence syndrome because denser stem allows the plant to grow taller and taller plant generally have higher persistence (Laurin, 2012). Stem density is related to height and hence competitive ability, because denser stems allow plants to grow taller (Laurin, 2012).

Among shrubs *Abrus precatorius* has the best persistence syndrome because of its highest canopy height, stem density, SLA, perennial life span and phanerophyte life form. Larger the SLA, higher is the persistence of plant because SLA is directly related to relative growth rate and higher the relative growth rate higher is the persistence (Cornelissen *et al*., 2003). Perennials plants are preferred because perennials replace annuals and biennials during succession (Weiher *et al.*, 1999).

v. Effect on environment syndrome

Plants traits like: tallest canopy height, large ramet distance, perennial life span, deciduous phenology and high leaf thickness were considered for the effect on environment syndrome. Among trees, *Aegle marmelos* has best effect on environment syndrome because it has largest ramet distance, largest leaf thickness, Perennial life span and deciduous phenology. *Abrus precatorius* has best effect on environment syndrome because it has highest canopy height, perennial life span and deciduous phenology.

Higher the canopy height, larger is its effect on environment because canopy height creates microclimatic condition for other species including amount of light, temperature extremes, wind and humidity (Westoby, 1998). Canopy height also determines the potential for windbreaks and wind erosion potential (Laurin, 2012). Increased ramet distance gives more potential to produce a network of roots/rhizomes, which again can stabilize the soil hence has better effect on environment syndrome (Laurin,2012). Higher the leaf thickness, higher is the biomass under the canopy and more is the litter production (Cornelissen *et al.*, 2003) for nutrient recycling. Perennial plant species has more influence on the environment because it stays there for longer time (Laurin, 2012). Deciduous species has better effect on environment as compared to evergreen because deciduous species produce higher quality of litter as compared to evergreen species (Chapin *et al.*, 1996).

Acacia catechu, *Abrus precatorius* and *Uraria lagopodiodes* have better effect on environment as they are nitrogen fixing plant.

5.3 Synopsis of all the syndromes

Laurin, 2012 suggest that at early successional stage, best establisher will be targeted. It can be poor or intermediate disperser.

Laurin, 2012 also suggests for the land which already has few plant species, plant with ability to produce biomass, persist affect the ecosystem.

Ecological succession is a fundamental concept in plant community and restoration ecology (Johnson and Miyanishi, 2008).

i. Early succession

Present study suggest that *Annona squamosa* is suitable for early succession. Bhatnagar *et al.*, (2012) suggest that *Annona squamosa* being very hardy, survives well under drought, salinity and marginal soil conditions. It grows very well even on shallow soils at the mercy of nature.

Present study suggest *Abrus precatorius* to be good for early succession but according to Blood (2008), *Abrus precatorius* had spread into new places very quickly, harmed other local plants in the area and became ‘potentially invasive’ very easily. Yanucalevu and Mabulau. Ghazanfar *et al*., (2001), stated that *Abrus precatorius* has an oceanic mode as the main means of dispersal. *Abrus precatorius* is already a key threat to the other plant communities in other parts of the world. For example in certain places in Australia, it acts as a transformer species, altering the nature of the plant communities by smothering existing vegetation, both in the ground layer and canopy, altering the light climate and suppressing the regeneration of native species (Blood, 2008).

So, it might not be wise to use *Abrus precatorius* for early succession as it will harm any other species growing there. It might be wise to grow herb like: *Polypogon monospeliensis* can be used for early succession.

ii. For land which already has few species

Present study suggests *Aegle mamelos*, *Acacia catechu*, *Annona squamosa*, *Rhus parviflora* and *Abrus precatorius* for the succession of land which already has few plant species. As we already discussed that it might not be wise to use *Abrus precatorius* for sucession, it might be excluded.

Aegle marmelos has reputation in thriving in a place where other plants cannot survive (Sampath Kumar *et al*., 2012). Sekar *et al*., (2011) suggest that *Aegle marmelos* grows well in dry places. Vijayalaxmi *et al*., (2017) suggest that,*Aeglemarmelos* is distributed throught the dry forest in hill and plain areas.

Bhattacharya *et al*., (2013) suggests that *Annona squamosa* grows well in hot dry climates and adjusts in any kind of soil. Martinez (2013) says that the sugar apple grows from sea level to 1,000 masl and requires no cold periods; and so, develops and grows well in relatively stable conditions of temperature.

Jha and Mandal (2019) suggests that *Acacia catechu* is one of the very few species which grows well in the degraded lands and could be very useful for the community plantations in Nepal.

5.4. Soil

Soil Organic Matter ranged from 1.2 to 2.4 % indicating that some areas at higher altitude have slightly degraded soil but possibly can help for the survival of the plants. If organic matter is below 1% then it is not suitable for plantation (Brian, 2015).Soil texture ranged from sandy to sandy loam. In the present study, soil pH ranged from 6.016 to 7.4, which is within the optimal range (Lauchli and Grattan, 2012) i.e. 6.5 to 7.5. Hence, no adverse effect on the establishment of plant in the study site is expected. Soil electrical conductivity of our study area ranged from 65.792 to 85.912 µS/cm which is equivalent to 0.065 to 0.0859 dS/m and is within the range (less than 1 dS/m).

Hence, through this result it can be concluded that soil properties like: soil organic matter, soil pH, soil electrical conductivity has no effect on the establishment of plant species.

6. Conclusion

On the basis of different syndrome studied, it can be concluded that the tree species like *Annona squamosa* is a best plant candidate for establishment and also for persistence in the environment. *Acacia catechu* shows high dispersal as well as persistence syndrome. But the tree species *Aegle marmelos* is good candidate for high biomass producing syndrome and hence its effect on environment is prevalent.

Among the shrubs *Abrus precatorius* is good establisher. It also persist and influences the environment. *Rhus parviflora* is candidate for dispersal and biomass production. The herb *Polypogon monospeliensis* are good candidate for establishment.

So, only few species seems to be suitable for restoration. So, the predicted null hypothesis is rejected.

7. Recommendation

For the restoration in the bare land, *Annona squamosa* should be encouraged among trees, *Abrus precatorius* among shrubs and *Polypogon monospeliensis* among herbs.

For the restoration of land which already had few plant species, tree species like: *Aegle marmelos*, *Acacia catechu* and *Annona squamosa* should be encouraged. Among shrubs, *Abrus precatorius* and *Rhus parviflora* should be encouraged.

References

Abrahamson W.G. 1980. Demography and vegetative reproduction. *In*: Solbrig OT. ed. *Demography and evolution in plant populations*. Oxford: Blackwell, pp 89–106.

Adviento-Borbe M., Doran J., Drijber R. and DobermannA. 2006. Soil Electrical Conductivity and Water Content Affect Nitrous Oxide and Carbondioxide Emissions in Intensively Managed Soils. *Journal of environmental quality.* **35**(6): 1999-2010doi: 1999-2010. 10.2134/jeq2006.0109.

Baldock J. and Nelson P. 2000. *Soil organic matter*. A handbook of Soil Science, CRC Press, Australia pp B25-B84 doi: 10.1038/194324b0

Bekker R.M., Bakker J.P., Grandin U., Kalamees R., Milberg P., Poschlod P. 1998. Seed size, shape and vertical distribution in the soil: indicators of seed longevity. *Functional Ecology*, **12**(3) pp**.**834–842.

Bhatnagar P.,Singh J., Jain M., Singh B.2012. Evaluation of land races of Custard apple (*Annona squamosa* L.). *Plant Archives*. **12**(2):1045-1048.

Bhattacharya A. and Chakraverty R. 2013. The pharmacological properties of *Annona squamous. International journal of pharmacy and engineering*. **4**(2):692-699.

Blood K.2008. *Environmental weeds: A field guide for Southeast Australia*. Cornell University. Publishers C.H. Jerrom and associates, Ithaca, New York pp.112

Bot A. and Bonites J. 2005. *The importance of soil organic matter*. Food and Agriculture Organization of United Nation. Rome,Italy. pp. 44-50

Brian M. 2015. Key soil functional properties affected by soil organic matter - evidence from published literature. *In: IOP Conference Series Earth and Environmental Science*. Australia, pp: 1-5

Brown R. W., Johnston R. S. and Johnson D. A. 1979. Revegetation of disturbed alpine rangelands. *In*: Johnson, D. A., (eds.) *Special management needs of alpine ecosystems. Range Science Series No. 5.* Denver: Society for Range Management. pp: 1-16

Brown R.W. and Amacher M. C. 1999 Selecting plant species for ecological restoration: A perspective for land managers.*In*: Holzworth L.K.; Brown R.W.,(eds.) *Proceedings for Society for Ecological Restoration annual meeting in department of agriculture*,US, pp.1-16.

Chaer G.M., Resende A.S., Campello E.F., Faria S.M., and Boddey R.M. 2011. Nitrogen-fixing legume tree species for the reclamation of severely degraded lands in Brazil. *Tree physiology*, **31**(2):139-49.

Chapin III F.S., Bret-Harte M.S., Hobbie S.E. and Zhong H. 1996. Plant functional types as predictors of transient responses of arctic vegetation to global change. *Journal of Vegetation Science.* **7**(3): 347-358.

ChapinIII F.S. 2003. Effect of plant traits on ecosystems and regional processes: a conceptual framework for predicting the consequences of global change. *Annals of Botany*. **91**(4): 455-463.

Chapman R. R. and Crow G.E.1981Application of Raunkiaer's Life form System to plant species survival after fire.*Torrey Botanical Society*. **108**(4): 472-478

Chaudhari, P.R., Ahire, D.V., Chkravarty, M., and Maity, S. 2014. Electrical Conductivity as a Tool for Determining the Physical Properties of Indian Soils. *International Journal of Scientific and Research Publications.* **4**(4): 1-4

Chave J. 2005. Measuring wood density for tropical forest trees: a field manual for the CTFS sites.Pan Amazonia Project.

Clark J.S., Iverson L., Woodall C.W., Allen C.D., Bell D.M., Bragg D.C., D'Amato A.W., Davis F.W., Hersh M.H., Ibáñez I., Jackson S.T., Matthews S.N., Pederson N., Peters M.P., Schwartz M.W., Waring K.M., and Zimmermann N.E. 2016. The impacts of increasing drought on forest dynamics, structure, and biodiversity in the United States. *Global change biology*, **22**(7): 2329-2352

Cottam G., and Curtis J. T. 1956. The Use of Distance Measurements in Phytosociological *Sampling Ecology*, **37**(3):451-460.

Cornelissen J.H.C., Quested H.M., Gwynn-Jones D., VanLogtestijn R.S.P., DeBeus M.A.H., Kondratchuk A., Callaghan T.V. and Aerts R. 2004 Leaf digestibility and litter decomposability are related in a wide range of subarctic plant species and types. *Functional Ecology* **18**(6): 779–786.

Cornelissen, J.H.C, Lavorel, S., Garnier, E., Diaz, S., Buchmann, N., Gurvich, D., Reich, P., ter Steege, H., Morgan, H., van der Heijden, M., Pausas, J., and Poorter, H. 2003. A handbook of protocols for standardized and easy measurement of plant functional traits worldwide. *Australian Journal of Botany* **51**(4): 335-380.

DeMalach N. (2018). *Priority effects between annual and perennial plants.* Department of Biology, Stanford University, Stanford, California 94305, USA (Thesis)

Dhakad A. K. and Chandra A. 2018. Impact of *Lantana camara* Linn. on plant diversity in Shiwalik hills of Haryana *International Journal of Environmental Science* **8** (2):199-204.

Díaz S. and Cabido M. 1997. Plant functional types and ecosystem function in relation to global change. *Journal of Vegetation Science*. **8**(4): 463-474.

Díaz S., Hodgson J.G.,Thompson K., Cabido M., Cornelissen J.H.C., Jalili A., Montserrat-Martí G.,Grime J.P., Zarrinkamar F., Asri Y., Band S.R., Basconcelo S., Castro-Díez P.,Funes G., Hamzehee, B.; Khoshnevi, M.; Pérez-Harguindeguy, N.;Pérez-Rontomé, M.C.; Shirvany, F.A.; Vendramini F., Yazdani S., Abbas-Azimi R., Bogaard A.,Boustani S., Charles M., Dehghan M.,de Torres-Espuny L., Falczuk,V., Guerrero-Campo J., Hynd A., Jones G., Kowsary E.,Kazemi-Saeed, F., Maestro-Martínez M., Romo-Díez A., Shaw S., Siavash B., Villar-Salvador P. and Zak, M.R. 2004. The plant traits that drive ecosystems: Evidence from three continents. *Journal of Vegetation Science.* **15**(3): 295-304.

Dorner J. 2002. *An introduction to using native plants in restoration projects* Center for Urban Horticulture, University of Washington, and Publishers *Environmental Protection Agency* pp.5-10

Farahani H. J., Buchleiter G.W. and Brodahl M.K. 2005.Characterization of apparent soil electrical conductivity variability in irrigated sandy and nonsaline fields in Colorado. *American Society of Agricultural Engineers* **48**(1)**:** 155−168.

Fathi A. and Barari D. 2016. Effect of Drought Stress and its Mechanism in Plants. *International Journal of Life Sciences.* **10**(1): 1-6

Fischer, S., Poschlod, P. and Beinlich, B. 1996. Experimental studies on the dispersal of plants and animals by sheep in calcareous grasslands. *Journal of Applied Ecology* **33**(5)**:** 1206-1222.

Ghazanfar, S. A., Keppel, G. & Khan, S. 2001. Coastal vegetation of small islands near Viti Levu and Ovalau, Fiji. *Journal of Botany*, **39**(4): 587-600.

Ghodsi M., Nuzeri M.and Zarea-Fizabady A. 1998. *The reaction of new cultivars and Alite lines on spring wheat into drought stress*, Collection of abstract articles of 5th Iranian agronomy and plant breeding conference, Karaj, Iran.252p.

Glass S. 2004 Ecological Restoration as a Strategic Framework for Invasive Species Management Planning: The University of Wisconsin Experience 2004.*Proceedings of 12th North American Prairie Conferences.*pp 84

Gleason H.A.1926 The individualistic concept of the plant association. *Bulletin of the Torrey Botany Club*, **53**(1): 7–26.

Glover J.D. 2003. Characteristics and Impacts of Annual vs Perennial Systems.*In*: *Proceedings of Sod Based Cropping Systems Conference, North Florida Research and Education Center-Quincy*, Florida, pp: 1-6

Google Map(2019, October 7), Retrieved October 7, 2019 from https://www.google.com/maps/

Gondard H., Jauffret S., Aronson J. and Lavorel S. 2003. Plant functional types: a promising tool for management and restoration of degraded lands. *Applied Vegetation Science***.** **6**(2): 223-234.

Grime, J. P. and Hunt, R. 1975. Relative growth-rate: its range and adaptive significance in a local flora. *Journal of Ecology*, **63**(2): 393-422.

Grotkopp E., and Rejmánek M. 2007. High seedling relative growth rate and specific leaf area are traits of invasive species: phylogenetically independent contrasts of woody angiosperms. *American journal of botany*, **94** (4):526-32.

Guo Q., Chi X., Xie Z. and Tang Z.2017. Asymmetric competition for light varies across functional groups, *Journal of Plant Ecology*, **10** (1)**:** 74–80

Gupta P.K. 2000 *Methods in Environmental Analysis Water, Soil, Air* Agrobios, Indiapp.100-150

Harris, J. A., and van Diggelen, R. 2006. Ecological restoration as a project for global society. *In:*J. van Andel and J. Aronson(eds.). *Restoration Ecology*: *The New Frontier* , Blackwell Publishing, Malden, MA, pp. 3–15

Hashmat M.A. and Hussain R. 2013. A review on Acacia catechu Willd. *Interdisciplinary Journal of contemporary research in business* **5**(1): 593-600

Hendry G.A.F. and Grime J.P. 1993. *Methods in Comparative Plant Ecology: A laboratory manual.* Chapman & Hall. New York, USA.

Hewitt N. 1998. Seed size and shade-tolerance: A comparative analysis of North American temperate trees. *Oecologia***114**:432-440.

Horáčková M, Řehounková K. and Prach K. 2016. Are seed and dispersal characteristics of plants capable of predicting colonization of post-mining sites? *Journal of Environmental Science and Pollution Research*. **23**(14):13617-13625

Howe H.F. and Smallwood J. 1982. Ecology of seed dispersal. *Annual Review of Ecology and Systematics***13**:201–228.

Jha R., Baral S., Aryal R. and Thapa H. 2016. Restoration of degraded sites with suitable tree species in the Mid-hills of Nepal. *Banko Janakari*, **23**(2)**:** 3-13.

Jha P. and Mandal R. 2019. Assessment of Growth Performance of *Acacia catechu*. *InternationalJournal of Advanced Research.* **5**(1): 1-5

Johnsonn E.A. and Miyanishi K. 2008. Testing the assumptions of chronosequences in succession *Ecology Letters*,**11**(5): 419-431

Kao W. Y., Shih C. N. and Tsai T. T. 2004. Sensitivity to chilling temperatures and distribution differ in the mangrove species *Kandelia candel* and *Avicennia marina*. *Tree Physiology* **24**(7): 859–864.

Khainga N. and Mitlohnerb R. 2013. *Performance of Native Tree Species to Dry land Environmental Stresses.* The Republic of the Union of Myanmar Ministry of Environmental Conservation and Forestry, Forest Department. Retrieved from: https://www.forestdepartment.gov.mm/. Retrieved on: October 4, 2019

King D.A., Davies S.J., Tan S., and Noor N.S. 2006. The role of wood density and stem support costs in the growth and mortality of tropical trees. *Journal of Ecology* **94**(3): 670-680

Laban P., Metternicht G., and Davies J., 2018. *Soil Biodiversity and Soil Organic Carbon: keeping drylands alive*. Gland, Switzerland: IUCN. viii + 24p . Retrieved on: September 23, 2019

Lambers H. and Poorter H. 2004. Inherent Variation in Growth Rate between Higher Plants: A Search for Physiological Causes and Ecological Consequences. *Advances in Ecological Research.* **34**: 283-362

Laurin C. 2012*Identification of candidate plant species for restoration of newly created uplands in Subarctic: A functional ecology approach, Ontario* (M.Sc. Dissertation).Retrieved from:https ://www 3. laurentian. ca/living withlakes/ wpcontent/ uploads/2015 /09/Laurin-2012-MSc-Thesis.pdf . Retrieved on: August 23, 2019

Liesman M.R., Wright I.J., Moles A. T. and Westoby M. 2000.*The ecology of regeneration of plant communities*. CAB International Walingford, Australia. pp. 31-57

Liu M, Wang Z, Li S, 2017 Changes in specific leaf area of dominant plants in temperate grasslands along a 2500-km transect in northern China. *Scientific Reports*. **7**(1): 10780.

Liu M., Wang Z., Li S., Lü X., Wang X., and Han X. 2017. Changes in specific leaf area of dominant plants in temperate grasslands along a 2500-km transect in northern China. *Scientific Reports.* **7**(1): 1-9

Lu Y, Ranjitkar S, Harrison RD, Xu J, Ou X and Ma X, 2017 Selection of Native Tree Species for Subtropical Forest Restoration in Southwest China. *PLoS ONE***12**(1)

Maina P., Wachira P., Okoth S., Kimenju J., Otipa M., and Kiarie J. 2015. Effects of Land-Use Intensification on Distribution and Diversity of *Fusarium* Species in Machakos County, Kenya. *Journal of Agricultural Science, **7***(4):48

Martínez M. F., Miranda D., and Magnitskiy S. 2013. Anatomy of sugar apple (*Annona squamosa* L.) seeds (Annonaceae). *Agronomia Colombiana.* **31**(3): 279-287.

Marx E.S., Hart J and Stevens R.G. 1999.*Soil Testing Interpretation Guide*, Oregon State University and Corvallis. Pp.1-7

McCauley A., Jones C. and Olson-Rutz K. 2017. *Soil pH and Organic Matter* .Montana State University, Bozemon, Montana. pp 5-10

McGill B.J., Enquist B.J., Weiher E. and Westoby M. 2006.Rebuilding community ecology from functional traits. *Trends in Ecology and Evolution*. **21**(4): 178–185.

Moles, A.T. and Westoby, M. 2004 Seedling survival and sees size: a synthesis of the literature. *Journal of Ecology*, **92**(3): 372–383

Morse D.H. and Schmitt J. 1985. Propagule size, dispersal ability, and seedling performance in *Asclepias syriaca*. *Oecologia* .**67**: 372–379

Muller-Landau H.C., Wright S.J., Calderon O., Condit R. and Hubbell S.P. 2008. Interspecific variation in primary seed dispersal in a tropical forest. *Journal of Ecology*, **96**(4): 653–667.

Nathan R. and Muller-Landau HC. 2000. Spatial patterns of seed dispersal, their determinants and consequences for recruitment. *Trends in Ecological Evolution***15** (7): 278–285.

Osone Y., Ishida A. and Tateno M. 2008. Correlation between relative growth rate and specific leaf area requires associations of specific leaf area with nitrogen absorption rate of roots. *The New phytologist*. **179**(2):417-27.

Parsad R., Brodie G., Vanderwoude C. and Hodge S. 2015. Potential of the weed *Abrus precatorious* Linnaeus (Fabales: Fabaceae) for control of insect pests in the South Pacific: a review. *International Journal of Entomological Research*. **3**(3): 113-124.

Paul E. D., Sangodare R. S. A., Uroko R. I., Agbaji A.S. and Dakare M. A. 2013. Chemical analysis of leaves of *Abrus precatorius.International Journal of Plant Physiology and Biochemistry* **5**(5):65-67.

Pausas, J.G. and Lavorel, S. 2003. A hierarchical deductive approach for functional types in disturbed ecosystems. *Journal of Vegetation Science*. **14**(3): 409-416.

Peco, B., Traba, J., Levasor, C., Sánchez, A.M. and Azcánteran, F.M. 2003. Seed size, shape and persistence in dry Mediterrannean grass and scrublands. *Seed Science.* Res., **13** (1): 87–95

Perring M. P., Standish R.J., Price J.N., Craig M.D., Erickson T.E., Ruthrof K.X., Whiteley A.S., Valentine L.E., and Hobbs R.J. 2015. Advances in restoration ecology: rising to the challenges of the coming decades. *Ecosphere* **6(8)**p.131.

Pumphrey F.V. 1980. Precipitation, temperature, and herbage relationships for a pine woodland site in northeastern Oregon *Journal of Range Management* **33**(4)**:** 307-310

Rajeshwar T., Vijay Kumar G., Sreesha E.,Rajashekar D.,Manohar G., Rajitha D. and Jyothi S. 2015. Investigation and study of pharmacognostical and phytochemical features of leaves of *Abrus precatorius.* Linn (Leguminosae) An unexplored medicinal plant of India. *Journal of Natural Product and Plant Resources*. **5**(3): 1-11

Randall J.M. 1997. Defining weeds of natural areas. In J. Luken and J. Theiret (eds.) *Assessment and management of plant invasions*. *Springer*, New York. pp.18-25.

Reich P.,Walters M., Ellsworth D. 1992 Leaf life-span in relation to leaf, plant, and stand characteristics among diverse ecosystems *Ecology Monograph***62**(3): 365-92

Reich P.B., Wright I.J., Cavender-Bares J., Craine J.M., Olek-syn, J., Westoby M. and Walters M.B. 2003. The evolution of plant functional variation: traits, spectra, and strategies. *International Journal of Plant Science* **164**(S3): S143–S164.

Richards R.T., Jeanne C. C., and Christopher R. 1998. Use of native plants on federal lands: Policy and practice.*Journal of Range Management.* **51**(6): 625-632.

Roberts R.E., Clark D.L. and Wilson M.V. 2010. Traits, neighbors, and species performance in prairie restoration.*Applied Vegetation Science*. **13**(3): 270-279

Ryan E. O'Dell, Stephen L. Young P.,Victor P. and Claassen P.2007.Native roadside perennial grasses persist a decade after planting in the Sacramento Valley. **61**(2): 79-84

Sampath kumar K.P., Umadevi M., Bhowmik D., Singh D.S., DuttaA.S. 2012.Recent trends in medicinal uses and health benefits of Indian Traditional Herbs *Aegle marmelos*. *The Pharma Innovation.***1**(4): 79-84

Sekar D.K., Kuma G., Karthik L. and Rao K.V.B.2011. A review on pharmacological and phytochemical properties of *Aegle marmelos* (L.) Corr. Serr. (Rutaceae) *Asian Journal of Plant Science and Research*, **1**(2):8-17

Shipley B. and Peters R.H. 1990. The allometry of seed weight and seedling relative growth rate. *Functional Ecology*. **4**(4):523-529.

Shrestha A., Acharya N.D., Shrestha N.B. and Adhikari H., Shrestha S.K. 2015 *An assessment of drought in Ramechhap district* District Development Committee,Manthali, Ramechhap

Skarpaas O., Silverman E.J., Jongejans E. and Shea K. 2010. Are the best dispersers the best colonizers? Seed mass, dispersal and establishment in *Carduus thistles*. *Evolutionary Ecology*, **25**: 155-169.

Slattery B. E., Kathryn R., and Susan M. 2003. *Native Plants for Wildlife Habitat and Conservation Landscaping: Chesapeake Bay Watershed*. U.S. Fish & Wildlife Service, Chesapeake Bay Field Office, Annapolis ,pp.82

Soons, M.B., Heil, G.W., Nathan, R. and Katul, G.G. 2004. Determinants of long-distance seed dispersal by wind in grasslands. *Ecology*, **85**(11): 3056–3068.

Thompson F., Moles A.T., Auld T.D. and Kingsford R.T. 2011. Seed dispersal distance is more strongly correlated with plant height than with seed mass*Journal of Ecology* **99**(6): 1299-1307

Thompson F.J., Letten A.D., Tamme R., Edwards W. and Moles A. T. 2017 Can dispersal investment explain why tall plant species achieve longer dispersal distances than short plant species? *New Phytology* **17**(1): 407-415.

Tordoff, G.M., Baker, A.J.M. and Willis, A.J. 2000. Current approaches to the revegetation and reclamation of metalliferous mine wastes. *Chemosphere*.**41**(1-2): 219-228.

United States Department of Agriculture and Natural Resources Conservation Service. (2011).The Plants National Plant Data Team, Greensboro, North Carolina. Retrieved from: https://plants.sc.egov.usda.gov . Retrieved on: November 12, 2019

Venable D.L. and Brown J.S. 1988. The selective interactions of dispersal, dormancy, and seed size as adaptations for reducing risk in variable environments. *American Naturalist*,**131**(3): 360–384

Verkaar, H., Schenkeveld, A. and Van De Klashorst M. 1983. The Ecology of Short-Lived Forbs in Chalk Grasslands: Dispersal of Seeds. *The New Phytologist* ,**95**(2)**:** 335-344.

Verkaar H.J. 1990.Corridors as a tool for plant species conservation. *In*: Bunce, R.G.H. and Howard, D.C. (editions): *Species Dispersal in Agricultural Habitats*, Belhaven Press, London.pp.82-97.

Verkataratanam L., Satyanaranaswamy G., 1956. Studies on genetic variability in *Annona squamosa. Indian Journal of Horticulture*, **15**(3): 228-238.

Vieira S., Trumbore S., Camargo P.B., Selhorst D., Chambers J. Q., Higuchi N., Martinelli L.A. 2005. Slow growth rates of Amazonian trees: Consequences for carbon cycling *National Academy of Sciences* **102** (51): 18502-18507

Vijayalakshmi S. and Venkatalakshmi P. 2017. An updated review on the phytopharmacological significance of *Aegle marmelos* (L.) *World Journal of Pharmaceutical Research.* **6** (16):1390-1422.

Vile D., Garnier E., Shipley B., Laurent G., Navas M.L., Roumet C., Lavorel L., Diaz S., Hodgson J.G., Lloret F., Midgley G.F., Poorter H., Rutherford M.C., Wilson P.J. and Wright I.J. 2005 Specific Leaf Area and Dry Matter Content Estimate Thickness in Laminar Leaves. *Annals of Botany* .**96**(6): 1129–1136.

Violle C., Navas M., Vile D.s, Kazakou E., Fortunel C., Hummel I. and Garnier E. 2007, Let the concept of trait be functional!*Oikos,* **116**(5):882-892.

Walker L.R. and Moral R. 2003. *Primary succession and ecosystem rehabilitation. Cambridge Press* **213**(3):40-45

Walker L.R., Moral R. and Bakker J.P.2006 Insights Gained from Succession for the Restoration of Landscape Structure and Function. *In*: Walker L.R., Walker J., Hobbs R.J. (eds) Linking Restoration and Ecological Succession. *Springer series of environmental management Springer*, New York. pp. 19-26

Walkley A. and Black I.A.1934 An Examination of the Degtjareff Method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid Titration Method. *Soil Science*, **37**(1): 29-38.

Weiher E., Van der Werf A., Thompson K., Roderick M., Garnier E. and Eriksson O. 1999. Challenging Theophrastus: A common core list of plant traits for functional ecology. *Journal of Vegetation Science*.**10** (5)**:** 609-620

Weller D.E.1989.The interspecific size-density relationship among crowded plant stands and its implications for the-3/2 power rule of self-thinning. *American Naturalist*. **133**(1): 20–41.

Weraduwage S.M., Chen J., Anozie F.C., Morales A, Weise S.E., Sharkey T.D.2015. The relationship between leaf area growth and biomass accumulation in *Arabidopsis thaliana. Frontier Plant Science.* **6**(167)

Westoby M. 1998. A leaf-height-seed (LHS) plant ecology strategy scheme. *Plant and Soil*.**199**: 213–227.

White T.A., Campbell B.D., Kemp P.D., Hunt C.L. 2000. Sensitivity of three grassland communities to simulated extreme temperature and rainfall events. *Global Change Biology* **6**(6):671 –684

Wright I.J., Reich P.B., Westoby M.2004. The worldwide leaf economics spectrum. *Nature* **428:** 821–827.

Zobel D.B, Jha P.K., Behan M. J. and Yadav U.K.R., 1987. *The Practical Manual for Ecology*, Ratna Pustak Bhandar, Kathmandu, Nepal

Photos

Photo 1: Study area

Photo 2: Observing study area

Photo 3: Identifying plant at KATH, Godawari

Photo 4: Observing soil properties on study area