**FINAL PROJECT REPORT ON**

# IMPACTS OF CLIMATE CHANHGE ON THE LOCAL ECOSYSTEMS OF KASHMIR HIMALAYAS

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# PAYMENT OF ECOSYETEM SERVICES

**SUBMITTED BY**

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# *PAYMENT OF ECOSYETEMSERVICES*

SUBMITTED TO

**GLOBAL CHANGES IMPACT STUDY CENTER (GCISC)**

MINISTRY OF CLIMATE CHANGE, GOVERNMENT OF PAKISTAN

SUBMITTED BY

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# ABSTRACT

The western Himalayan region of Kashmir is a globally recognized biodiversity Hotspot harboring high levels of biodiversity in a wide range of habitats due to its diverse geography and environment. The local ecosystems of Kashmir and under immense pressure due to socio economic transformation and rapid population growth in the area. The region is particularly vulnerable to climate change due to its ecological fragility and economic marginality Climate change is a serious threat to all natural ecosystems of the Kashmir Himalayas and their sustainability. The main drivers of the climate change in the area include deforestation, land use changes and pollution resulting into significant deteriorating impacts on local biodiversity, hydrological regimes and ecosystem services. Current project was designed to investigate the impacts of climate change on local ecosystems of Kashmir Himalayas using an integrated approach.

The local carbon stocks in the forest biomass and soils of AJK were quantified in the subtropical forests of Muzaffarabad District which revealed an average carbon stock value of 137.52 tons/hectare with a biomass and soil carbon share of 10.3.57 and 34.53 tons/hectare respectively. Dendrochronological investigations were conducted on *Pinus roxburghii* forest stands in district Kotli. An average annual growth rate of 0.93 cm was determined for the past 160 years with an average yearly increment of 1.20 m. *Pinus* trees showed an average age of 100.5 years with a DBH of 93.2 cm.

Invasive alien species are nonnative species that have arrived outside their natural range alter the vegetation structure by displacing native flora and deteriorating changes in the environment. The present study conducted in the sub-tropical vegetation stands in the sub urban areas of Muzaffarabad city also investigated the diversity and distribution of invasive species and their impact on the native vegetation. A total of 43 Invasive Alien species species belonging to 25

families and 41 genera were recorded from the area. Road construction and land slide disturbances were identified as the major factors responsible for the spread of invasive aliens in the area. It was concluded that a better management is needed for early detection to discourage introduction of invasive alien species with integrated monitoring.

The economic evaluation of the ecosystem services (ESS) is of great importance as they are often taken for granted and not fully understood by the dependent communities in monetary terms and hence are ignored in policy decisions. Payment of ecosystem services (PES) is a key step in this direction that making meaningful impacts at the local and regional levels. The incentives for the ecosystem services provide an opportunity for the behavioral change of the benefiting communities towards management of ecosystem services. Quantification of ESS was carried out in Shounthar valley, district Neelum in the PES context.

An average of 7.3 tons/year fuel wood was recorded to be consumed by each house hold. Community was utilizing about 38 medicinal plants for their primary health care along with 23 wild vegetables and mushroom collection in the area. Results will lead in developing a practical module for PES in selected areas of AJK with a potential for improvement and up scaling in the whole AJK. The communities were consulted through conveying and negotiating approaches to establish willingness to Pay, and set quantified goals of PES. Results revealed that heavy dependence of the local populations on ESS.

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

Climate change refers to significant, long-term changes in the global over time, whether due to natural variability or as a result of human activity. Climate change impacts have become highly visible affecting different aspects of human society and ecosystem across the globe. Climate change has a wide range of impacts on other natural resources and biodiversity causing threats to forest conservation, species extinction and occurrence of pests and Disease (IPCC, 2007). It has further amplified impacts on health sector; extended scope and increase in the frequencies of disease (IIED, 2008). Moreover, change in rainfall pattern, insufficient water supply for crops, extreme weather incidents, spread of pests and crop Disease have been directly affecting agricultural crops production and hence on food security.

The Economic Impact Assessment of Climate Change in Key Sectors reveals that the current climate variability and extreme events has costs equivalent to 1.5 to 2 per cent of global GDP. Climate change poses huge risks to human lives and natural ecosystems. Risks related to climate change arise from climate-related hazards (climate trends and extremes) and the vulnerability of exposed societies, communities or systems (in terms of livelihoods, infrastructure, ecosystem services and governance systems).

Effective measures to adapt to climate change and reduce the risks associated with climate change can address all three aspects of risk: hazard, vulnerability and exposure. The vulnerability and exposure of societies and ecological systems to climate-related hazards vary constantly because of changes in economic, social, demographic, cultural, and institutional and governance circumstances. Rapid and unsustainable urban development, international financial pressures, increases in socioeconomic inequality, failures in governance and environmental degradation affect vulnerability.

These changes unfold in different places at different times, meaning that strategies to strengthen resilience and reduce exposure and vulnerability need to be locally or regionally specific. The countries like Pakistan that are rapidly urbanizing are vulnerable to climate change if their economic development is slow. In other countries, urbanization may present opportunities to adapt to climate change. Poverty is also a critical factor in determining vulnerability to climate change and extreme events.  Mountain ecosystems and communities are extremely vulnerable to climate change.

There is evidence that temperatures are rising faster at higher altitudes. High mountains are 'highly temperature sensitive regions', with several extreme impact events of recent decades attributed to warming, according to the Intergovernmental Panel on Climate Change (IPCC). Glacier retreat has led to Lake Outburst floods, debris flows, rock fall and avalanches, and reduced water availability for mountain and downstream populations. There is evidence that temperatures are rising faster at higher altitudes, and high mountains are 'highly temperature-sensitive regions' according to the IPCC. Several extreme impact events of recent decades can be qualitatively attributed to warming, namely glacier lake outburst floods due to glacier recession and subsequent formation of unstable lakes, debris flows from recently DE glaciated areas, and rock fall and avalanches following the loss of mechanical support accompanying glacier retreat.

Glacier retreat is reducing water availability for mountain communities and downstream populations.  These changes are already having significant impacts on mountain ecosystems and the livelihoods of the indigenous and traditional peoples who depend on them for survival. Mountain regions are home to some of the world's poorest and most marginalized people. According to the IPCC's Fifth Assessment Report, even modest changes in climate can push transient poor and marginalized people into chronic poverty – such shifts have already been observed among climate sensitive livelihoods in high mountain environments.

Yet in many countries, mountain communities rarely receive support for adaptation and are rarely involved in adaptation planning. Key risks identified for Asian Countries including Pakistan are water and food shortages linked to rising temperatures, extreme temperatures and drying trends. More erratic rainfall in parts of Asia could lower rice yields and lead to higher food prices and living costs, malnutrition, and worsened rural poverty.

## 1.2 IMPCATS OF CLIMATE CHANGE ON KASHMIR HIMALAYAS

Climate change impacts in the Kashmir Himalayas have been experienced in different sectors in including agriculture, forests and biodiversity, water resources and energy. While several policies have been devised at the central level, effective implementation of such policies and plans at local and community level is a challenge due to limitations including lack of availability of integrated and reliable data and information on different facets of climate change impacts. One of the visible impacts is observed in the glaciers and glacial lakes in the Himalayas which are changing in an unprecedented rate.

Increase in pre-monsoon (March-May) precipitation has been observed over the western Himalaya including Pakistan and Kashmir during 1901-2003 (Guhathakurta and Rajeevan, 2008). Literature on precipitation trends in Himalayan region suggests largely random fluctuations and the absence of trend on annual or seasonal basis (Tsering, 2003). Studies have shown that Himalayan glaciers are retreating fast with the annual rate of about 10 to 60 m that has caused vanishing of small glaciers of less than 0.2 km2. Similarly, change in different climatic variables has caused increased frequency of disasters including flash floods posing more than 1.9 million people to high vulnerability and exposing additional 10 million people to the risks of climate induced disasters (MoPE, 2012).

Riverine, coastal and urban floods linked to extreme rainfall events, rising sea level and cyclones could cause widespread damage to infrastructure, livelihoods and settlements. The risk of floods, and loss of life and property associated with floods, is highest in Pakistan. A large proportion of Asia's population lives in low elevation zones that are particularly at risk from climate change hazards, including sea-level rise, storm surges and typhoons (IPCC, 2014).

The population and assets exposed to coastal risks will increase significantly in the coming decades due to population growth, economic development and urbanization. Half to two-thirds of Asia's cities with 1 million or more inhabitants are exposed to one or multiple hazards, with floods and cyclones the most important. By the 2070s, the Fifth Assessment Report indicates that the Asian port cities that could be most at risk, in terms of population and assets exposed to coastal flooding. Another key risk for Pakistan is increased mortality due to rising temperatures and extreme temperatures. This will become a major public health concern across the country.

The considerable threats could undermine the progress made in tackling disease, malnutrition and early deaths in the past decades, together with gains in improving agricultural productivity. Adaptation can reduce these risks and bring immediate benefits. Climate change also poses more risks in regional tourism in the Western Himalayan Mountains of North Pakistan including AJK and Gilgit Baltistan region.Tourism has intrinsic relation with climate particularly the nature based tourism. Most of the nature based tourism activities in the country are weather sensitive. For example, rain and foggy conditions significantly decrease the quality of the trekking experience in the Himalaya (Neupane and Chhetri, 2009). Frequent changes on climatic variables has adverse impact on tourism as tourists might change the travel pattern or destination in future if weather continues affecting their travel plans. Likewise, climate change is expected to increase the risk of illness while travelling and consequently discourage tourism.

The conventional wisdom is that modern civilization will either adapt to whatever weather conditions we face and that the pace of climate change will not overwhelm the adaptive capacity of society, or that our efforts such as those embodied in the Kyoto protocol will be sufficient to mitigate the impacts. The IPCC documents the threat of gradual climate change and its impact to food supplies and other resources of importance to humans will not be so severe as to create security threats. Optimists assert that the benefits from technological innovation will be able to outpace the negative effects of climate change.

The Kashmir Himalayan region holds significant importance in terms of biological (species) richness, biodiversity, socio-cultural diversity, and wealth. The region is one of 34 worldwide "biological hotspots" i.e., a natural environment with a high biodiversity containing a large number of endangered endemic species, as identified by Conservation International (CI, 2011).The region's indigenous people consider the Himalayas sacred and look upon them with reverence. In essence, the Himalayas are both pride and necessity of the region.

Conservation biologists warn that 25 percent of all species could become extinct during next twenty to thirty years (Khera et.al, 2001). The cause for the loss of species is numerous but the most important are the climate changes and natural habitats degradation. One of the foundations for conservation of biological diversity in forest landscapes is to understand and manage the disturbance regimes of a landscape (Spies and Turner, 2004).

In the western Himalayan region of Kashmir, along the altitudinal transect, distinct changes in vegetation types are apparent. The sub-tropical *Pinus roxburghii* forests are replaced by broadleaf *Quercus* spp. and coniferous (*Cedrus deodara, Cupressus* spp.) forests in temperate zone. In sub-alpine areas, birch (*Betula utilis*) and fir (Abies pindrow) forests along with the various combinations of broadleaf species exhibit dominance, which finally give way to the vast areas of alpine meadows.

The most prominent of these changes in Kashmir Region along the altitudinal range is represented by the subalpine transition between temperate forests and alpine grassland ecosystems, termed as timberline zone (Dhar, 2000). Understanding the distribution pattern of species along the elevation gradient and the factors governing the same would help to understand biodiversity and aid in conservation (Hunter and Yonzon, 1993).

Himalaya is a mega diversity centre of world. It supports about 18,440 species of plants, of which 25.3% are endemic to Himalaya (Singh and Hajra, 1997, Samant et.al., 1998). The diverse topographic features of the Himalayas sustain an enormous perennial reservoir of vegetation resources (Gaur et al., 1995).The high altitude of this region have unique vegetation due to their diverse geo-morphology which provides different microhabitats for specific plant growth. The alpine vegetation of this part has many characteristic features in connection with the separation zone from timber line, seasonal succession and distributional pattern. On the basis of distribution the alpine plants represent distinct habitats. They are found on exposed dry rocks crevices, ravines and on much fertile loamy soils constituting the alpine meadows (Semwal & Gaur, 1981).

High mountain ecosystem are comparatively thrilling and sensitive at least at the upper elevation levels, and are determined by abiotic climate related ecological factors (Gaur et.al, 2005). Species richness increases remarkably partially due to the invasion of plant species from alpine belt. The well known cause for declining plant species diversity are habitat loss, narrow distribution range, low population size, fragmentation degradation of population and genetic variation (Kala, 2009). To save this precious natural wealth, protected areas have been established and within the Himalayas there are many protected areas that contain rich medicinal plant diversity. The flora and its ecological characters such as life forms were studied that indicates climate and human disturbance on a particular area (Cain & Castro, 1959). Very little work is available on this aspect.

## 1.3 PAYMENT OF ECOSYSTEM SERVICES

Payment of Ecosystem Services (PES) is a voluntary transaction for a well-defined environmental service (or a land use likely to secure that service), purchased by at least one environmental service buyer from at least one environmental service provider, if and only if the environmental service provider meets the conditions of the contract and secures the environmental service provision (Wunder, 2005). Payments for Environmental or Ecosystem Services (PES) have become a means to promote biodiversity conservation and rural development, particularly in tropical and sub-tropical regions (Gutman, 2007).

Small-scale PES projects promoted by nongovernmental organizations to enhance watershed protection and biodiversity conservation, as well as to protect carbon reservoirs and sinks under the umbrella of the United Nations Framework Convention on Climate Change as carbon offset and REDD+ projects have also been developed worldwide. These programs and projects have usually become part of a conservation policy mix, in which the direct incentives provided by PES co-exist with more traditional regulatory conservation approaches.

In response to growing concerns, markets are emerging for ecosystem services in countries around the world. Formal markets some voluntary and others mandated by law now exist related to greenhouse gases (carbon), water, and even biodiversity. In addition, focused business deals and

PES are also being forged to invest in restoration and maintenance of particular ecological systems and the services that they provide. The key characteristic of these PES deals is that the focus is on maintaining a flow of a specified ecosystem service such as clean water, biodiversity habitat, or carbon sequestration capabilities in exchange for something of economic value.

A payment for environment service may be a voluntary transaction in which a well-defined environmental service (ES), or a form of land use likely to secure that service is bought by at least one ES buyer from a minimum of one ES provider if and only if the provider continues to supply that service (Wunder, 2005).

These benefits are known as ecosystem or environmental services. At present, however, many of these ecosystem services are either undervalued or have no financial value at all. Decisions often focus on immediate financial returns, many ecosystem structures and functions are being fundamentally undercut (Gretchen,. 1997). The most comprehensive assessment of ecosystem services to date the Millennium Ecosystem Assessment, which included over 1,300 scientists from 95 countries found that over 60% of the environmental services studied are being degraded faster than they can recover (MEA, 2005).

The degradation of these ecosystems and the services that they provide creates greater hardship for the rural poor at times being the principal factor causing rural poverty and social conflict (MEA, 2005). The progress of environmental policies in order to achieve multifunctional objectives of ecosystem management has been recommended as an immediate measure. Payment for ecosystem services (PES) is one of those mechanisms that are increasingly and typically used to sustain ecosystem services. Many scholars have considered PES as an incentive for local communities to secure their efforts in conserving natural capital through redistribution of livelihood resources and transfer of financial support (Gutman, 2007; Kumar & Managi, 2009).

There is a growing global awareness of the services that natural ecosystems provide. The value of these ecosystem services and the long term costs of their loss, however, are rarely taken into account in decisions about how natural resources are used. Forests provide key ecosystem services such as clean water, timber, habitat for fisheries, carbon sequestration, pollination, and biodiversity. However, many of these services are being lost or degraded at a furious pace, brought about by human activity. This has led to an increased use of payments for ecosystem services (PES) programs. PES offers conditional payments to motivate private landowners to invest in land-use practices that lead to conservation or production of ecosystem services (Ferraro and Kiss 2002, Wunder 2005). There are many different ways to pay for ecosystem services. Two of the largest PES programs in the world, the Chinese national sloping land conservation program (SLCP) and the Brazilian Bolsa Floresta Program (BFP) in the State of Amazonas, offer compensation packages combining direct cash with in-kind payments.

National or regional PES programs are currently implemented in countries like Costa Rica, Mexico, Ecuador, Vietnam, China, South Africa or the United States, while smaller regional programs have been tested in European countries like Germany and the UK. Due to growing demands for natural resources (such as timber, fresh water, food, fbre, fuel, etc.), humans have extensively changed ecosystems which has resulted in a substantial and largely irreversible loss in the diversity of life on earth. On the one hand, these changes have contributed to economic development and net gains in human well-being of many people; on the other hand, they have also resulted in degradation of ecosystems and their services, increased poverty of large groups of people, and risks for future generations whose livelihoods depend equally on ecosystem services.

If humanity continues to misuse its water resources and the ecosystems on which these depend, individuals and societies will ultimately suffer social and economic insecurity engendered by severely degraded rivers, lakes and groundwater reserves, and will be confronted with increasingly serious conflicts in time of scarcity (IUCN 2000). Ecosystem services in the Himalayas, and thus the lives and livelihoods they support, are at risk. In many cases, ecosystem services are in decline, with consequences for literally billions of people. Examples include erosion, landslides, loss of agricultural topsoil, water pollution caused by upstream activities, loss of traditionally harvested plants and animals from forests, and loss of forests as a whole. The loss of these services has severe and direct implications for the rural and mountain communities who have traditionally derived direct benefit from those ecosystem services.

These communities often access ecosystems directly at the source: food, water, and materials for heating and cultural activities. Ecosystem services that regulate water and land stability (controlling flood levels, soil loss, and providing landslide control) can also be affected by changes to ecosystems. Forest cover and poverty are positively correlated at a global scale, there has been a push among policymakers to promote PES as an instrument for both environmental protection and poverty alleviation (e.g. Landell-Mills & Porras, 2002; Rios & Pagiola, 2010; Lipper, 2009).

## 1.4 JUSTIFICATION OF THE STUDY

The geographical coverage of Western Himalayan region including AJK is much more widespread as compared to Eastern part and the huge number of biodiversity is present. There is a huge pressure by growing population (more than million people with 2% growth rate) and world climatic change on the ecosystem of Kashmir Himalayas. The services related with the natural ecosystems are the most important contributors to the social welfare and economy of people.

Although, patterns of climate change in the other part of the Himalayas have been worked out but there is a serious more gap in information on climate change impacts on Azad Jammu and Kashmir Himalayan range. The research on this aspect has not received much attention yet, and hence gaps in information and knowledge on these natural ecosystems still persist. So the Western Himalayan range demands special exploration and keeping in view the above mentioned facts this study was designed to identify the drivers of climate change and its impacts on the Himalayan region of Azad Jammu and Kashmir.

## 1.5 SPECIFIC OBJECTIVES

1. To develop the inventory of invasive alien plant species in urban and sub urban areas as an indicator of climate change.

2. To collect the dendrochronological data from the Chir Pine forest zone to investigate the growth responses of trees to climate change and reconstruct past climate scenario.

3. To measure the carbon stocks in the sub-tropical zone to quantify the sequestration potential in the soil of study area.

4. To identify the natural resources which can be included in PES for Forest ecosystem modules in Neelum Valley.

5. To offer guidance and the baseline data in order to facilitate the future research.

# CHAPTER 2

# STUDY AREA

THE STATE OF AZAD JAMMU AND KASHMIR

## 2.1 <u>GEOGRAPHY & TOPOGRAPHY</u>

The state of Azad Jammu and Kashmir lies between longitude 73° – 75° and latitude 33° – 36° and comprises an area of 5134 square miles (13,297 Km2). AJK falls within the Himalayan orogenic belt. As such, its topography is mainly hilly and mountainous characterized by deep ravines, rugged, and undulating terrain. The northern districts, Neelum, Muzaffarabad, Jhelum valley, Bagh, Haveli, Poonch, and Sudhnoti, are generally mountainous while southern districts, Kotli, Mirpur, and Bhimber, are relatively plain. The mountain ecosystems are relatively unstable and have low inherent productivity. Within this fragile environment, however, there is a great variety of ecological niches upon which people base their livelihood. Small land holdings and scarcity of cultivable land are the main factors limiting on-far income. The area is full of natural beauty with thick forest, fast flowing rivers and winding streams. Main rivers are Jhelum, Neelum and Poonch (GoAJK, 2016).

## 2.2 <u>POPULATION</u>

According to the 1998 population census, the state of Azad Jammu & Kashmir had a population of 2.973 million, which was estimated to have grown to 4.361 million in 2014. Almost 100% population is Muslim. The Rural to Urban ratio is 88:12. The population density is 328 persons per Sq Km. The literacy rate has increased from 55% to 74% after 1998 census. Infant mortality rate is approximately 62 per 1000 live births, whereas the immunization rate for the children under 5 years of age is more than 94% (GoAJK, 2017).

## 2.3 <u>CLIMATE AND HYDROLOGY</u>

Depending on the altitude that varies from 360 meters in the south to 6325 meters in the north, AJK has a wide range of climatic conditions. The south has dry sub-tropical climate while the north most moist temperate. There is significant variation in the rainfall pattern across different regions both in terms of amount and distribution. Average annual rainfall ranges from 1000 mm to 2000 mm. In the northern district 30% to 60% precipitation is in the shape of snow. In winter snow line is around 1200 meters while in summer it is 3300 meters. Average maximum temperature ranges from 20°C to 32°C while the average minimum temperature range is 04°Cto 07°C. River Neelum, Jhelum and Poonch are the main rivers of the state with several tributaries. Magla Dam Lake is the biggest water reservoir in the region (PAK-MET, 2017).

## 2.4 EDUCATION & HEALTH

Govt. of Azad Jammu & Kashmir has about 30% of its total recurring budget allocated to this sector with a literacy rate of 74% at present the gross Enrollment rate at primary level is 119% for boys and 113% for girls. Health coverage in Azad Jammu & Kashmir is still inadequate. There are approximately 3331 hospital beds available in the area averaging one bed per 1309 people. The total number of Doctors, including Administrative Doctors, Health Managers & Dentists is 887 out of which there are 762 Medical Officers/Specialists, 69 Dental Surgeons and 56 Health

Managers giving an average of 0.203 per 1000 population in respect of Doctors, 0.175 Per 1000 Population in respect of Medical Officers/Specialists, 0.016 per 1000 Population in respect of Dentists and 0.013 per 1000 pop., in respect of Health Managers, whereas only 30 hospital beds & 11 dispensaries were available in the area at the time of independence (GoAJK, 2016).

## 2.5 AGRICULTURE

Area under cultivation is around 194260 hectares, which is almost 13% of the total Geographical area out of which 92% of the cultivable area is rain-fed. About 87% households have very small land holdings between one to two acres. Major crops are Maize, Wheat & Rice whereas minor crops are Grams, Pulses (red kidney beans), Vegetables and Oil-seeds. Major fruits produced in AJK are Apple, Pears, Apricot and Walnuts. Agriculture and livestock income ranges between 30-40% of household earnings. The remaining share comes from other sources including employment, businesses and remittances received by the families of AJ&K living abroad. Reduced agriculture productivity has adversely affected the traditional lifestyle and per capita income of the rural households (GoAJK, 2014).

## 2.6 <u>FOREST RESOURCES</u>

About 42.6% of the total Geographical area (0.567 million hectares), is controlled by the Forests Department. The per capita standing volume is 299.5 Cft and per capita forest area is 0.35 Acre. Annual wood demand is 1.65 million cubic meters and sustainable production is 1.94 million cubic meters. The local communities have traditional rights in terms of use of the forests and on an average three trees are burnt by one household every year for the fuel-wood requirements in the absence of alternate sources. Similarly, about 5 trees on average are required to construct a house for which the wood roofs have to be replaced after every 8-10 years (Shaheen et al, 2012).

## CHAPTER 3

# DENDROCHRONOLOGIOCAL INVSETIGATIONS OF THE CHIR PINE (*PINUS ROXBURGHII*) FOREST STANDS

# 3.1 INTRODUCTION

Dendrochronology is an emerging science in Pakistan, started in 1986 whereas its systematical study started in 2005. Frequent use of this emerging science in other fields includes Glacial Hydrology, archeology, climatology forestry, Ecology, earthquake, population dynamics and other disciplines. Dendrochronological records of Pinus species for age and growth estimation from different forest of Pakistan have been reported (Sheikh, 1985; Iqbal et al., 2017). The age factor, DBH and growth rate correlate with species sustainability for dendrochronological investigations (Ahmed & Naqvi 2005; Khan et al., 2008). The increment borer is a precision survey tool that was developed in Germany in 1855. Sample Core extraction from alive tree for dendrochronological study is applied to estimate growth rate and age of the tree from different ecological zones (Grissino-Mayer, 2003).

Systematic investigation of tree ring and related parameters provide insight about how climate effects the plant growth and trees store history. Climate change is another challenge for most of the forest ecosystem. One proxy record that helps us for a better understanding of palaeoclimate is the tree growth ring pattern. Present study focused on tree growth rings in *Pinus roxburghii* in sub-tropical forest stand of Azad Jammu and Kashmir.

In the Himalayan region, generally the meteorological stations are few and situated in the towns. This makes it difficult to use climatic data to build climate record. Similarly, accurate and balanced is also are not available for longer duration for any particular Himalayan forested landscape (Srivastava et al., 2001). Systematic forest monitoring is required to investigate the effect of environmental changes on forest trees. Due to lack of technological issues, enough dendrochronological studies have not been done in western Himalayas (Singh et al., 2005).

Dendrochronology is a multidisciplinary science which provides answers about human behavior, prehistoric, and recent past astonishing environmental data, archive environmental data, fire history, hydrology, forestry, pollution studies, climatology and ecology. Tree rings study also provides us with climatic and seasonal variation impact on the growth pattern of trees, anatomical wood investigation, annual rainfall events on the basis of density and fluctuations in intra-annual rings (Krepkowski et al., 2012). Dendrochronology can also be used to assess the biomass productivity from an ecosystem (Mbow et al., 2013). Annual ring width of growing trees is a linear function measured by dendrograph. The growth in tree bark doesn't remain constant, so bark studies can't be used for the study of growth rings and physiological activities in tree species.

Present study plan is a pioneer step in emerging field of dendrochronological sciences to get pervious data from trees growth rings in Azad Jammu and Kashmir. The study area is totally unexplored in the field of Dendrochronology. Climatic change is a major environmental threat which effects all life and is also major threat for vegetation. Current work provides first base line study of dendrochronology and fill Knowledge gap by investigating effect of climatic variation trend on annual growth rings of *Pinus roxburghii* in sub-tropical forest stands of Azad Jammu & Kashmir.

*Pinus roxburghii* show great potential for dendrochronological study. These trees show sensitivity to environmental factors and long age (Bokhari et al., 2013). Tree rings chronology from *Pinus roxburghii* can provide preliminary assessment of its health and stand dynamics at sub-tropical elevation (Speer et al., 2017). *Pinus roxburghii* grows at steep slopes, in soil depth with low infiltration of water. *Pinus roxburghii* can adopt to the xerophytic conditions (Shah et al., 2015).

The present study was carried out to investigate the age and growth rate of *Pinus roxburghii* L. in Azad Jammu and Kashmir by using dendrochronological approach. *P. roxburghii* grows in lower elevation sub-tropical vegetation zone of Azad Jammu and Kashmir. Chir Pine forest are an important forest type of Himalayan foothills in Kashmir which provide vital ecosystem services to the environment as well as local communities. A total of 4 sites were selected for the collection of core samples from living trees of *P. roxburghii* for the determination of age, range and growth rate. A total of 40 trees were selected for extraction of 70 cores from the selected sites each core were separately analyzed under microscope.

## 3.2 GEOGRAPHIC CHARACTERISTICS OF THE SAMPLING SITES

The dendrochronological investigations were carried out in district Kotli, Azad Jammu and Kashmir. It was selected because of its typical subtropical climate that makes it a hotspot for the Chir Pine growth. A total of 4 forest sites comprised of *Pinus roxburghii* pure stands were selected for sampling.

Barali site has an elevetional range of 723 m to 963 m. The site is located at Longitude 073° 52' 35 .81" North and Latitude 33° 26' 46 .71" East. The site is located on Eastern aspect having a slope class of 250 to 450.

Doongi site has an elevetional range of 831 m to 950 m. The site is located at Longitude 73° 58' 43 .92" North and Latitude 33° 23' 34 .50" East. The site is located on Eastern aspect having a slope class angle ranging from $20^0$ to $30^0$.

Pirlasoura site has an elevetional range of 1240 m to 1300 m. The site is located at Longitude 074° 05' 49 .23" North and Latitude 33° 29' 10 .62" East. The site is located on South-Eastern aspect having a slope class in the range of $25^0$ to $45^0$.

Charohi site has an elevetional range of 640 m to 794 m. The site is located at a Longitude of 073° 54 .962' North and Latitude 33° 22. 588' East. The site is located on South-Eastern aspect having a slope class of $15^0$ to $20^0$.

## 3.3 SAMPLING METHODOLOGY AND DATA COLLECTION

*Pinus roxburghii* alive trees were selected to evaluate dendrochronological attributes. The wood core samples were taken from alive trees. Each sample was taken at diameter breast height with different geographical location, elevation and slope angle. Swedish increment borer was used to extract core samples by following the protocol of Stoke and Smiley (1968); Ahmed (2014).

Maximum samples were taken from the trees showing maximum height and DBH. Two samples were taken opposite to radii in all the trees with maximum DBH values for cross match ring pattern as it shows variation in the same species according to Cleav land, (1980). Cores extracted from trees were inserted in drinking straws to avoid breakage and both sides were sealed with masking tape. The collected samples straws were labeled with site name, number and DBH of the sampled tree along with date of sampling. These samples were carefully carried in core holder frame from field to laboratory in order to avoid breakage of core.

## 3.4 LABORATORY APPARATUS

The apparatus consisted of an increment borer, flexible measuring tapes, clipboards, pencils, masking tape, and sample packing poly bag zip-lock and dendrochronology bags, wooden frame box, sanding machine, sand paper, VRO measuring instrument and binocular microscope (Fritts, 1976; Cook & Kairiukstis, 1990; Fonti et al., 2007).

## 3.5 DATA ANALYSIS

The samples were brought to laboratory, Department of Botany, University of Azad Jammu and Kashmir. Initially the samples were air dried at room temperature by removing masking tape from both sides. Core samples were mounted in wooden frame by using glue and the position of core tracheids were kept in vertical position. The information labeled on straw was copied on wooden frame to hold core in frame use masking tape. After drying, the masking tape was removed and samples were passed through series of sanding by using different grade of sanding paper (No#2, No#1, N0#0). The samples core extracted from trees were rubbed with sand paper and polished to make surface of rings clear (Asherin & Mata, 2001). The extracted cores were polished with abrasive tape to highlight the annual rings (Eckstein et al., 2004). After the final preparation of the samples, dendrochronological analysis was carried out in tree ring laboratory, Karachi University. Tellervo, COFECHA and ARSTRAN software were used to obtain the ring width measurement and to develop tree ring chronologies.

## 3.6 VISUAL CROSS DATING OF CORES

Polished cores were analyzed by using binocular long arm microscope. Skeleton plot technique was used for visual cross dating following Stoke and Smiley (1968). Narrow and wide rings with respect to year were drawn on skeleton graph. The cores showing narrow rings extreme presence in the same year were considered as pointer years. For representation of decade, fifty and century on core single dot, two dots and three dots were used respectively. The cores which show sensitivity in rings were subjected to further studies whereas the age and growth rate of all other samples were determined. Wood samples reliability were calculated by using method of Ogden (1980), given as

Reliability= Actual length of core/ tree radius x 100

## 3.7 CHRONOLOGY PREPARATION

COFECHA program was used to develop chronology whereas ARSTRAN software was used for removing lags and standardization.

## 3.8 COFECHA

The width measurement of raw ring's measured in millimeter was subjected to COFECHA (Grissino-Mayer, 2003). It developed internal master chronology with statistically compared segments of 50 year from each measured core against the master core.

## 3.9 ARSTRAN

The program ARSTRAN was used to develop series of tree ring measurements with the help of detrending and standardization (indexing) the TRW series (Cook, 1985). ARSTRAN program maximizes the common signals reduces the amount of noise in the chronologies produced. The robust estimation of mean values is used for removing the endogenors disturbance. A detrending and negative exponential curve with 25% frequency was used to cutoff smoothing spline. The reason for running the computer program COFECHA is to check dating and measurement quality, while the reason for running ARSTRAN is to build a robust master chronology after standardization of individual samples. In additional most of the non-climatic effects are removed from tree ring width series due to standardization process of ARSTRAN.

# 3.10 RESULTS OF THE DENDROCHRONOLOGICAL INVESTIGATIONS

**STRUCTURAL AND DENDROCHRONOLOGICAL ATTRIBUTES OF THE *Pinus roxburghii* FOREST STANDS**

### 3.10.1. <u>DIAMETER AT BREAST HEIGHT (DBH)</u>

The average DBH of the trees sampled from the study sites was recorded to be 78.6 cm. The minimum average DBH among the all sites was recorded 48 cm from Pir Lasoura Site at an elevetional range 1246-1308m m. The maximum average DBH among the all sites was recorded to be 120 cm from Brali site at an altitudinal range of 723-964 m. A total of 40 cores samples were extracted from 40 trees for dendrochronological investigations (Table 3.5).

### 3.10.2 <u>GROWTH RATE YEAR/CM</u>

The average growth rate of *Pinus roxburghii* was calculated to be 1.20 ± 0.02 year/cm among the all sites. The mean value with highest growth rate among all sites were calculated to be 0.92 ± 0.02 year/cm from Charohi site at an elevetional range of 640 m to 794 m. The mean value with lowest growth rate was calculated to be 1.39 ± 0.04 year/cm from Pir Lasoura site at an elevetional range of 1246-1308 m (Table 3.6).

### 3.10.3. GROWTH RATE CM/YEAR

The growth rate (cm/year) was calculated to be 0.95 cm/year among all the sites. The site with maximum average growth rate was Charohi site with mean value of 1.13 ± 0.04 cm/year at an elevetional range of 640 m to 794 m. The site with minimum growth rate of 0.82 ± 0.06cm/year was Pir Lasoura site at an elevetional range of 1246-1308 m (Table 3.6).

### 3.10.4. TOTAL AGE

The overall average age of *Pinus roxburghii* trees specimen sampled from the study area was calculated to be 100.5 years. The site with maximum average age of 119.5 was Pir Lasoura site at an elevetional range of 1246-1308 m. The site with minimum average age of 74.5 years was Charohi at an elevetional range of 640 m to 794 m (Table 3.6). The structural attributes and dendrochronological characteristics of the

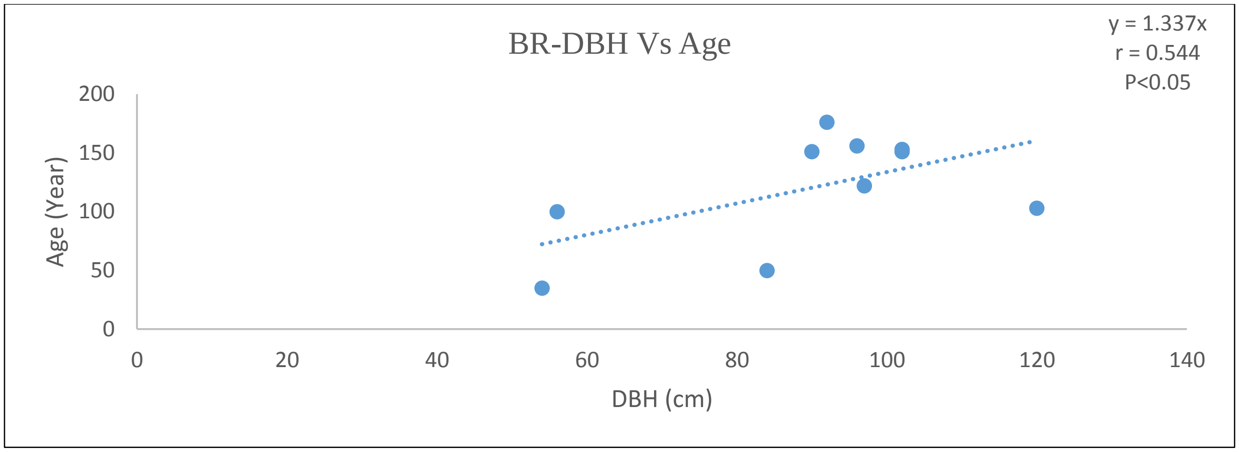
*Pinus roxburghii* forest stands are discussed in detail according to the samples sites as following.

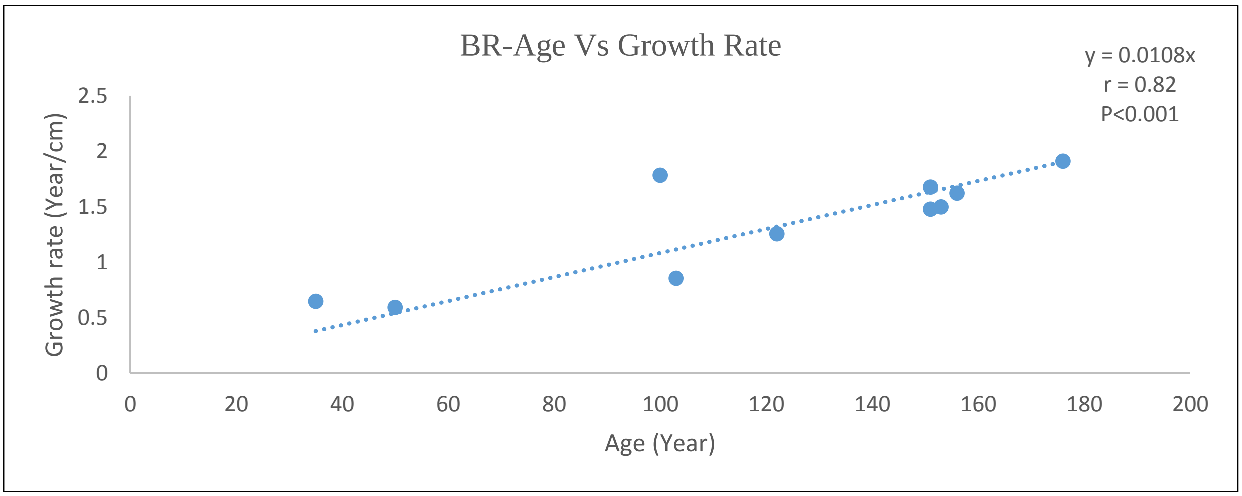
### 3.11 DENDROCHRONOLOGICAL DETAILS OF BARALI SITE

At this site (Barali) a total of 10 cores from different trees of *Pinus roxburghii* were collected. The recorded mean growth rate was 0.88 ± 0.11 cm/year with a minimum of 0.52 cm/year and maximum of 1.54 cm/year. Average DBH was recorded to be 93.2 cm with a minimum of a DBH 54 cm and maximum of a DBH 120 cm. Average core length was founded to be 24.5 cm with a minimum of 15 cm and maximum of 27.5 cm. The oldest tree with an age of 176 years and 92 cm of a DBH. Five trees rings counted with age more than 150 years. Area of (BR) was with moderate canopy cover showing span of rings from 1841-2017 A.D (Table 3.1).

Table 3.1 Dendrochronological details of *Pinus roxburghii* recorded from Barali.

| Core No. | DBH (cm) | Radius (cm) | Core Length (cm) | Missing Radius (cm) | Total Rings | Number of Ring Missing Radius | Reliability (%) | Total Age | Growth rate | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Year/cm | cm/year |
| 1 | 54 | 27 | 15 | 12 | 22 | 10 | 56 | 35 | 0.65 | 1.54 |
| 2 | 90 | 45 | 24 | 21 | 101 | 47 | 53 | 151 | 1.67 | 0.59 |
| 3 | 96 | 48 | 27.5 | 20.5 | 108 | 46 | 57 | 156 | 1.63 | 0.61 |
| 4 | 84 | 42 | 22.5 | 19.5 | 32 | 15 | 54 | 50 | 0.59 | 1.68 |
| 5 | 102 | 51 | 25 | 26 | 100 | 51 | 49 | 153 | 1.50 | 0.66 |
| 6 | 92 | 46 | 25.2 | 20.8 | 120 | 54 | 55 | 176 | 1.91 | 0.52 |
| 7 | 56 | 28 | 22 | 6 | 81 | 17 | 79 | 100 | 1.78 | 0.56 |
| 8 | 97 | 48.5 | 25 | 23.5 | 81 | 39 | 52 | 122 | 1.26 | 0.79 |
| 9 | 102 | 51 | 22 | 29 | 95 | 54 | 43 | 151 | 1.48 | 0.67 |
| 10 | 120 | 60 | 27 | 33 | 65 | 36 | 45 | 103 | 0.86 | 1.16 |
| Mean | 93.2 | 46.6 | 24.5 | 22.1 | 87 | 40 | 54 | 129 | 1.41 | 0.88 |



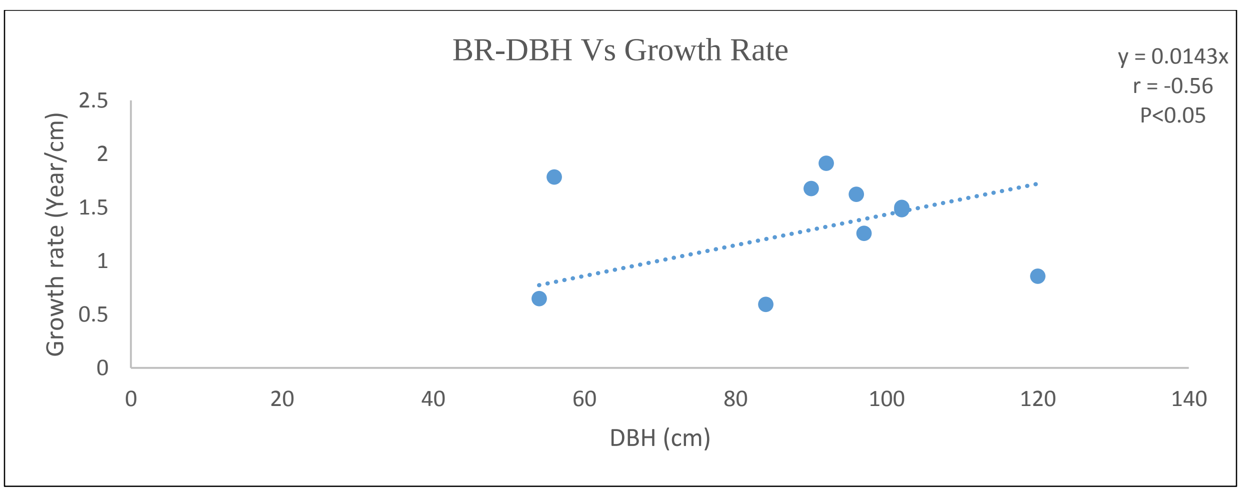



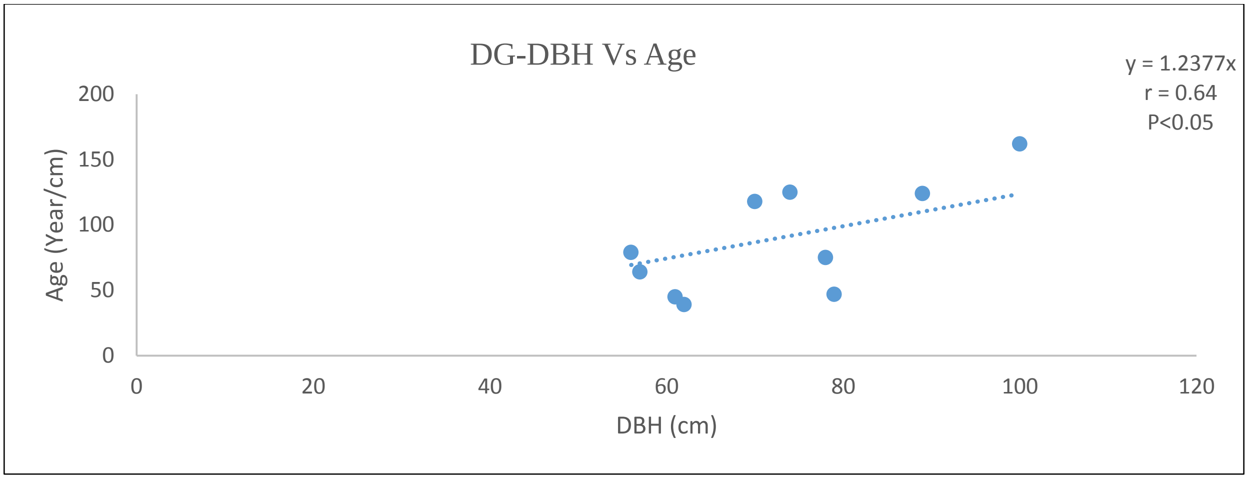

Figure 3.1. Correlation and linear regression values of DBH, Growth rate and Age at Barali Site.

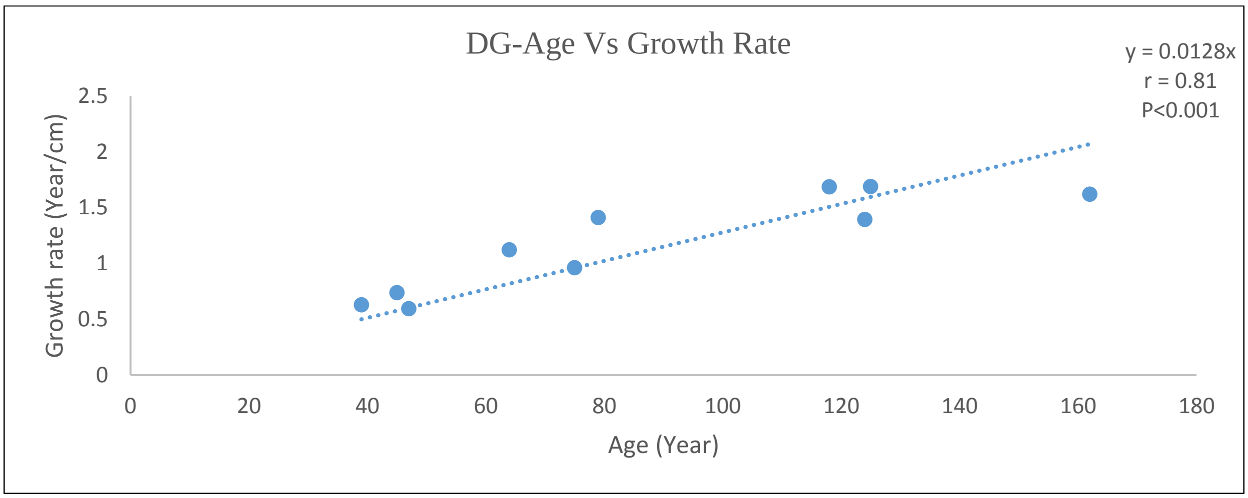
## 3.12 DENDROCHRONOLOGICAL DETAILS OF DOONGI SITE

The sampled site of (DG) forest is comparatively protected than other forest sites. A total of 10 wood cores were obtained from this site. The value of mean growth rate was 0.97 ± 0.10 cm/year with a minimum of 0.59 cm/year and a maximum of 1.68 cm/year. Average DBH was recorded to be 72 cm with a minimum of 56 cm and a maximum DBH of 100 cm. Average core length was found to be 21.5 cm with a minimum of 16.5 cm and a maximum of 27 cm. The oldest tree were recorded with the age of 162 years and with a DBH of 100 cm. A total of 4 cores showed age above 110 years revealing the growth interval from 1855-2017 A.D (Table 3.2).

Table 3.2 Dendrochronological details of *Pinus roxburghii* recorded from Doongi.

| **Core No.** | **DBH (cm)** | **Radius (cm)** | **Core Length (cm)** | **Missing Radius (cm)** | **Total Rings** | **Number of Ring Missing Radius** | **Reliability (%)** | **Total Age** | **Growth rate** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Year/cm** | **cm/year** |
| 1 | 78 | 39 | 27 | 12 | 56 | 17 | 69 | 75 | 0.96 | 1.04 |
| 2 | 57 | 28.5 | 23 | 5.5 | 51 | 10 | 81 | 64 | 1.12 | 0.89 |
| 3 | 100 | 50 | 26.4 | 23.6 | 109 | 51 | 53 | 162 | 1.62 | 0.62 |
| 4 | 70 | 35 | 24.5 | 10.5 | 89 | 27 | 70 | 118 | 1.68 | 0.59 |
| 5 | 74 | 37 | 24 | 13 | 91 | 32 | 65 | 125 | 1.76 | 0.59 |
| 6 | 89 | 44.5 | 26.5 | 18 | 87 | 35 | 60 | 124 | 1.39 | 0.72 |
| 7 | 61 | 30.5 | 18 | 12.5 | 30 | 12 | 59 | 45 | 0.74 | 1.35 |
| 8 | 56 | 28 | 17.4 | 10.6 | 55 | 21 | 62 | 79 | 1.41 | 0.71 |
| 9 | 62 | 31 | 16.8 | 14.2 | 25 | 11 | 54 | 39 | 0.63 | 1.58 |
| 10 | 79 | 39.5 | 16.5 | 23 | 28 | 16 | 42 | 47 | 0.59 | 1.68 |
| Mean | 72 | 36 | 21.5 | 14.5 | 62.7 | 23.8 | 60.6 | 89.2 | 1.22 | 0.97 |



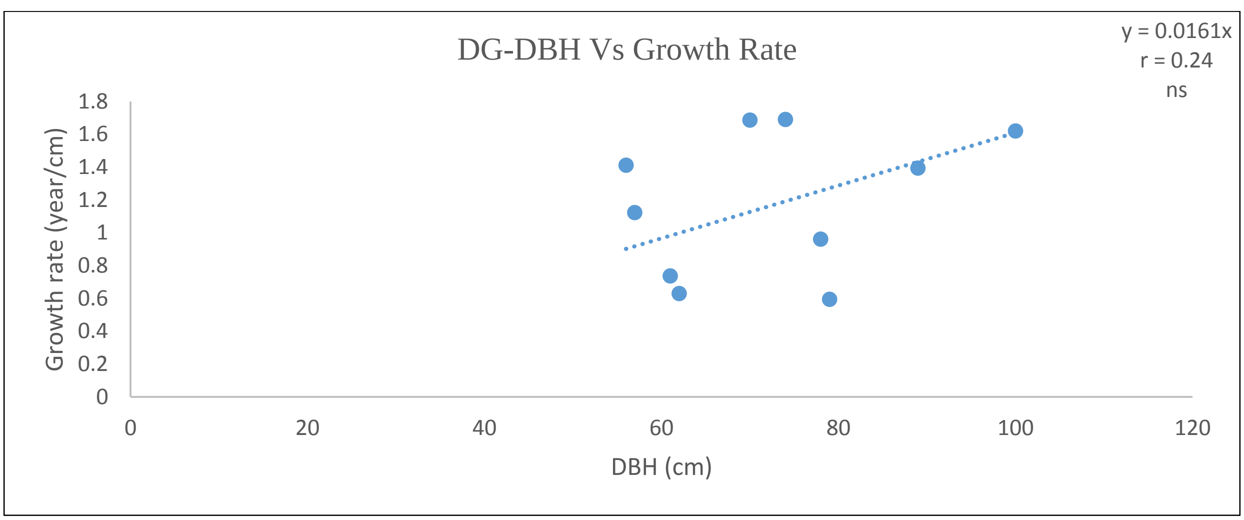



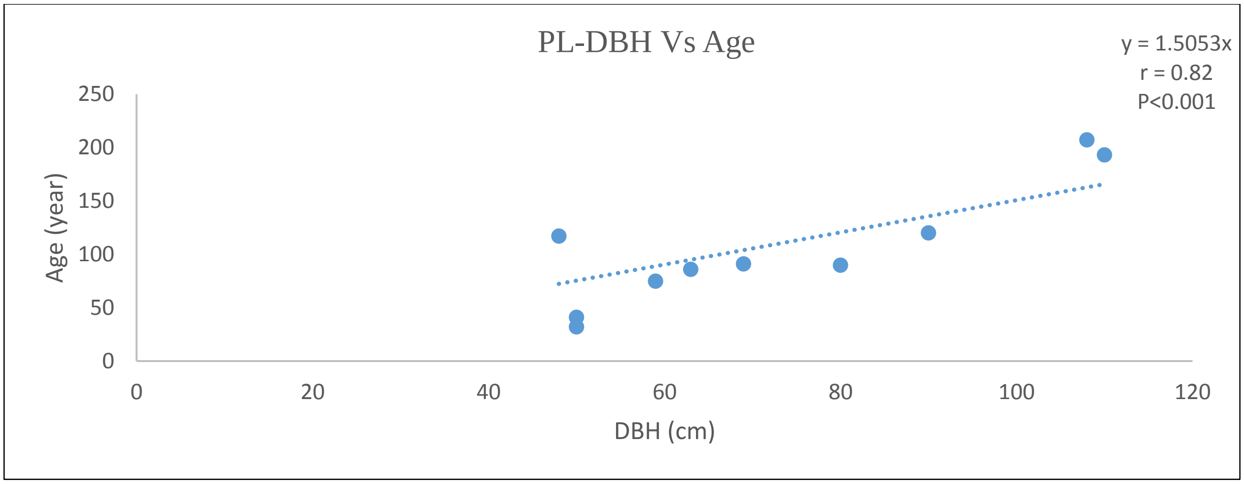

Figure 3.2. Correlation and linear regression values of DBH, Growth rate and Age at Doongi Site.

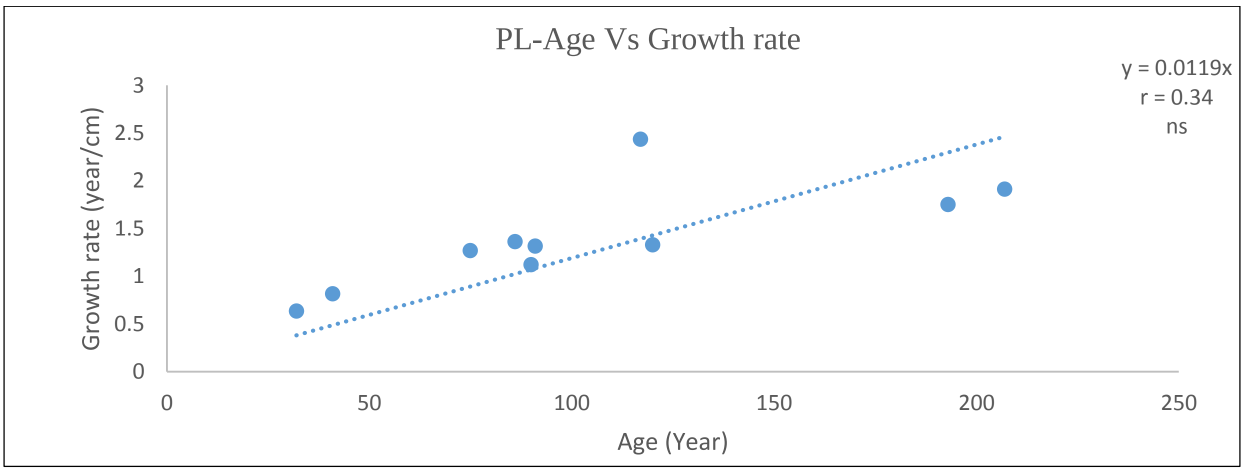
### 3.13 DENDROCHRONOLOGICAL DETAILS OF PIR LASOURA SITE

A total of 10 cores samples were taken from (PL) forest. The calculated mean growth rate was 0.82 ± 0.06 with a minimum of 0.41 cm/year and a maximum of 1.56 cm/year. Average DBH was recorded to be 75.2 cm with a minimum of 48 cm and a maximum DBH of 110 cm. Average core length was found to be 22.2 cm with a minimum of 13.5 cm and a maximum of 26.5 cm. This site was characterized by an individual of *Pinus roxburghii* with 207 years with a DBH of 108 cm which acquired time interval from 2017 to 1810 A.D. The age of 4was cores was recorded to be more than 110 years (Table 3.3).

Table 3.3 Dendrochronological details of *Pinus roxburghii* recorded from Pirlasoura.

| **Core Num.** | **DBH (cm)** | **Radius (cm)** | **Core Length (cm)** | **Missing Radius (cm)** | **Total Rings** | **Number of Ring Missing Radius** | **Reliability (%)** | **Total Age** | **Growth rate** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Year/cm** | **cm/year** |
| 1 | 50 | 25 | 17.5 | 7.5 | 22 | 7 | 70 | 32 | 0.64 | 1.56 |
| 2 | 69 | 34.5 | 26.5 | 8 | 72 | 17 | 77 | 91 | 1.32 | 0.76 |
| 3 | 63 | 31.5 | 23.2 | 8.3 | 66 | 17 | 74 | 86 | 1.36 | 0.73 |
| 4 | 90 | 45 | 26 | 19 | 82 | 35 | 58 | 120 | 1.33 | 0.75 |
| 5 | 50 | 25 | 16 | 9 | 28 | 10 | 64 | 41 | 0.82 | 1.22 |
| 6 | 108 | 54 | 26 | 28 | 135 | 70 | 48 | 207 | 1.92 | 0.52 |
| 7 | 59 | 29.5 | 18.5 | 11 | 53 | 19 | 63 | 75 | 1.27 | 0.78 |
| 8 | 80 | 40 | 24 | 16 | 63 | 25 | 60 | 90 | 1.13 | 0.88 |
| 9 | 110 | 55 | 26.5 | 28.5 | 126 | 65 | 48 | 193 | 1.75 | 0.57 |
| 10 | 48 | 24 | 13.5 | 10.5 | 80 | 35 | 56 | 117 | 2.44 | 0.41 |
| Mean | 75.2 | 37.6 | 22.2 | 15.4 | 78.3 | 32.5 | 68.8 | 113.3 | 1.48 | 0.82 |



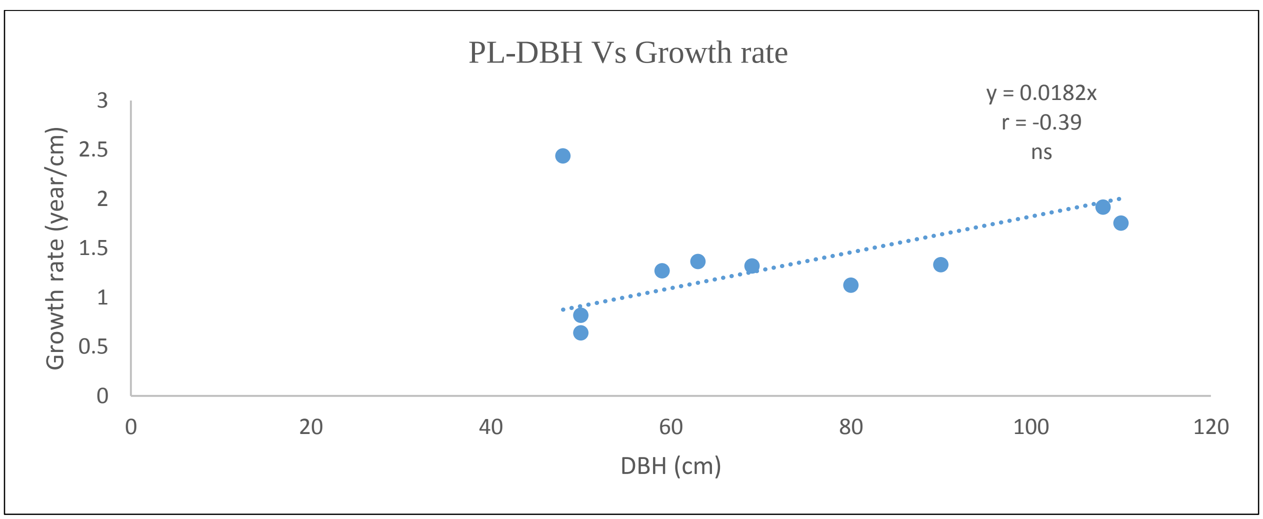



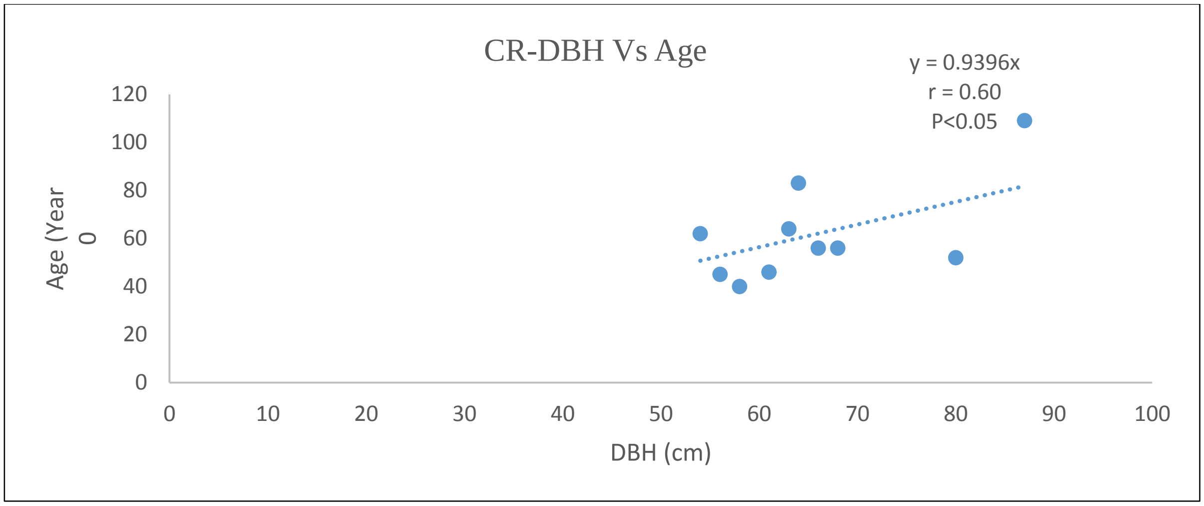

Figure 3.3. Correlation and linear regression values of DBH, Growth rate and Age at Pirlasoura.

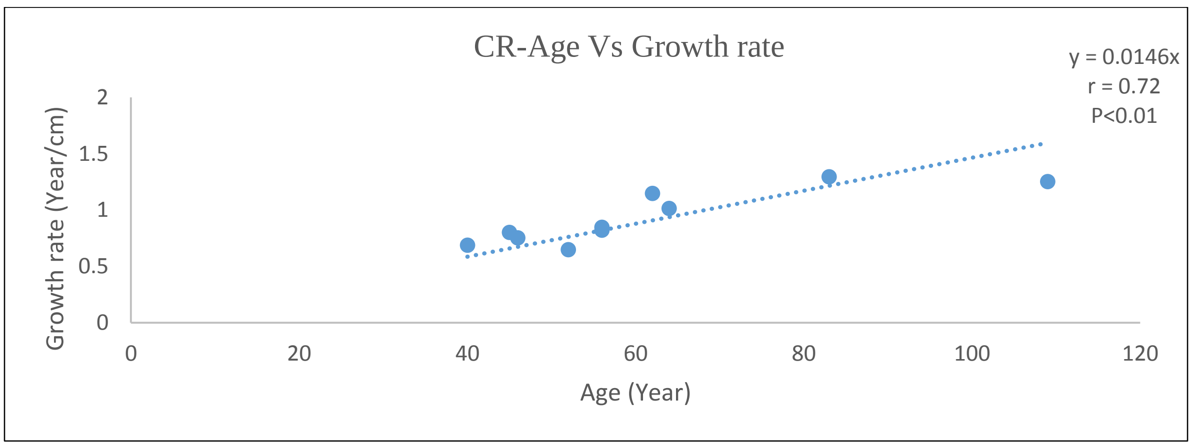
### 3.14 DENDROCHRONOLOGICAL DETAILS OF CHARHOI SITE

From Charohi (CH) a total of 10 woody cores were taken. Forest showed a mean growth rate of 1.13 ± 0.04 cm/year with a minimum of 0.77 cm/year and a maximum of 1.54 cm/year. Average DBH was recorded to be 66.5 cm with a minimum of 54 cm and a maximum DBH of 87 cm. Average core length was found to be 22.5 cm with a minimum of 18 cm and a maximum of 27.5 cm. The oldest tree at this site was 109 years with a DBH of 87 cm. Only a single tree was recorded with more than 100 year's rings showing growth duration from 2017 to 1909 A.D (Table 3.4).

Table 3.4 Dendrochronological details of *Pinus roxburghii* recorded from Charohi.

| **Core No.** | **DBH (cm)** | **Radius (cm)** | **Core Length (cm)** | **Missing Radius (cm)** | **Total Rings** | **Number of Ring Missing Radius** | **Reliability (%)** | **Total Age** | **Growth rate** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Year/cm** | **cm/year** |
| 1 | 58 | 29 | 21 | 8 | 29 | 8 | 72 | 40 | 0.68 | 1.45 |
| 2 | 64 | 32 | 22.5 | 9.5 | 62 | 18 | 70 | 83 | 1.29 | 0.77 |
| 3 | 66 | 33 | 27.5 | 5.5 | 46 | 8 | 83 | 56 | 0.85 | 1.17 |
| 4 | 68 | 34 | 21 | 13 | 38 | 15 | 62 | 56 | 0.82 | 1.21 |
| 5 | 54 | 27 | 20.8 | 6.2 | 48 | 11 | 77 | 62 | 1.15 | 0.87 |
| 6 | 87 | 43.5 | 25 | 18.5 | 75 | 32 | 57 | 109 | 1.25 | 0.79 |
| 7 | 61 | 30.5 | 21.5 | 9 | 33 | 10 | 70 | 46 | 0.75 | 1.33 |
| 8 | 80 | 40 | 27 | 13 | 38 | 12 | 68 | 52 | 0.65 | 1.54 |
| 9 | 63 | 31.5 | 20 | 11.5 | 45 | 16 | 63 | 64 | 1.01 | 0.98 |
| 10 | 56 | 28 | 18 | 10 | 31 | 11 | 64 | 45 | 0.80 | 1.24 |
| Mean | 66.5 | 33.3 | 22.5 | 10.7 | 46.2 | 14.7 | 68.2 | 63.6 | 0.95 | 1.13 |



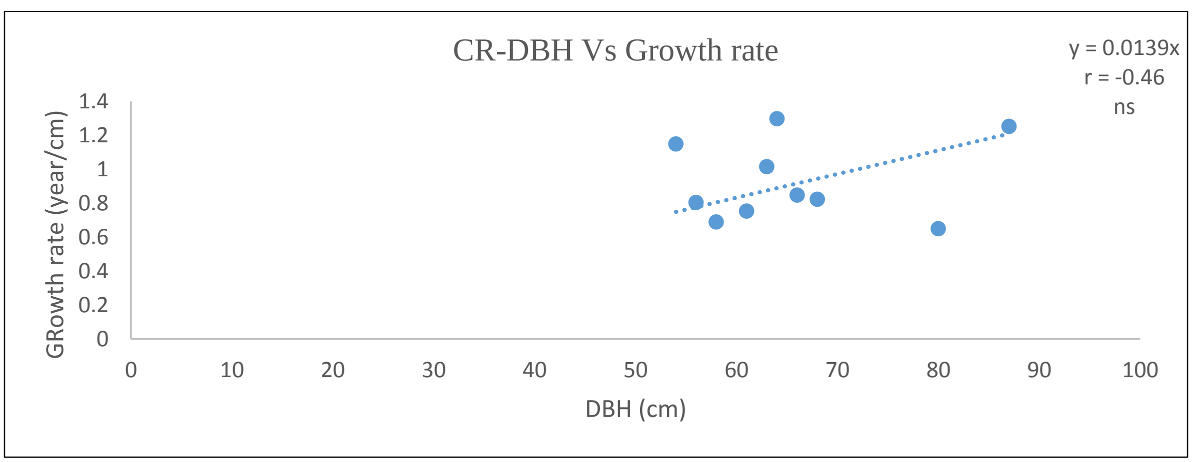




Figure 3.4. Correlation and linear regression values of DBH, Growth rate and Age at Charohi Site.

# 3.15 DISCUSSION

*Pinus roxburghii* is a key stone gymnosperm species and a vital component of the sub-tropical forest stand of Azad Jammu and Kashmir. *Pinus roxburghii* exhibits annual growth rings which can be interpreted to reveal past climatic history. In present study by using the dendrochronological techniques, we investigated the annual growth ring patterns and variations in the growth rings of *Pinus roxburghii*. The core samples were extracted from 16 different subtropical forest sites of Azad Jammu and Kashmir. During samples collection it was observed that *Pinus roxburghii* stands were experiencing disturbances in term of anthropogenic pressures, forest fires and natural disasters. The growth of *Pinus roxburghii* is adversely effected by geological and anthropogenic disturbance which threatens its distributions and diversity (Singh et al., 2014).

Dendrochronological investigations are helpful to reconstruct previous climatic history including fire effect, rain pattern and seismological event times. Dendrochronological data is also used to understand the pattern of climatic variations and its subsequent impacts on the growth rate of plant species. Previously the age of some conifer trees has been calculated in Pakistan by using method of simple counting but the results of those studies showed over estimation of age (Champion et al., 1965, Sheikh 1985). According to Ahmed, (2014) the age calculation of trees need modern dendrochronological techniques otherwise simple counting of rings provides over estimation of age.

*Pinus roxburghii* is a vital species for dendrochronological studies which is negatively impacted by forest fire, road construction and human disturbances (Speer et al., 2017). The present study of *P. roxburghii* is worthwhile for dendrochronology due to its long age and show long climatic continuum. An instance of change in age and growth rate results of different site in *P. roxburghii* showing that only DBH is not good growth rate and age indicator. The young trees of *P. roxburghii* growth rate was faster due to the reduction of competition in *Pinus roxburghii* inter species and intra species which effect growth rate. The impact of disturbance on tree can be predicted by growth rate which is helpful for the management and improvement of forests (Dale et al., 2001; Touchan et al., 2005). The availability of long-term climatic data on instrumental bases is challenging to understand the impact of climate change. It is recommended that the Tree rings chronologies should be constructed for further keystone taxa to reconstruct past climatic history and its impacts on specific species in this region.

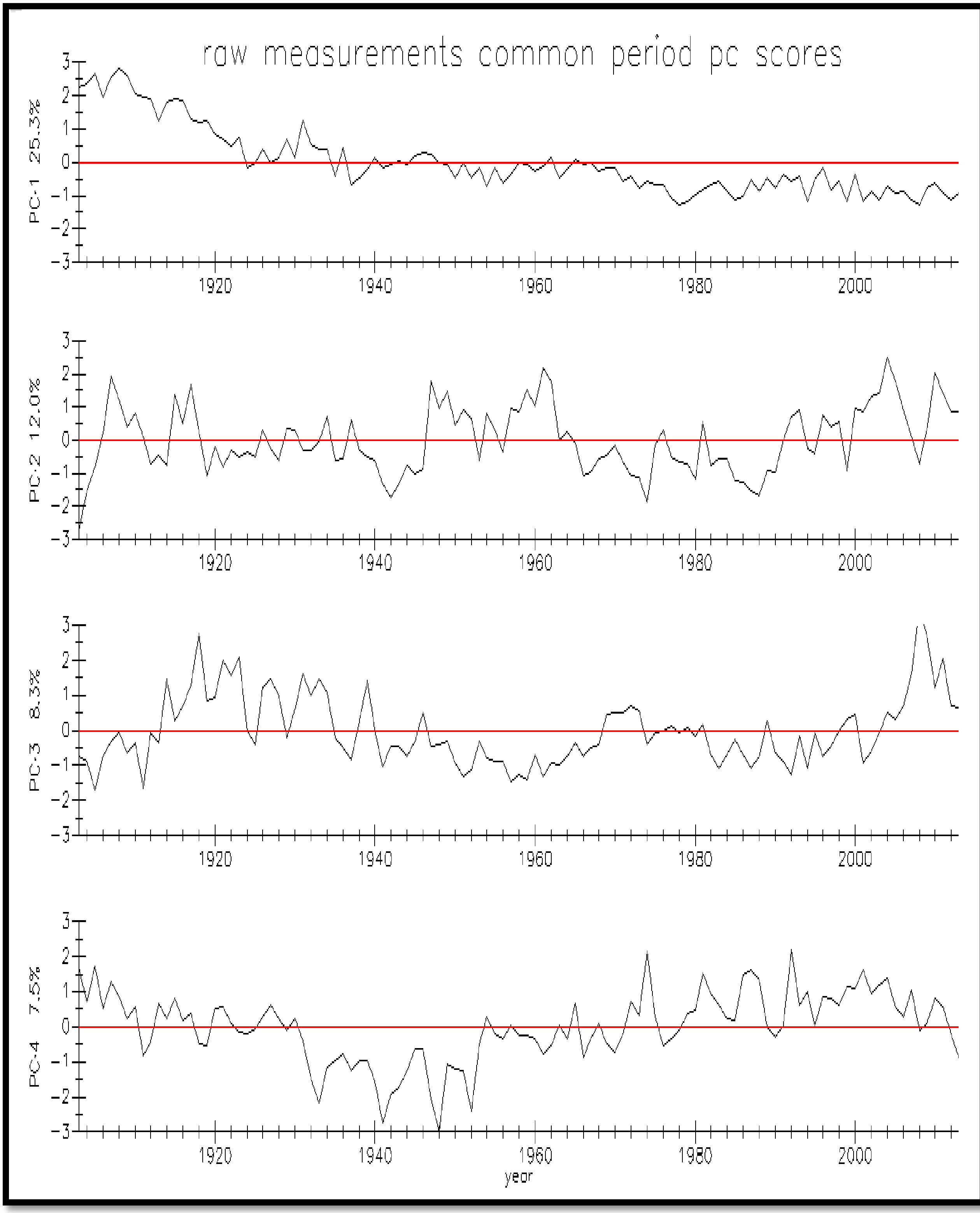



Figure 3.5. Showed PC1, PC2, PC3 and PC4 scores obtained from TRW chronology.

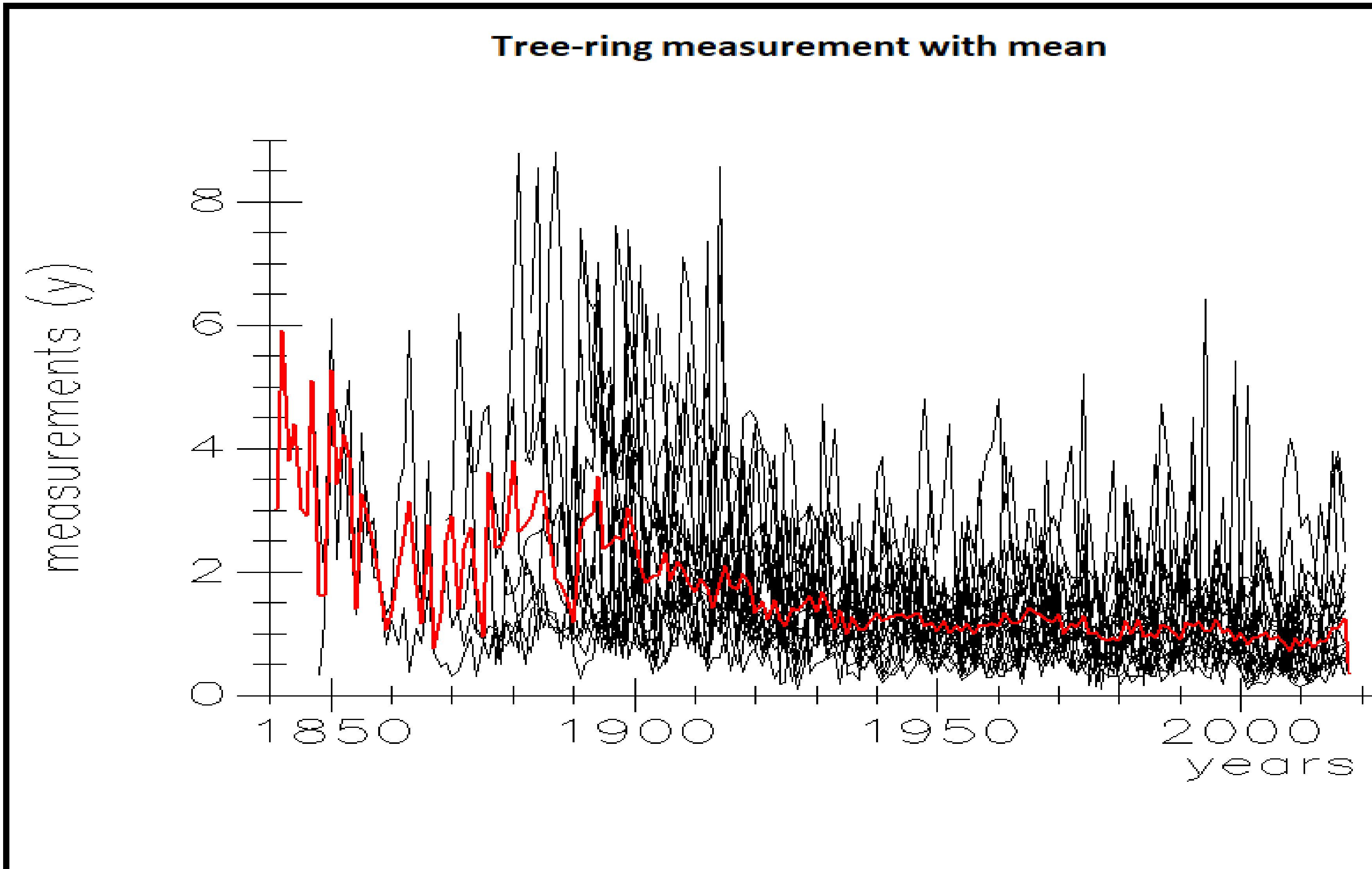



Figure 3.6: Tree-ring width index with mean measurement on y-axis in mm with respective years on x-axis obtained from *Pinus roxburghii* tree of Azad Kashmir and Kashmir forest stands

Table. 3.5 .The *Pinus roxburghii* structural attributes recorded from the sampling sites.

| S/N0 | Site Name | Elevation Range (m) | | Aspect | Canopy Cover | Cores No. | DBH Range | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | Mean |
| 1 | ***Barali*** | 723 | 964 | E | Open | 10 | 54 | 120 | 87 |
| 2 | ***Doongi*** | 831 | 950 | E | Moderate | 10 | 56 | 100 | 78 |
| 3 | ***Pirlasoura*** | 1246 | 1308 | S-E | Moderate | 10 | 48 | 110 | 79 |
| 4 | ***Charohi*** | 640 | 794 | S-E | Open | 10 | 54 | 87 | 70.5 |

Table. 3.6 .The *Pinus roxburghii* dendrochronological attributes recorded from the sampling sites.

| S/N0 | Site Name | Total Age Range | | | Growth rate | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Year/cm | | | cm/Year | | |
| | | Min | Max | Mean | Min | Max | Mean ±SE | Min | Max | Mean ±SE |
| 1 | ***Barali*** | 35 | 176 | 105.5 | 0.59 | 1.91 | 1.33 ± 0.09 | 0.52 | 1.58 | 0.88 ± 0.11 |
| 2 | ***Doongi*** | 39 | 162 | 100.5 | 0.59 | 1.68 | 1.18 ± 0.06 | 0.59 | 1.68 | 0.97 ± 0.10 |
| 3 | ***Pirlasoura*** | 32 | 207 | 119.5 | 0.64 | 2.43 | 1.39 ± 0.07 | 0.41 | 1.56 | 0.82 ± 0.06 |
| 4 | ***Charohi*** | 40 | 109 | 74.5 | 0.65 | 1.29 | 0.92 ± 0.02 | 0.77 | 1.53 | 1.13 ± 0.04 |

# CHAPTER 4

# CARBON STOCK ASSESSMENT IN SUB TROPICAL VEEGTATION ZONE OF AZAD JAMMU AND KASHMIR

## 4.1 INTRODUCTION

Carbon sequestration is defined as long term capture and storage atmospheric carbon in different carbon sinks. It is estimated that more than two third of atmospheric carbon is stored by forest ecosystems in vegetation and soil (Sedjo et al., 1998). Forest carbon sequestration involves absorption of atmospheric $CO^2$ during photosynthesis in order to increase forest Biomass and soil organic matter (Bass et al., 2000). Photosynthetic organisms make carbohydrate by using Carbon dioxide (Kaufman and Franz, 1996).

Change in climatic conditions due to anthropogenic activities has resulted in increased level of GHGs and consequent rise in in global temperatures. An average 0.6 0C rise in global temperature has been recorded for the last century. TIn the next few years, it is predicted to observe increased temperatures, while also experiencing drier summer and wet winter seasons, with a greater chance of droughts (Ray et al., 2008).

A system with the capacity to store or emit Carbon is known as Carbon pool. Examples are forest biomass, soil, and the atmosphere (IPCC, 2003). Above ground living biomass includes stem, stump, bark, foliage and seeds (Wharton and Griffith, 1997). Roots are included in living below ground biomass (Eswaran et al., 2005). Dead wood and litter biomass in different forms on ground and soil is the form of non-living woody biomass that includes wooden logs on forest floor and dead roots (IPCC, 2003; Schröder and Pesch, 2011).

Carbon stock estimation is a key step to quantify the carbon sequestration potential of any ecosystem; and to gauge the potential of any ecosystem to mitigate the impacts of climate change. The quantification of local carbon pools is necessary to analyze the impacts of climate change related processes on biomass and soil dynamics. One of the main objectives of this project is to quantify the biomass and soil carbon stocks of represented Chir Pine and subtropical broad leaf forest sites in district Muzaffarabad.

## 4.2 STUDY AREA FOR CARBON STOCK ASSESSMENT

The study area lies in District and Tehsil Muzaffarabad, the capital city of the state of Azad Jammu and Kashmir and includes two subdivisions Muzaffarabad and Pattika Nasirabad, 25 union councils and 415 villages (GoAJK, 2013). The total area of the district is 6,117 $km^2$ (Anonymous 2013a). It is located at 34.21. North latitude and 73.28 East Latitude.

### 4.2.1 CLIMATE

Climate of the area is subtropical monsoon type in lower range which changes into moist temperate in the middle and subalpine to alpine in upper region. The summer season is hot in lower altitudes and pleasant in upper region and the winters are cold (Awan *et al.*, 2004). The area above 1200 m receives heavy snowfall from November to April however there is no permanent snow cover in the area. Average maximum and minimum temperatures are recorded during July and is about 35 to 23°C; and in January temperature remains 16 to 3°C respectively (Abbasi, 1998). Mean annual precipitation in district Muzaffarabad is 1511 mm. The maximum rainfall is observed in June and July which is 307.22 mm and 213.19 mm respectively. The relative humidity is recorded to be fluctuating between 58 percent and 84 percent whole the year (PAK-MET, 2016).

### 4.2.2 DEMOGRAPHY

Population of Muzaffarabad, according to 1998 census was 0.454 million (0.235 million male and 0.219 million female population) and growth rate was recorded as 2.80 percent. Recent estimates shows that a total of 0.126 million people are living in urban areas with a ratio of 0.69 million male and 0.56 million female population, while 0.542 million people are living in rural areas in which 0.276 million are male and 0.266 million are female population (GOAJK, 2013).

### 4.2.3 <u>AGRICULTURE</u>

Agricultural land holding capacity of Muzaffarabad is 84843 hectares, out of it 28077 hectares area is under cultivation. Major crops are Maize (24135 hectares, 206311 Metric Tons), Wheat (5169 hectares, 128486 Metric Tons), and Rice (594 hectares, 5459 Metric Tons). Major vegetables (731 hectares) are Tomato, Beans, Spinach, Turnip and Potato. Fruits include Apple, Walnut, Apricot, Plump and cherry (GoAJK, 2013).

## 4.3 SAMPLING METHODOLOGY

Five forest sites with different forest types i.e. subtropical mixed forests, *Olea cuspidata* forest and *Pinus roxburghii* forests were selected in the study area. GPS was used for the measurement of longitude and latitude of each forest site. At each site, five temporary plots were established for trees and soil sampling. The size of the plot in each forest was kept 20 m x 20 m (400 m2). Tree DBH was measured by following standard sampling technique. Tree height was measured by marking at a height of 1.5 m at each tree. Then, by standing at a distance of 3 meters from the standing tree, from tree base top the number of 1.5 m sections were counted and then multiplied by a factor of 1.5 to get the tree height in meters (Waran, 2001).

Soil samples (0-30 cm depth) were taken by using a metallic soil sampler. Four soil samples from the corner and one from the center of each plot were taken. Five soil samples (0-30 cm depth) were taken from the agricultural land near every site. Soil samples were weighed using a digital balance in the field and were stored in polythene bags for determination of soil carbon stocks in the laboratory.

### 4.3.1 BIOMASS AND SOIL CARBON STOCKS ESTIMATION

Above and below ground biomass of tree species in the forest site was estimated to calculate the actual carbon stocks of the forest.

Above ground tree biomass (AGTB) was calculated by using allometric equations developed on the basis of forest stand types, species and ecological conditions. The literature survey was carried out for the proper selection of species specific and generic allometric models. Tree species and their relevant allometric equations used for biomass estimation (kg) are given below.

- *Accacia* spp. 0.071+0.0818*DBH^ (2)*H (Maguire et al., 1990)
- *Broussonetia papyrifera* 0.776*(ρD2H) 0.940 (Chave et al., 2005)
- *Dalbergia sissoo* 0.667*DBH^ (1.832) (Rai et al., 2010)
- *Ficus spp*. 0.0421*(DBH^ (2)*H) ^ (0.9440) (Hung et al., 2012a)
- *Mallotus philippinensis* 0.0547*(DBH^ (2.1148))*(H^ (0.6131)) (Hung et al., 2012b)
- *Pinus roxburghii* 0.0509* ρ D2 H (Chave et al., 2005)

D = diameter of a tree at breast height (in cm),

H = height of a tree (in m) and

ρ = wood density value ($g\ cm^{-3}$)

General formula based on 1:5 for root to shoot value was applied for estimation of below ground biomass (BGB) estimation.

Soil samples were brought to the laboratory and were mixed very well to make a composite accordingly. For determining the Carbon concentration in the forest and agricultural soils, Walkley-Black method of chromic acid wet oxidation was followed.

The soil bulk density was also calculated by using the given formula (Nizami, 2010)

Soil bulk density= Oven dried weight of soil ÷ Volume of cylinder

Amount of Carbon (%) obtained was transformed into topsoil organic Carbon (SOC) in t/ha. Inventory of soil Carbon pool stated as t/ha or Mg /ha used for a specific deepness was calculated after multiplying the SOC (in Mg /kg) with bulk density of the soil (in g cm-3) and depth (in cm) (Carlos et al., 2001).

SOC (t /ha) = OC (Mg / kg) × bulk density (g / cm3) × depth (cm)

## 4.4 RESULTS OF THE CARBON STOCKS ASSESSMENT

Total biomass Carbon and soil Carbon values were combined at all sites to calculate total Carbon stocks for the area. An average Carbon stocks value of 137.5 t/ha was determined for the study area. The highest Carbon stock value of 228 t/ha was recorded from site 5 at Dewlian whereas the lowest value of 75.86 t/ha Carbon stock recorded at site 2 at Barsala (Table 4.1). Biomass Carbon stock was considered as 50 percent of total biomass. Average biomass Carbon stock value at all forest types was 151.38 t/ha. Average value of Soil Carbon stocks at all five sites was 33.9 t/ha. Maximum soil Carbon stocks value of 43.76 t/ha was recorded from site 5 whereas minimum soil Carbon values were recorded from site 1 that was 25.64 t/ha (Table 4.1).

Table 4.1. Mean biomass and soil carbon stock Values Recorded from the study sites

| Site No. | Above ground biomass (t/ha) | Below ground biomass (t/ha) | Total biomass (t/ha) | Biomass Carbon Stock (t/ha) | Soil organic Carbon (t/ha) | Total Carbon (t/ha) |
|---|---|---|---|---|---|---|
| 1 | 137.5 | 27.5 | 165 | 82.5 | 25.64 | 108.14 |
| 2 | 72.3 | 14.5 | 86.8 | 43.4 | 32.46 | 75.86 |
| 3 | 308.0 | 61.6 | 369.6 | 184.8 | 43.76 | 228.56 |
| Average | 172.6 | 34.53 | 207.13 | 103.57 | 33.95 | 137.52 |

## 4.2 FOREST BIOMASS

Total estimated biomass at all five sites was 207.134 t/ha. The maximum biomass value of 369.6 t/ha was estimated from site 3 at Dewlian and the minimum from site 2 that was recorded as 86.8 t/ha. Average above ground tree biomass (AGTB) at all sites was recorded as 172.6 t/ha. The highest AGTB value of 308 t/ha was found at site 3 at Dewlian whereas the lowest AGTB value was quantified at site 2 in Barsala which was as 72.3 t/ha. Average value of BGB was calculated as 34.53 t/ha.

*Pinus roxburghii* was the most significant species in terms of net primary productivity containing an average biomass value of 191.8 t/ha and shares 63.35 percent in average estimated biomass of the study site. *Olea cuspidata,* being the second significant species made a total biomass of 68.9 t/ha by sharing 22.67 percent. *Accacia modesta* made a biomass value of 12.71 t/ha and makes 4.19 percent. Biomass value of *Dalbergia sissoo* was 12.01 t/ha, contributing 3.96 percent. *Broussonetia papyrifera* made a total of 5.93 t/ha biomass and shares 1.95 percent. Biomass value of *Punica granatum* was recorded as 2.27 t/ha by participating 0.74 percent in total biomass. Contribution of *Mallotus philippinensis* and *Albezia lebbeck* in biomass was estimated as 2.2 t/ha and 1.8t /ha by sharing 0.73 and 0.59 percent respectively. Quantified values of biomass in *Ficus palmata* and *Acacia arabica* were 1.51 t/ha and 1.4 t/ha by making 0.50 and 0.46 percent respectively, whereas in *Melia azedarach*, biomass amount was 1.14 t/ha constituting 0.37 percent. The lowest average biomass value of 1.07 t/ha was calculated in *Ficus carica* and its share in total biomass was 0.40 percent (Table 2).

## 4.2.1 Carbon Stocks Assessment at Site 1 (Kohala)

### 4.2.1.1 Site Description

Site 1 was located near Kohala, District Muzaffarabad (34006.39 N, 73029.72 E, 675 m). Five plots were established at site 1 from which 4 were on Southern and 5th was on Northern aspect. Average site distance from settlements was recorded 180 meters. Intensity of grazing, slope degree and soil erosion were of class 1. Anthropogenic pressure like pruning, looping, tracks, stumps and water supply lines were found to be present in this site.

### 4.2.1.2 Total Carbon Stocks

Total Carbon stock at sit 1 was recorded as 108.14 t/ha. Total biomass Carbon values in this site were 82.5 t/ha constituting 76.29 percent of total Carbon stocks. AGTB and BGB were calculated as 66 t/ha and 16.5 t/ha respectively. The determined value of soil Carbon was 25.64 t/ha making 23.71 percent of the total Carbon stocks.

### 4.2.1.3 Forest Biomass

Total tree biomass at site 1 was recorded as 165 t/ha. AGTB value was 137.5 t/ha and BGB was calculated as 27.5 t/ha. *Dalbergia sissoo* was the most significant species in terms of net primary productivity containing a biomass value of 44.38 t/ha and shares 62.66 percent in total estimated biomass of the study site. *Olea cuspidata,* being the second significant species made a total biomass of 41.48 t/ha by sharing 25.14 percent. *Broussonetia papyrifera* made a biomass value of 17.98 t/ha and makes 10.9 percent. Biomass value of *Accacia modesta* was 15.8 t/ha by contributing 9.62 percent. *Punica granatum* made a total of 11.38 t/ha biomass and shares 6.9 percent. Biomass value of *Ficus palmata* was recorded as 7.56 t/ha by participating 4.59 percent in total biomass. Contribution of *Accacia arabica* and *Ficus carica* in biomass was 7 t/ha and 5.38

t/ha by sharing 4.28 and 3.27 percent respectively. Quantified values of biomass in *Albezia lebbeck* and *Mallotus philippinensis* were 5.34 t/ha and 4.8 t/ha by making 3.24 and 3.02 percent respectively. The lowest biomass value of 3.9 t/ha was calculated in *Melia azedarach* and its share in total biomass was 2.38 percent.

## 4.2.2 Carbon Stocks Assessment at Site 2 (Barsala-Shahdara)

### 4.2.2.1 Site Description

Site 2 was located between Barsala and Shahdara villages of Kohala, District Muzaffarabad (34008.56 N, 73029.50 E, 634 m). Five plots were established at site 2 on Southern aspect. Average site distance from settlements was recorded 137 meters. Intensity of grazing was categorized in class 2, both the slope degree and soil erosion were placed in class 3. Anthropogenic pressure signs like pruning, looping, tracks, stumps and road construction were observed in this site.

### 4.2.2.2 Total Carbon Stocks

Total Carbon stock at sit 2 was recorded as 75.86 t/ha. Total biomass Carbon values in this site were 43.4t/ha constituting 57.21 percent of total Carbon stocks. AGTB and BGB were calculated as 34.72 t/ha and 8.68 t/ha respectively. The determined value of soil Carbon was 32.46 t/ha making 42.79 percent of the total Carbon stocks.

### 4.2.2.3 Forest Biomass

Total tree biomass at site 2 was recorded as 86.8 t/ha. AGTB was 72.3 t/ha and BGB was 14.5 t/ha. *Accacia modesta* was the most significant species in terms of net primary productivity containing a biomass of 47.75 t/ha and shares 55 percent in total estimated biomass of the study site. *Dalbergia sissoo*, being the second significant species made a total biomass of 15.71 t/ha by sharing 18.1 percent. *Broussonetia papyrifera* made a biomass value of 11.71 t/ha and makes 13.5 percent. Biomass value of *Mallotus philippinensis* was 6.21 t/ha by contributing 7.16 percent. *Albezia lebbeck* made a total of 3.6 t/ha biomass and shares 4.14 percent in total biomass. The lowest values of 1.82 t/ha biomass were recorded in *Melia azedarach* and it share was 2.1 percent.

## 4.2.3 Carbon Stocks Assessment at Site 3 (Devlian)

### 4.2.3.1 Site Description

Site 5 was located near Devliyan, ($34^{0}27.15$ N, $73^{03}4.22$ E, 1097 m). Five plots were established at site 4 on Southern aspect. Average site distance from settlements was recorded 620 meters. Intensity of grazing was categorized in class 1, the slope degree and soil erosion were of class 3 and class 2 respectively. Presence of stumps in this site indicated the anthropogenic pressure.

### 4.2.3.2 Total Carbon Stocks

Total Carbon stock at sit 5 was recorded as 228.56 t/ha. Total biomass Carbon values in this site were 184.8 t/ha constituting 80.85 percent of total Carbon stocks. AGTB and BGB were calculated as 147.84 t/ha and 36.96 t/ha respectively. The determined value of soil Carbon was 43.76 t/ha making 19.15 percent of the total Carbon stocks.

### 4.2.3.3 Forest Biomass

Total tree biomass at site 5 was recorded as 369.6 t/ha. Total AGTB was calculated as 308 t/ha and BGB as.6 t/ha.

Table 4.2 Species wise biomass contribution in the studied forest stands of subtropical zone

| No. | Species | Site 1 | Site 2 | Site 5 | Biomass (t/ha) | Carbon stocks (t/ha) | Percentage Contribution |
|---|---|---|---|---|---|---|---|
| 1. | *Accacia arabica* | **7.0** | **0** | **0** | **1.4** | **0.7** | **0.46** |
| 2. | *Accacia modesta* | **15.8** | **47.75** | **0** | **12.71** | **6.36** | **4.19** |
| 3. | *Albizia lebbeck* | **5.34** | **3.6** | **0** | **1.8** | **0.9** | **0.59** |
| 4. | *Broussonetia papyrifera* | **17.98** | **11.71** | **0** | **5.93** | **2.97** | **1.95** |
| 5. | *Dalbergia sissoo* | **44.38** | **15.71** | **0** | **12.01** | **6.01** | **3.96** |
| 6. | *Ficus carica* | **5.38** | **0** | **0** | **1.07** | **0.53** | **0.40** |
| 7. | *Ficus palmata* | **7.56** | **0** | **0** | **1.51** | **0.75** | **0.50** |
| 8. | *Mallotus philippensis* | **4.8** | **6.21** | **0** | **2.20** | **1.1** | **0.73** |
| 9. | *Melia azedarach* | **3.9** | **1.82** | **0** | **1.14** | **0.57** | **0.37** |
| 10. | *Olea cuspidata* | **41.48** | **0** | **0** | **68.9** | **34.45** | **22.76** |
| 11. | *Pinus roxburghii* | **0** | **0** | **369.6** | **191.8** | **95.9** | **63.35** |
| 12. | *Punica granatum* | **11.38** | **0** | **0** | **2.27** | **1.14** | **0.74** |
| | **Total** | **165** | **86.8** | **369.6** | **302.74** | **151.38** | **100** |

## 4.4 DISCUSSION

Carbon sequestration is the absorption and long term storage of atmospheric $CO_2$ in a system known as a Carbon pool (FAO, 2005). The main biomass C pools in forests are plants, woody debris, litter and soils (IPCC, 2003; Richards and Evans 2004). The potential of forests to both sequester and emit GHGs coupled with ongoing intensive deforestation, has resulted in forests and land-use changes being included in the United Nations Framework Convention on Climate Change (UNFCCC) and in the Kyoto Protocol (UNFCCC; 1992; KYOTO, 1997). Allometric equations are used to assess forest biomass because it is nondestructive and less laborious method to quantify forest biomass (Montès *et al*., 2000). Majority of studies about biomass and Carbon stocks are conducted in tropical or temperate forests ecosystems whereas subtropical forests have not been given due attention (Lin *et al*., 2012). The quantitative assessment of Carbon stock in subtropical forests is of great importance since they refer to estimates obtained in a very poorly studied vegetation type as compared to other forests (Rosenfield and Souza, 2013).

This study revealed an average **Carbon stocks value** of 137.52 t/ha in subtropical forest of District Muzaffarabad. This value is lower than the reported Carbon stocks values of 250 t/ha in forests of Southeast Asia (Houghton and Hackler, 1999); 285.0 t/ha in rain forests (Malhi, 1998; Press *et al.*, 2000); 250-300 t/ha in central Himalayan forests (Singh and Singh, 1985, 1992); 173.7 to 262.6 t/ha in Chir pine and Banj oak forests of Kumaun Himalaya (Jina *et al.* 2008). The results are also lower than the estimates of 219.86-490.33 t/ha in Oak- pine forest of Garhwal Himalaya (Vikrant and Chauhan, 2014); 203.9 t/ha in broadleaved forest of China (Zhang *et al*., 2012) and 274 to 194 t/ha in subtropical forests of Vietnam (Zemek, 2009).

This decrease in values can be attributed to the fact that the forest sites had relatively lower biomass yield (IPCC, 2003; Segura, 2005; Chave *et al*., 2005). Present study revealed that our average biomass value of 207.3 t/ha is lower than 1157-827 t/ha (Sharma *et al.*, 2008) and 790.47 t/ha (Vikrant and Chauhan, 2014) reported in Himalayan region.

This study was, in specific methodological sense, pioneer and pilot-research in in subtropical region of the state of Azad Jammu and Kashmir. Methodology involved a variety of research operations depending upon the type of the data collected. Field survey and laboratory tests were carried out in order to insure the key allometric and soil data crucial for the biomass and soil carbon sequestration.

Forest sites showed a variation in carbon stock values due to a combination of natural and anthropogenic factors like temperature, precipitation, slope, soil erosion, deforestation and grazing intensity. *Pinus roxburghii* forests showed a higher value of 326.32 and 228.56 t/ha Carbon stocks followed by *Olea cuspidata* forest having value of 192.49 t/ha. Mixed forest sites showed comparatively lower values of 108.14 and 75.86 t/ha carbon stocks. Carbon stocks in the forests are observed to be threatened by local community as the forests are currently facing heavy fuel and timber wood extraction, grazing and soil depletion that ultimately lead to a reduced forest cover and Carbon stock.

Results are comparable with similar studies from Himalayan region and all over the world. This study offers a keen and more intensive research in future for a better understanding of forest and soil Carbon sequestration. There is still a further need to study and develop the present forest status and methodologies to estimate biomass of all forest types and components in order to strengthen the policies for the forest conservation and climate change mitigation. There is a need to undertake research to improve understanding of future impacts of climate change and to examine adaptive management strategies.

## 4.5 RECOMMENDATIONS

1. Due to deforestation pressure, DBH and height values were recorded to be low. Forest conservation and management needs to be improved for an increased amount of biomass and soil carbon stocks.

2. For fuelwood and construction purposes, local community depends on nearby forest land that reduces forest cover and consequently carbon stocks. The problem can be avoided by providing alternative fuel and construction materials.

3. Unmanaged and intensive grazing alter the vegetation structure and soil carbon dynamics, which can be managed by controlling heavy nomadic and household cattle grazing in the growing season to save growing seedlings and nutrient enriched soils.

4. Soil erosion due to a higher slope degree and road construction can be decreased by afforestation and reforestation. Check dames and protection walls can minimize soil erosion intensity.

5. Rate of agricultural soil carbon sequestration can be maximized through managed agriculture, organic forming and crop rotation.

6. Governmental support is required for public and stakeholder's awareness, forest and agricultural management and national scale policy making for the climate change mitigation

# CHAPTER 5

# INVESTIGATION OF THE INVASIVE ALIEN SPECIES (IAS) IN SUB-URBAN VEGETATION OF MUZAFFARABAD

## 5.1 INTRODUCTION

Invasive species are defined as those species that are not inhabitant to an area and that may displace or otherwise harmfully change native plant species (Drake *et al* .,2003). The terms 'alien', 'exotic', 'non-native', 'non-indigenous' and 'introduced' refer to those taxa or species that are commonly viewed as 'foreign' and arrive outer their natural range, where they did not originally occur but have recognized themselves in a new place as a result of direct or indirect human activity (White *et al*., 1993; Kalwij *et al*., 2008).

The invasion of alien plant species in the new regimes has become the second highest threat to plant diversity after the habitat loss (Hobbs and Humphries, 1995). They are toxic and cause negative impact in environment, habitats, ecosystems, native biodiversity, economics and even human health. Introduction of these species may occur unintentionally or through their being imported for a limited purpose and consequently escaping or deliberately on an outsized scale (Khanna, 2009).

Biological invasion has been considered as one of the most important mechanism of global change. It is posing serious threats to the conservation of native ecosystems world-wide (Dukes and Mooney, 1999; Lonsdale 1999; Mack *et al*., 2000). Global changes due to invasions are significant and have long-term effects. They are at least as important as other influences like changes in climate, the atmosphere, and land use because these may not be reversible in hundreds to thousands of years (D'Antonio and Vitousek, 1992).

During the last century, human activities, especially international trade, have overcome oceanic and others natural barriers for world's biota. The instability in the natural ecosystems offers the great opportunities to the alien invaders to set up themselves. On the other hand, invasive species impudence the scale, rate and impact of climate change by altering ecosystem composition, structure and function.

Invasive alien species (IAS) can impede species diversity, richness, composition, abundance and interactions including mutualisms. The direct effects of IAS at the species level occur through processes such as predation, competition with and parasite transmission to individual organisms (Daszak *et al.*, 2000; Blumenthal 2005; Colautti *et al.* 2005). Invasive alien species (IAS) can lead to the fragmentation, destruction, alteration and even the whole replacement of habitats. In turn, these effects on habitats often result in consequences for even more species and ecosystem processes, primary to the functional collapse of the native ecosystem (O'Dowd *et al.*, 2003).

Azad Kashmir has a forest area comprising 12% of its total area as compared to the world's standard of about 33% (GOAJK, 1998). Forested area have been entirely transformed to naked land due to heavy tree cutting for fuel and house construction by as well as an intense grazing pressure (Khan *et al*., 2014). Beside these factors Invasive species play a major role to destroy the native flora of Azad Kashmir. The present study will be conducted to study the effect of Invasive species on the subtropical zone of Muzaffarabad District, Azad Jammu and Kashmir.

## 5.2 STUDY AREA AND SAMPLING METHODOLOGY

The study sites were located in Muzaffarabad city, Kohala-Muzaffarabad trcak and Muzaffarabad-Garidupatta track. A total of 3 sites, 1 in City, 1 in Kohala Muzaffarabad track and 1 in Muzaffarabad Garhidopata track were sampled. The data was recorded using quadrats method. In each sites number of quadrats was five. Five quadrats of the size 10 x10 m, 5 x 5m, and 1 x 1m for trees, shrubs and herbs, were taken respectively. Each quadrat was subdivided into 5 x 5 m sample plot for recording shrubs and samplings and 1 x 1 m for herbs and seedlings. The herbaceous cover was determined by the Daubenmire’s cover scale (Daubenmire, 1959). Trees with diameter at breast height (1.5m) were measured to obtain basal area (Hussain, 1989).

The density, frequency and coverage/basal areas was converted to relative values and added to obtain importance values Index (IVI) by using the methods of (Ahmed and Shauqat, 2010). The study was conducted to enlist the species composition and then these species was identified in the herbarium of Botany Department University of Azad Jammu and Kashmir by the help of expert taxonomist. These species was evaluated on the basis of invasiveness and endemism with the help of published literature including flora of Pakistan and e-floras.

## 5.3 RESULTS

### 5.3.1 FLORISTIC COMPOSITION

A total of 121 plant species belonging to 58 families and 101 genera were recorded from the study area. The major contribution of local flora included Asteraceae 11 species with a weight age of 10% followed by Poaceae 10 species with a weight age of 8%. Rosaceae and Lamiaceae had 6 species with a weight age of 5% and Euphorbiaceae were represented by 5 species with a weight age of 4%. Amaranthaceae, Cyperaceae, Papilionaceae, Pteridaceae and Verbenaceae had 4 species with a weight age of 3%. Brassicaceae, Polygonacaea and Moraceae were represented by 3 species with a weight age of 2%; Whereas Meliaceae, Apocynaceae, Oleaceae, Malvaceae, Convolvulaceae, Solanaceae, Plantaginaceae, Salicaceae and Anacardiaceae were represented by 2 species with a weight age of 2%each. The remaining 36 families had single representative with a weight age of 30 % (Fig 5.1).

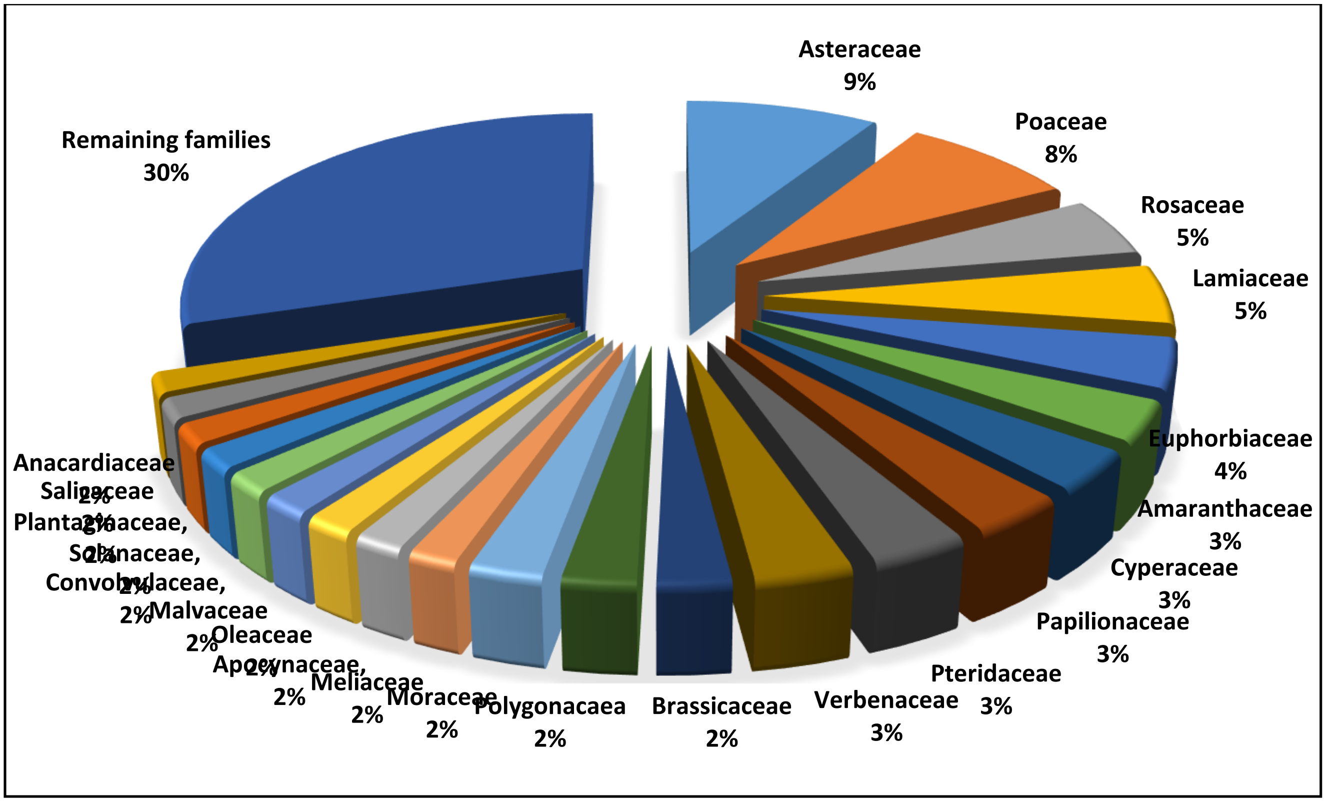



Fig. 5.1 Percentage of dominant plant families recorded from the area

### 5.3.2 <u>LIFE FORM</u>

Therophytes were the dominant life form represented by 45 species with a weight age of 37%. Nanophanerophytes were represented by 25 species with a weight age of 21%. Megaphanerophytes life form was represented by 20 species with a weight age of 16%. Chameophytes and Hemicryptophytes were represented by 10 species with age of 10%. Geophytes were represented by 7 species with age of 6%. Lianas were represented by 3 species with a weight age of 2%. Halophytes were represented by 1species with a weight age of 1 % (Fig 4.2).

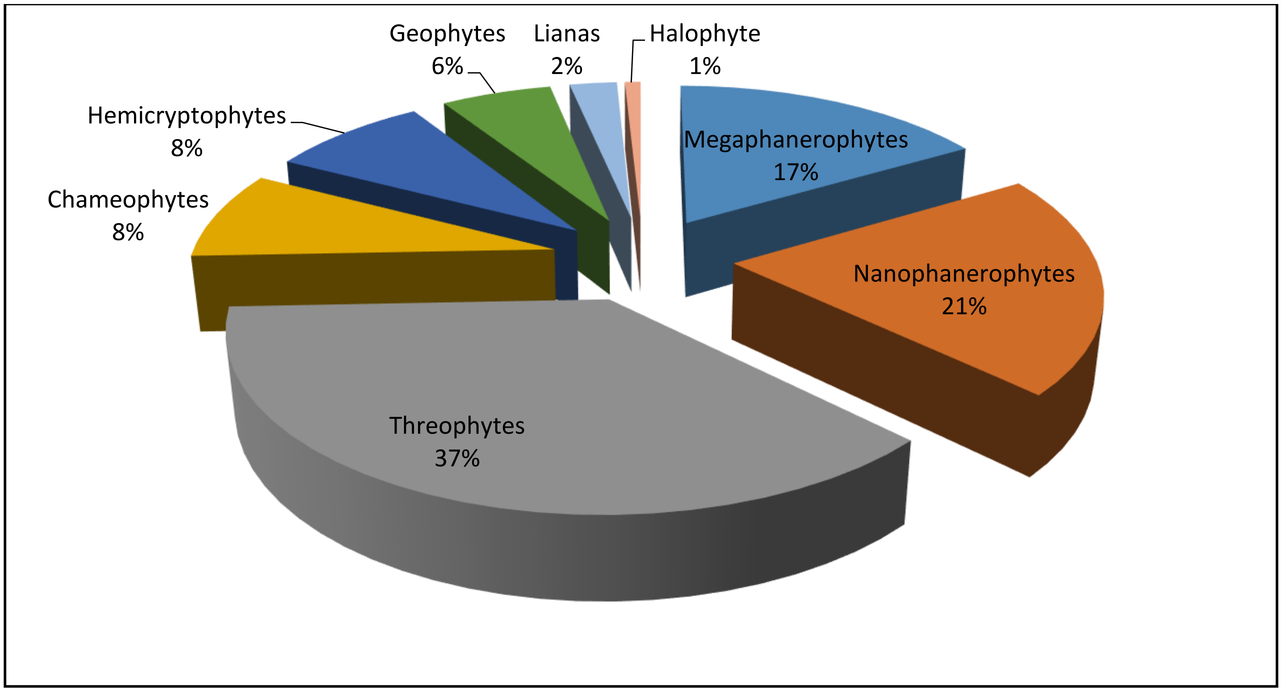



Fig 5.2 Percentage of life forms of species recorded from the study area.

### 5.3.3 LEAF SPECTRA

The dominant leaf spectrum was microphyll represented by 50 species with a weight age of 41%. Leptophyll was represented by 28 species with a weight age of 23%. Nanophyll was represented by 23 species with a weight age of 19%. Mesophyll was represented by 20 species with a weight age of 17 % (Fig.5.3).

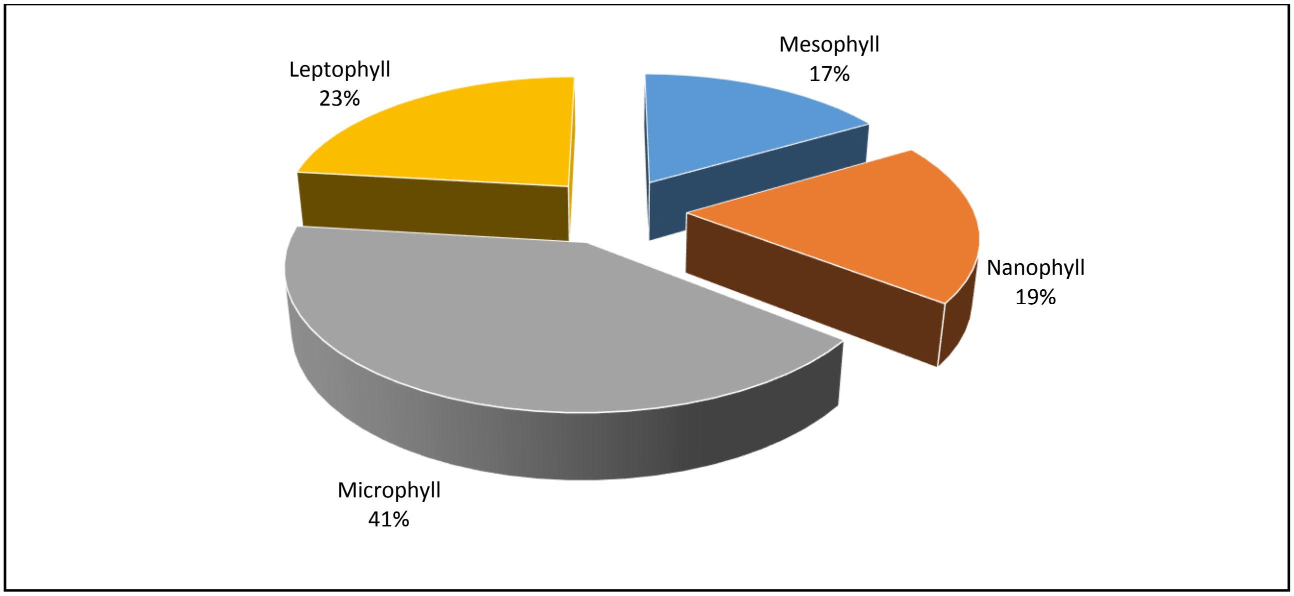



Fig. 5.3 Percentage of Leaf size Classes of the sampled flora

## 5.4 INVASIVE ALIENS FLORA OF MUZAFFARABAB CITY

Total numbers of Alien species which are recorded from the study area were 43 and these species belonging to 25 families and 41 genera. The major contribution of alien flora included Asteraceae having 8 species. Poaceae had 3 species. Amaranthaceae, Brassicaceae, Euphorbiaceae, Fabaceae, Moraceae, Polygonaceae, Plantaginaceae and Salicaceae had 2 species; and Simaroubaceae, Cannabiaceae, Caryophyllaceae, Scrophulariaceae, Verbenaceae, Rosaceae, Meliaceae, Oxalidaceae, Onagraceae, Malvaceae, Nyctaginaceae, Cyperaceae, Chenopodiaceae and Convovulaceae were represented by 1 species.

Herbs dominated the alien flora and were represented by 27 species. Trees were represented by 7 species. Shrubs were represented by 6 species. Climber and aquatic were represented by 1 species. Out of these 43 Aliens, Invasive aliens were represented by 20 species with a weight age of 46%. Casual aliens were represented by 6 with a weight age of 14%. Casual or naturalized were represented by 4 with a weight age of 9%. Naturalized aliens were represented by 11 with a weight age of 26%. Cultivated un-escaped aliens were represented by 2 with a weight age of 5% (Fig 5.4).

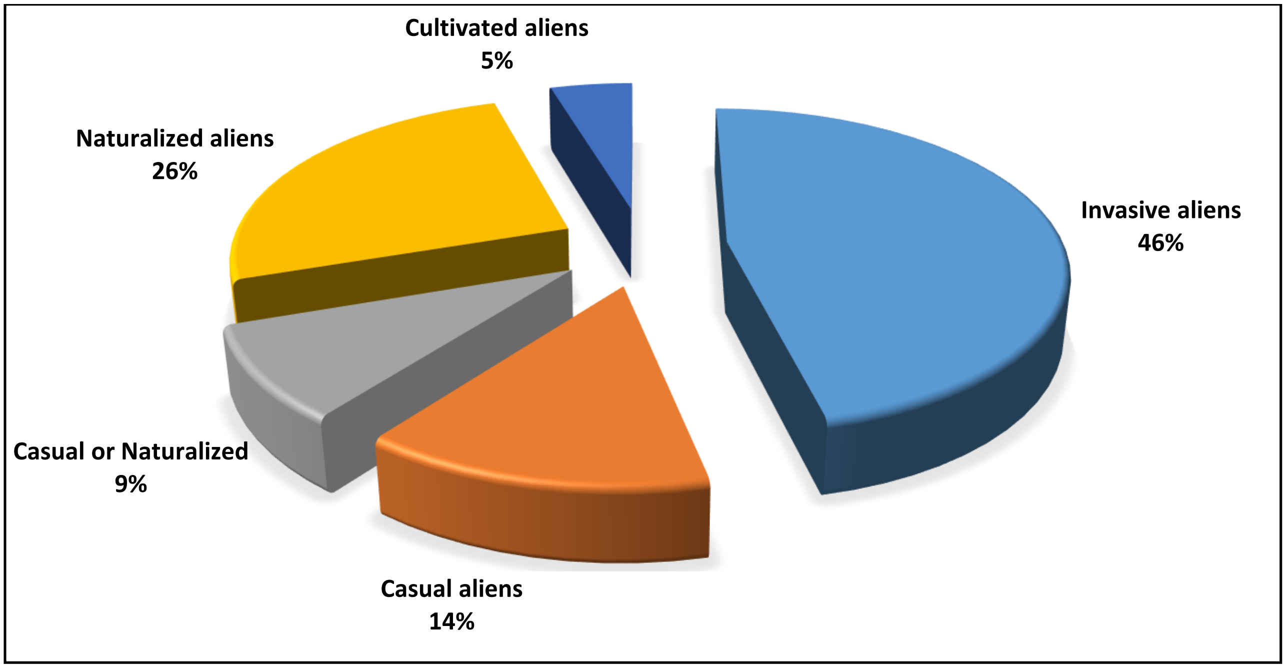



Fig 5. 4 Percentage of invasive alien species recorded from Muzaffarabad**.**

## 5.5 Community 1. *Justicia- Ailanthus- Eleocharis* community

### 5.5.1 Geographical characters

The stand was recorded at Langarpora site at an altitude of 731m. The latitude and longitude of the area was $34^0$19'035" north and $73^0$31'784" respectively. The slope of the community was in $30^0$ to $60^0$ class. The site was located on north facing aspect.

### 5.5.2 Phytosociological attributes

The community was dominated by *Justicia adhatoda* having importance value of 22.07 followed by *Ailanthus altissima* (18.24) and *Eleocharis indica* (14.08). Co-dominant species were *Mallotus philippensis* (13.31), *Broussonetia papyrifera* (13.31) and *Melia azedarach* (12.74).

### 5.5.3 Invasive alien species

The total numbers of invasive species in this community was 17 which constituting 39.53% of the community. It also includes *Ailanthus altissima* which was 2$^{nd}$ dominant. The invasive species recorded from the site include, *Melia azedarach*, *Broussonetia papyrifera*, *Ailanthus altissima*, *Ricinus communis*, *Xanthium strumarium*, *Conyza bonariensis*, *Parthenium hysterophorus*, *Cannabis sativa*, *Amaranthus spinosus*, *Rumex hastatus*, *Oenothera rosea*, *Taraxacum officinale*, *Capsella-bursa –pastoris*, *Trifolium repens*, *Oxalis corniculata*, *Euphorbia heliscopia*, *Chenopodium album* (Table 5.1).

## 5.6 Community. 2 *Parthenium- Dodonea- Broussonetia* community.

### 5.6.1 Geographical characters

The stand was recorded at Garidupata site at an altitude of 1199m.The latitude and longitude of the area was $34^{0}$15'867" north and $73^{0}$34'650" respectively. The slope of the community was in $30^{0}$ to $60^{0}$ class. The site was located on west and south facing aspect.

### 5.6.2 Phytosociological attributes

The community was dominated by *Parthenium hysterophorus* having importance value of 16.29 followed by *Dodonea viscosa* (14.48) and *Broussonetia papyrifera* (14.37). Codominant species were *Olea cuspidata* (11.24), *Eleagnus umbellata* (11.91) *and Punica granatum* (10.87).

### 5.6.3 Invasive alien species.

The numbers of invasive species in this community were 21 which constituting 42% of the community. It also includes *Parthenium hysterophorus, Broussonetia papyrifera* which was 2nd and 3rd dominant species. The invasive species recorded from the site include *Broussonetia papyrifera, Ailanthus altissima, Morus alba, Xanthium strumarium, Conyza bonariensis, Parthenium hysterophorus, Cannabis sativa, Tagetus minuta, Verbascum Thapsus, Amaranthus spinosus, Mirabilis jalapa, Elaeagnus umbellata, Oenothera rosea, Capsella-bursa –pastoris, Taraxacum officinale, Melia azedarach, Chenopodium album, Setaria pumilla, Nasturtium officinale, Rumex nepalensis, Oxalis corniculata* (Table 5.1).

## 5.7 Community 3. *Parthenium- Justicia- Dodonea* community

### 5.7.1 Geographical characters

The stand was located at Dulai site at an altitude of 659m. The latitude and longitude of the area was 340.18.279 north and 730.28.890 respectively. The slope of the community was in 10 to 300 class. The site was located on east facing aspect.

### 5.7.2 Phytosociological attributes

The community was dominated by *Parthenium hysterophorus* having importance value of 24.53 followed by *Justicia adhathoda* (20.99) and *Dodonea viscosa* (16.94). Codominant species were *Broussonetia papyrifera* (16.70), *Debregesia salicifolia* (11.47) and *Rubus fruticosus* (10.61).

### 5.7.3 Invasive alien species

The numbers of invasive species in this community were 18 which constituting 41.86% of the community. It also include *Parthenium hysterophorus* which was 1st dominant species. The invasive species recorded from the site include *Broussonetia papyrifera, Ailanthus altissima, Ricinus communis, Xanthium strumarium, Parthenium hysterophorus, Mirabilis jalapa, Conyza bonariensis, Cannabis sativa, Amaranthus Spinosus, Sonchus asper, Plantago lanceolata, Verbascum thapsus, Melia azedarach, Populas alba, Stellaria media, Oxalis corniculata, Salix alba, Setaria pumila* (Table 5.1).

**Table 5.1. List of Invasive Alien species of Muzaffarabad**

| S/no | Species name | Family | Origin | Mode | Invasion status | Primary published source |
|---|---|---|---|---|---|---|
| 1 | *Ailanthus altissima* | Simaroubaceae | AS | Pl | In | Ara *et al*., (1995) |
| 2 | *Artemisia scoparia* | Asteraceae | AS,EU | Md | Nt | Kaul, (1986) |
| 3 | *Amaranthus spinosus* | Amaranthaceae | SAM | Ui | In | Stewart, (1972) |
| 4 | *Achyranthes aspera* | Amaranthaceae | NAM | Ui | Cn | Kaul, (1986) |
| 5 | *Cichorium intybus* | Asteraceae | EU | Ui | In | Kaul, (1986 |
| 6 | *Cirsium arvense* | Asteraceae | AS | Ui | In | Stewart, (1972 |
| 7 | *Conyza bonariensis* | Asteraceae | SAM | Ui | Cs | Kaul, (1986 |
| 8 | *Parthenium hysterophorus* | Asteraceae | SAM | Ui | Cs | Yaqoob *et al*., (1988) |
| 9 | *Tagetes minuta* | Asteraceae | SAM | Ui | Nt | Singh and Kachroo, (1994) |
| 10 | *Taraxacum officinale* | Asteraceae | EU | Ui | In | Kaul, (1986) |
| 11 | *Xanthium strumarium*. | Asteraceae | AF | Ui | In | Kaul, (1986) |
| 12 | *Capsella bursa-pastoris* | Brassicaceae | EU | Ui | In | Kaul, (1986) |
| 13 | *Cannabis sativa* | Cannabaceae | AS | Ui | In | Kaul, (1986) |
| 14 | *Chenopodium album* | Chenopodiaceae | EU | Fd | In | Kaul, (1986) |
| 15 | *Ipomoea eriocarpa* | Convolvulaceae | AS;AU | O | Cn | Kaul, (1986) |
| 16 | *Cyperus rotundus*. | Cyperaceae | EU | Ui | In | Kaul, (1986) |
| 17 | *Elaeagnus umbellata*. | Elaeagnaceae | AS | Pl | Nt | Singh and |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | Kachroo, (1976) |
| 18 | *Euphorbia helioscopia* | Euphorbiaceae | AS;EU | Ui | In | Kaul, (1986) |
| 19 | *Ricinus communis.* | Euphorbiaceae | AF | Fd | Cs | Stewart, (1972) |
| 20 | *Medicago sativa* | Fabaceae | AF;EU | Fr | Nt | Dar *et al*., (2002) |
| 21 | *Trifolium repens* | Fabaceae | EU | Fr | In | Kaul, (1986) |
| 22 | *Hibiscus rosa-sinensis* | Malvaceae | AS | Ld | Nt | Naqshi *et al*., (1988) |
| 23 | *Melia azedarach* | Meliaceae | AS | Pl | Cl | Ara *et al*., (1995) |
| 24 | *Broussonetia papyrifera* | Moraceae | AS | Pl | In | Stewart, (1972) |
| 25 | *Morus alba* | Moraceae | AS | Ht | Nt | Dar *et al*., (2002) |
| 26 | *Mirabilis jalapa.* | Nyctaginaceae | SAM | O | Cs | Stewart, (1972) |
| 27 | *Oenothera rosea* | Onagraceae | SAM | Ui | In | Kaul, (1986) |
| 28 | *Oxalis corniculata* | Oxalidaceae | AS;EU | Ui | Nt | Kaul, (1986) |
| 29 | *Plantago lanceolata.* | Plantaginaceae | AF;EU | Ui | In | Kaul, (1986) |
| 30 | *Plantago major* | Plantaginaceae | EU | Ui | In | Kaul, (1986) |
| 31 | *Arundo donax* | Poaceae | AF;EU | Ui | Cs | Stewart, (1972) |
| 32 | *Setaria pumila* | Poaceae | AS;AF | Fr | Cn | Stewart, (1972) |
| 33 | *Rumex hastatus* | Polygonaceae | AS | Md | In | Reshi, (1984) |
| 34 | *Rumex nepalensis* | Polygonaceae | AF;EU | Fd | Nt | Munshi and Javied, (1986) |
| 35 | *Prunus persica* | Rosaceae | AS | Ht | Cl | Dar *et al*., (2002) |
| 36 | *Populus alba* | Salicaceae | EU | Pl | Nt | Javeid, (1972) |
| 37 | *Salix alba* | Salicaceae | AS;AF;EU | Pl | Nt | Javeid, (1972) |
| 38 | *Verbascum thapsus* | Scrophulariaceae | EU | Ui | In | Kaul, (1986) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 39 | *Stellaria media*. | Caryophyllacaeae | EU | Ui | In | Kaul, (1986 |
| 40 | *Lantana camara*. | Verbenaceaec | SAM | O | Cs | Stewart, (1972) |
| 41 | *Bidens tripartita* | Asteraceae | AF;EU | Ui | Cn | Kaul, (1986) |
| 42 | *Nasturtium officinale*. | Brassicaceae | EU | Ui | Nt | Kaul, (1986) |
| 43 | *Sorghum halepense*. | Poaceae | EU | Fr | In | Kaul, (1986) |

## KEY

**Origin**

**NAM**=North America; **SAM**=South America; **AF**= Africa; **EU**=Europe; **AS**=Asia; **AU**=Australia; **CH**=China.

**Growth form**

**H**=Herb; **S**=Shrub; **T**=Tree; **C**=Climbers; **Aq**=Aquatics; **G**= Grass

**Mode of introduction**

**Fd** = Food; **Fr** = Fodder; **Ht** = Horticultural; **Ld** = Landscaping; **Md** = Medicinal; **O** = Ornamental; **Pl** = Plantation; **Ui** = Unintentional.

**Invasion status**

**Cl** = Cultivated un-escaped aliens; **Cs** = Casual aliens; **Cn** = Casual or naturalized aliens; **Nt** = Naturalized aliens; **Ia** = Invasive aliens

## 5.8 DISCUSSION

Biological invasion has caused an extensive range of high profile impacts including decline in population of threatened and endangered species, habitat loss and alteration, increased frequency of fires, shifts in food webs and nutrient cycling, loss of agricultural crops and productive lands (Ruiz et al., 2000). The biological invasions have increased worldwide due to the expansion in the trade of services and goods, increased mobility of people, liberalization of markets and the use of exotic species for horticultural and ornamental purposes (Ohlemuller et al., 2006). There are thousands of alien species known to establish around the world and many more introduced species remain unrecognized or undetected. Plant invasions are visibly a strong force of change, operating on a global scale and affecting many dimensions of society (Wilcove et al., 1998).

In view of these impacts, present study was conducted to enlist the invasive alien species and their impacts on vegetation of Muzaffarabad. One hundred and twenty one plant species belonging to 58 families 108 genera were recorded from the study area. Out of these species 43 were recorded Invasive alien belonging to 25 families and 41 genera.

The climatic and edaphic similarities between the original and new habitats are very important factors for the establishment of alien species (Holdgate, 1986). Humid tropics of the Asia and Africa with highly leached soils are like to Latin American home of species such as *Lantana camara* and *Parthenium hysterophorus* enabling them to colonize and invade appropriate sites (Ramakrishnan, 1991). It explains the reason that why *Lantana camara* and P*arthenium hysterophorus* are so well established in the sub-tropical zone of Muzaffarabad due to suitable environmental conditions for their growth as similar to their native range.

*Parthenium hysterophorus* was present in all the investigated communities with an average IVI value of 11.77. It is an annual herb. It sharply colonizes disturbed sites and as well undisturbed and has major impacts on pasture and cropping industries, spreading to and impacting on new areas. It out competes native species, partially due to allelopathy. Regular contact with the plant, typically over a prolonged period, produces allergenic asthma and dermatitis in humans (Chaudary, 2009; Bhatia et al., 2010*). Parthenium* has an affinity to change the dominant flora in wide range of habitats cutting across state boundaries and agro-climatic regions because of its efficient biological activity and adaptability to varying microenvironments and soils. Very little vegetation can be seen in *Parthenium hysterophorus* dominated areas. Wherever it invades, it forms a territory of its own by substitution the native natural flora including medicinal herbs utilized by man as a source of medicine (Oudhia, 2000).

*Lantana camara* was present in 2 communities with an average IVI value of 10.59. *Lantana camara* is a perennial shrub. The success of *Lantana camara* may be attributed to the presence of a variety of pollinators, accounting for the high percentage of fruit-set (Sharma et al., 2007). Once shaped in high numbers, the seeds of *Lantana camara* are dispersed efficiently through the participation of a spread of animal dispersal agents that feed on its fruit such as birds, rodents, foxes, and other vertebrate foragers (Sharm et al., 2005; Simelane, 2002). The processes of invasion are further improved by nutrient additions, with animal droppings, canopy removal and soil disturbance, creating a good seed-bed (Fensham and Cowie, 1998; Duggin and Gentle, 1998). The higher cover or basal area of Lantana camara supports the growth of lesser number of species in its locality as compared to other species. The results of the present study are in conformity with the experimental model of most of the studies that with increasing invasive cover the diversity decreases (Stohlgren, 2002). Results showed that in community number 3, 5 and 6 dominated by *Lantana camara* have lower species diversity as compared to the other communities. One of the strategies Lantana adopted during its successful invasion is a strong allelopathic effect through modification of metabolic and cellular responses in target plants (Talukdar, 2013). Against bacteria it also possesses strong bioactive compounds (Bhadauria and Singh, 2011). In Bangladesh Semi-evergreen tropical forest also revealed that invasion of Lantana in forest gaps after human perturbations cause an unexpected decline in species richness (Islam, 2001).

*Xanthium strumarium* is an annual herb and wide spread invasive alien in Muzaffarabad. This specie was present in all of the investigated communities with an average IVI value of 9.92. This heat-loving and drought-resistant plant grows among habitations, along roads, dumps, on waste grounds, river banks along and ditches and in crops. It has developed herbicide resistance. The plant is rough to touch. Its dust and hair cause itching. The mechanical irritation of mouth happens if burs are ingested. A dermatitis and weeping eczema and can result from handling the plant (Gurley et al., 2010).

*Ailanthus aItissima* is a deciduous tree and it was present in the sampled communities with an average IVI value of 8.59. *Ailanthus aItissima* is a serious threat to ecosystems in introduced areas, as the plant is highly competitive due to chemicals that may inhibit the growth of many native plants. Because of its prolific reproduction it has invaded the wasteland and has replaced the local vegetation (Ding et al., 2007).

*Cannabis sativa* is an annual herbaceous plant and it was present in 2 communities with an average IVI value of 7.78. It is reported to invade waste areas, fence rows around farm building usually on bottomland soil (Qaiser, 1973). *Arundo donax* is a tall perennial shrub and it was present in disturb site with an average IVI value of 6.05. It mostly invade disturb site. Displacing native species around the water channels (Duke and Mooney, 2004). *Arundo donax* is also known to interfere with the management of flood defenses and wildlife habitat management. *Arundo* *donax* is also thought to modify hydrological regimes and decrease groundwater availability by transpiring large amounts of water from semi-arid aquifers and layers of permeable rock consuming three times extra water than native plants (Iverson, 1994). *Arundo donax* is an extremely flammable plant even when green. The thick stands ignite easily and quickly, and through their wide placement, can double the available fuel for wildfires which can extend quickly through entire riparian systems, often near urbanized areas. Post-fire regeneration of even superior quantities of *Arundo donax* can then occur (Scott, 1994).

*Melia azedarach* is a deciduous tree and it was present in all undisturbed sites with an average IVI value of 3.94. This specie invades the area and threat to the native plant species diversity (Luti et al., 1979). *Melia azedarach* is a real weed tree and a true biological vagrant, and one of the most widespread nonnative trees in southern forests. It normally invades wild lands. *Melia azedarach* is plentiful in native riparian woodlands in parts of Texas and often forms thick stands that condense light to other understory vegetation (Everitt et al., 1989). *Melia azedarach* leaf litter had an inhibitory effect on weeds in a cropland and may have a similar impact on native plants in wild lands (Hong et al., 2004). *Melia azedarach* leaf litter may increase nitrogen and hydrogen ion concentration (Singh et al., 1996); and decrease aluminum levels in the soil (Noble et al., 1996).

Understanding morphology, ecology, phenology, physiology and phytochemistry of IAS is essential for effective management of invasive alien species and conservation of local flora. Monitoring of invasion can be done through qualitative approach like species inventory and quantitative approach by using phytosociological methods. Results emphasize the need of a better arrangement for early detection and reporting of spread of invasive aliens in Muzaffarabad. It is recommended to develop an IAS detection network by establishing communication links between taxonomists, ecologists and land managers.

Open canopy, due to disturbance, landslides and roads construction were identified as the factors promoting the establishment and spread of invasive species in any area. The values of specie evenness and richness were recorded high at disturbed sites as landslides break canopy dominance allowing the invasive aliens species to grow rapidly. Higher presence of invasive aliens was recorded at disturbed sites. The invasive aliens may change native community composition, reduce species diversity, affect ecosystem process, and thus cause huge ecological imbalance. Further research projects to investigate the impacts of IAS on biodiversity; and their prevention and management are recommended.

# CHAPTER 6

# PAYMENT OF ECOSYSTEM SERVICES

# 6.1 INTRODUCTION

Payment of Ecosystem Services (PES) is a voluntary transaction for a well-defined environmental service, purchased by at least one environmental service buyer from at least one environmental service provider, if and only if the environmental service provider meets the conditions of the contract and secures the environmental service provision (Wunder, 2005). Payments for Environmental or Ecosystem Services (PES) have become a means to promote biodiversity conservation and rural development, particularly in tropical and sub-tropical regions (Gutman, 2007).

Small-scale PES projects promoted by nongovernmental organizations to enhance watershed protection and biodiversity conservation, as well as to protect carbon reservoirs and sinks under the umbrella of the United Nations Framework Convention on Climate Change as carbon offset and REDD+ projects have also been developed worldwide. These programs and projects have usually become part of a conservation policy mix, in which the direct incentives provided by PES co-exist with more traditional regulatory conservation approaches.

There is a growing global awareness of the services that natural ecosystems provide. The value of these ecosystem services and the long term costs of their loss, however, are rarely taken into account in decisions about how natural resources are used. Forests provide key ecosystem services such as clean water, timber, habitat for fisheries, carbon sequestration, pollination, and biodiversity. However, many of these services are being lost or degraded at a furious pace, brought about by human activity. This has led to an increased use of payments for ecosystem services (PES) programs. PES offers conditional payments to motivate private landowners to invest in land-use practices that lead to conservation or production of ecosystem services (Ferraro and Kiss 2002, Wunder 2005). There are many different ways to pay for ecosystem services.

## 6.2 PES DESIGN IN SHOUNTHAR VALLEY, UPPER NEELUM AJK

In Shounther valley, the sub valley of Neelum valley, the PES module was launched to be tested. This valley is rich in forests and local people usually depend on forests for the basic needs. So, a PES module was designed to investigate the willingness of the local people to provide the services. Various services were identified which could be included in the module, but only some specific, important and critical services were considered on trial basis. These services include, timber, fuelwood, soil conservation, biodiversity services, regulation of hydrological resources and scenic beauty.

These services were identified by field visits, direct observations, and group discussions with local people and discussion with specific target groups. The scope of these services was considered by observing the demand of the services. The services considered in this module were having high demand so, it was considered that they are having high values for incentives. All the outcomes, benefits and types of agreements were discussed with the natives and they were given a choice to sale these services in terms of protection, conservation and promotion.

All the stakeholders of the project were considered during the consultation process. This was done by discussions, interviews and talks. There were many types of the stakeholders which include the service providers, service buyers, local government, research and academic institutes and all the parties who were having a concern with the project. All the social and legal issues, caste and gender specification, traditional and desired role of women was also considered. To achieve this goal the existing literature was also consulted. The quantification of the services was done by mapping participatory community, focus group discussion, direct observations, statistical estimation and change in land cover link with service provision. Both types of the services, i.e. tangible and non-tangible services were estimated.

## 6.3 ECOSYSTEM SERVICES UTILIZED BY THE LOCAL INHABITATNTS

The ecosystem services play a vital role in the life of the inhabitants of the study atra. A wide array of ecosystem services vital for the livelihood of the locals was quantified by field expeditions in the 5 settlements of the area. The detailed results of the ecosystem services are given as follows.

### 6.3.1 MEDICINAL PLANTS

A total no of 38 medicinal plants belonging to 23 families were recorded during the field survey in the 5 sites of Shounthar valley.The predomenent families were polygonaceae (6 spp), Asteraceae (5 spp) and lamiaceae (4 spp). Different plant parts were used due to their high efficiency to cure diseases.

Roots/rhizome (60.62 percent), leaves (26.31 percent), whole plant (21.05 percent), arial parts (10.52 percent), stem (7.89 percent), bark (7.89 percent) and seeds (5.26 percent) of the medicinal plants were used in the investigated area. Major diseases includind asthma, stomachache, toothache, hepatitis, piles, dysentery, diabetes, joint pain, cough backache, constipation, fever, cold, and fracture treated by using Medicinal herbs.

Throughout the world about 80 percent populations are dependent upon herbal medicine for symbolic and medicinal values (Ahmed et al., 1999). The majority (1.5) billion of the population of the developing countries uses traditional medicines either because the people cannot afford synthetic medicine or because traditional medicine is more acceptable (FAO, 2001).

Forests of the valley are rich in medicinal plants, the cheif amongst these are Kuth, Baladona, Patrees, Banffsna, Mushkbala, Ajwain, Bankhakri, Jan-e-Adam, Zakhm-e Hiaat, Gogal dhoop etc. Medicinal herbs are also used by the local people of the area for the treatment of the animal diseases by different means, such as Diarrhea, Dysentery, indigestion etc. Similar findings were reported by (Khan, 2009). During the present research it has been observed that old age (50-90 years old) people in the upper sides of the villages mostly use the medicinal plants instead of Pharmaceutical products for the treatment of diseases. Old people have more knowledge and belief on the treatment by the medicinal herbs (Khan, 1996).

Locals of the area who donot have access to hospital treatment and forced on the medicinal flora. *Bergenia cilliata, Podoplyllum emodi, Valiriana wallichiaii* are extracted on large scale without scientific methods of collection. Local poor people soled up to 20 kg - 60 kg roots of *Trillium govanianum* without any permission from the forest deportment. Approximately 119 pure chemical substances are extracted from higher plants are used in medicine throughout the world which is used for the treatment of various diseases such as abdominal pain, diarrhea, dysentery and worm treatment etc. (Jan et al., 2008).

In most Himalayan regions native people use medicinal plants as their own assets (Ahmed et al., 2005). If these natural resources are not be conserved properly in coming 4-10 years the most important species become extinct (Jan et al.,2008).Unsustainable extraction and over grazing in the area are permanent threats to the existence of important and endangered medicinal herbs (IUCN, 2006).

Forest deportment annually auctions the collection of some plants, under the cover of which many medicinal plants are collected indiscriminately. The contractors and their middle men extract the medicinal herbs many times more than permission. Extra amount of these medicinal plants is smuggled to the local and other markets of the country. Nomads are also involved in illegal extraction and smuggling to Gilgit and Biltastan (Qamar and Minhas, 2006).

### 6.3.2 FUEL WOOD CONSUMPTION PATTERN

The average fuel wood consumption in each site of the study area was 7.3 ton /year. Out of all the investigated sites highest (11.3 metric tons/year) quantity of fuel wood was consumed by the local people of Magri village whereas the lowest (4.3 metric tons/year) quantity of fuel wood was consumed by the people of Arr Kassi. The result showed that 3 species of trees are used as fuel wood in the area. The preferred fuel wood species in the area included *Betula utilis, Juniperus excels* and *Abies pindrow*. In summer season from (April to October) the pressure on the forest for the fuel wood is comparatively less because local people do not need wood for heating their houses.

In winter season from (November to March) consumption of fuel wood increases 4 to 5 times then summer season due to additional requirements of fuel wood for keeping their house worm. In some places dry and dead tree plants are used for fire wood but these are not easily available everywhere, so green trees are cut down (Qadir, 1994). IUCN, (1996) estimated that if the current rate of forest depletion in AJ&K continues, the forest of the State will largely disappear by the middle of 21stCentury. In many villages and in high altitude pasture residences most people use torchwood for lightning, this practice also contribute to high wood consumption (Qazi, 2005).

FAO, (2001) statistics suggested that in 1999 some 1.75 billion $m^3$ ton of wood was extracted for fuel wood and conversion to charcoal, about 90 percent of which was produced and consumed in developing countries. The International Energy Agency (1998) assessed that, 11 percent of the world energy consumption comes from biomass, mainly fuel wood. 19 percent of China's primary energy consumption comes from biomass, the figure for India being 42 percent, and developing countries about 35 percent (IEA 1998; UNDP 2000). All sources agree that fuel wood is of major importance for poorer countries, and for the poor within those countries. Extraction rates may or may not be sustainable, depending on vegetation types and population. Fuel wood or charcoal infrequently enters international markets and a great part of the sale former is for direct consumption or local (Hein *et al.*, 2006).

The vegetation is scattered due to deforestation and disturbance caused by nomads and summer pasturing in the investigated area (Butt, 2006). Grazing pressure is contiously shifting towards the surrounding forest areas and causing the disturbance in the regenration of important plant species of the area (Negi, 2009).

Naborg, (2002) reported that under food insecurity and poverty local people manage their needs for short term gains from the nearest forest resources. This practice by large family size and huge herd size leads to longer run damage to natural forest resources. Same findings were reported by Shaheen et al., (2011) while studying the structural diversity, vegetation dynamics and anthropogenic impact on lesser Himalayan subtropical forests of Bagh district, Kashmir. Deforestation and over grazing are becoming more severe every year and the habitat is totally modified. Due to limited grazing area available for the livestock, over and illegal grazing of demarcated forest areas is a serious threat to the growing seedlings of important tree species (Alam and Ali, 2010).

### 6.3.3 WILD VEGETABLES

In the area most people of all the sites were found to collect the wild vegetables from their native forest in a large quantity, & have great importance to market vegetables. Important vegetables which were used mostly by the local villagers are *Dryopteris spp* (langroo) *Taraxacum spp* (hund) *Polygonum spp* (chikroon), *Epilobium spp* (nariia), *Mentha spp* (podina), *Rumex spp* (holla), *Rheum spp* (chontial), *Malva spp* (sonchal), *Allium spp* (piaz), *osmunda regalis* (kandhera), *Plantago spp* (chemche ptra) and *Phytolacca spp* (luber) etc. People of the area collect these wild vegetables in spring and summer season and use in fresh condition but for winter season local people dry these after boiling and some vegetables were directly dried under the heat of sun without boiling. Eighty five percent People of Domail were found using wild vegetables, followed by 67.5 percent of Bella, 57.5 percent of Magri and 37.5 percent of Behak.

Primitive collection of wild vegetables is being practiced all over the Valley. Local people collect these vegetables in spring and summer season to use in fresh condition and also keep in dry condition for winter season. Similar observations were reported by Qureshi, (1990). Dar et al., (2012) from Machiara National Park, Azad Kashmir. Wild vegetables play a potential role in house hold security therefore these vegetables are used in most sites of the area (Modi et al., 2006). Wild vegetables present in the forest sites are a great source of micronutrients, which are essential for reduction of malnutrition effects.

### 6.3.4 MUSHROOM EXTRACTION

Mushrooms were not found in great numbers in all forests of the area but in Bella and Arr Kassi forests. Different types of morels (mushrooms) especially (Morchella spp) were found. Local people of these two sites were found to collect these mushrooms for selling purposes. Local market price of the current year was Rs.20000/ kg. People sale per year up to 3 to 5 kg/ house and earned Rs 80,000 to 90,000 in a year.

Thirty six percent people of the Bella village were found to extract mushroom from their forests followed by 21% in Arr Kassi. On the other hand, people of Behak, Magri and Domail were not found to collect any type of mushroom. Local forests are rich in mushroom resources. Locals collect these mushrooms for income purposes. Same findings were reported by (Butt, 2006) from Machiara National Park.

Pakistan exports annually 100 tons of *Morchella* spp to Europe and other countries of the world (Shinwari, 2002). The important minor forest product found in the forest of the valley is *Morchella esculenta* locally called “Guchhi”.This mushroom is in great demand in foreign markets. In view of poor living standard of the people of the area, forest deportment has left its open collection to the local *Zamindars*. The deportment charges only a nominal royalty for its export (Qureshi, 1990).

It has also been estimated that the total world production of Morales is about 150 tons dry weight. India and Pakistan are major producing countries, each producing about 50 tons of dry Morales (Negi, 2006). During the house hold survey it was reported that some local people soled upto 3-5kg *Morchella esculenta* annually to earn PK Rs 20,000-90,000 rupees per house hold annually.

### 6.4.4 FORAGE AND GRAZING AREA

The study area also serves as a grazing ground for the live stocks of the locals. The livestock rearing is a fundamental practice of the mountainous life which fulfills the basic needs of the locals in terms of Milk, meat, leather, wool and force. Reported data revealed that the investigated area exhibit a big family size of 9.77 with a small average land holding of 0.7 acres/house hold. Average herd size in the area was very high (8.67cattle/house hold). But each house hold has an average grazing area of 0.125 acres/cattle unit which is very low than the permissible limit of 8.51 Acers /grazing unit / year for the Himalayan regions (Singh et al., 1984). In the investigated areas of the Shounthar Valley all people have a large herd size, but the grazing area for their cattle is very small due to which forest of the area is under severe trampling, browsing, and grazing pressure. The local grazers of the area are cows, goats, sheep, horses, donkeys, mules and buffalos etc. Similar findings were reported by Istiaq and Perveen, (2009) about the browsing practice in the forest sites.

Highest grazing pressure enhanced the increased growth of non-palatable species and also reduced the regeneration capacity of trees. Same situation was observed in forest of the investigated sites.

Grazing pressure in all sites of the forest of District Neelum was severe due to availability of very low grazing area for cattle grazing due to which all important seedlings were damaged owed to trampling and severe browsing in the area (IUCN, 1996). This practice was seen during the investigation of vegetation sampling in the forest sites. Due to preference of some important (Butt, 2006).

## 6.5 THREATS TO THE ECOSYSTEM SERVICES

Biotic and abiotic disturbance lead to the conversion of natural vegetation to semi natural (Morgenthal et al., 2001).Vegetation of the area is under severe anthropogenic pressure as well as human induced disasters. Main threats to the forest ecosystem are as:

- Lack of awareness, inappropriate land use, over use, lack of effective management, and negative attitude of local communities adversely affect the forest structure and its function.
- Intercommunity conflicts, military activities, armed conflicts on borders, lack of forest policy implementation, and lack of interdepartmental coordination are the important destructors of forest biodiversity.
- Increasing population with increasing demands contributes over exploitation of forest resources and disturbs the flora and fauna of the area.
- Economically important plant species including *Betula utilis*, *Cedrus deodara*, *Pinus wallichiana*, *Abies pindrow*, and *Juniperus* are exploited to meet the needs of local people which lead to decline in the population of these species.

- Illegal trade of biodiversity products such as mushrooms and medicinal herbs from the native area to out sides has adverse effects on biological diversity of the area. Illegal extraction and supply of timber wood in forest based wood industries is a serious threat to the forest structure.
- Important medicinal herbs such as *Aconitum hetrophyllum, Sassuria spp, Rheum spp, Geranium, Jurenia, Bergenia, Fritilleria, Polygonum* etc. are becoming endangered due to over and unscientific collection.
- High grazing and browsing practice in forest pastures is destroying the young seedling of important plant species. Due to browsing pressure by nomads and local grazers non palatable species are becoming dominant in the grazed area.
- Natural disasters including floods, glaciers, fires, erosion, heavy rain fall, competition, droughts, and diseases affect the growth, productivity, and regeneration of vegetation.

## 6.6 RECOMMENDATIONS FOR THE CONSERVATION OF ECOSYSTEMS

There is a need to integrate the livelihood of local inhabitants with conservation measures through participatory forest management in such a way so that the local communities are able to draw large share of services from the conserved forest (Sharma et al., 2009). There is also a general desire to maintain the natural habitat and biodiversity for the enjoyment of life and continue wellbeing of nature (Iqbal et al., 2008). For the sack of future generations, afforestation and reforestation of important plant species is the need of hour (Hussain et al., 2010).

- Sound measures should be adopted for the conservation of important species.
- Illegal trade of forest resources should be checked and banned by applying proper rules and regulations.
- Conservation of forest structure and forest resources needs selection of some areas as reserve Parks for the protection of endemic species.

- Restoration of degraded forest ecosystem by effective management plans should be started.
- Government should provide the alternate sources of fuel and medicines to locals for the maintenance of forest ecosystem functioning and future safety.
- Over grazing practices should be restricted in rich diversity areas and rotational grazing should be allowed.
- Plantation of fast growing plant for fuel and fodder purposes reduces the pressure on the natural forest of the area.
- Educational programs on importance and conservation of forest ecosystems should be launched at different levels of society.
- Public should be made aware about the proper use of medicinal plants, mushroom extraction, wild vegetable collection and utilization.

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# APPENDICES

Figure 1. During Core sample extraction from *Pinus roxburghii* Charohi site.

Figure 2. Shounthar Valley in the Neelum District, Site for Ecosystem services Study

Figure 3. Researcher with the Local community in the Shounthar Valley

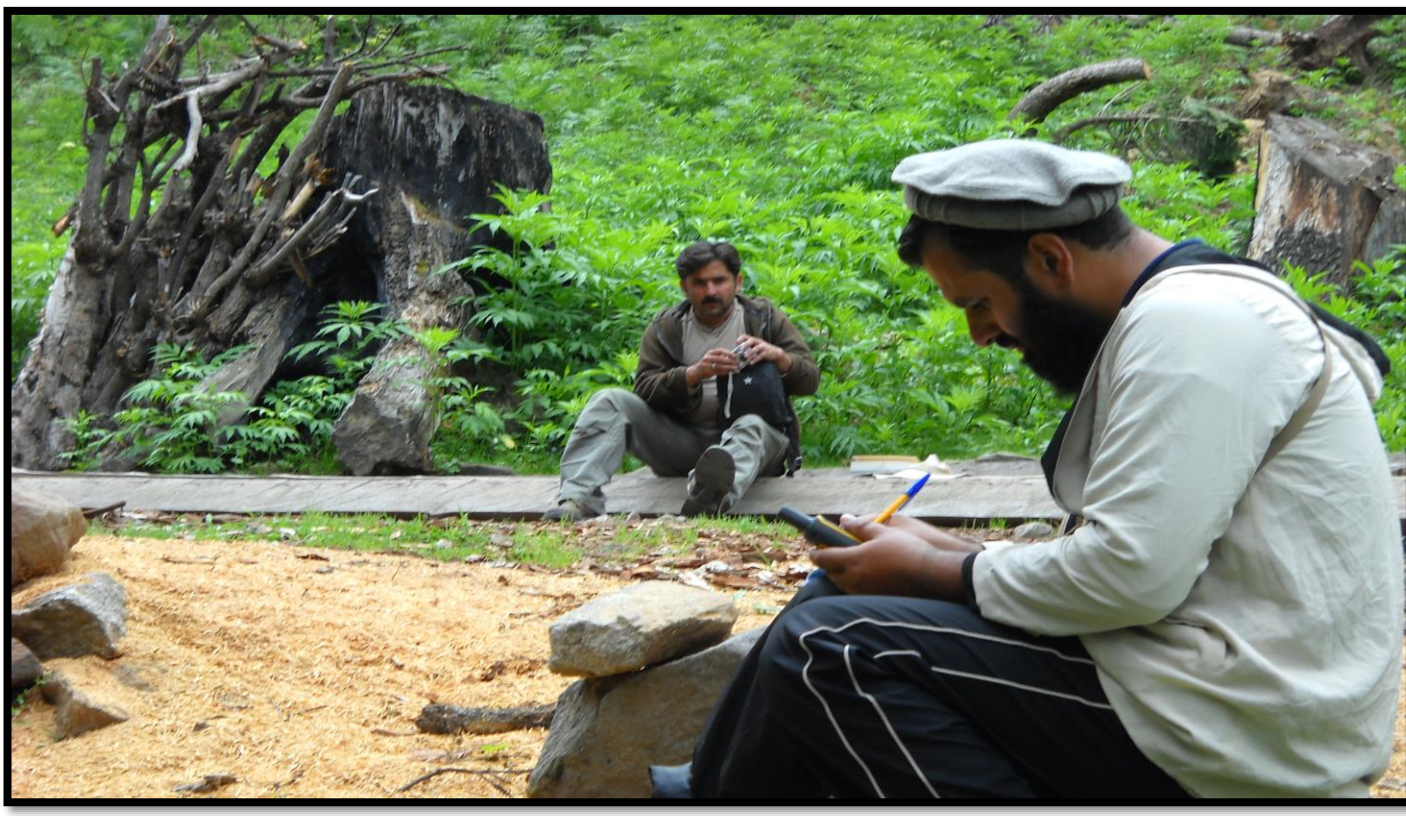

Figure 4. Recording the data about fuel wood consumption in Neelum Valley

Figure 5. *Aconitum chasmenthum*, an important medicinal plant of Kashmir

Figure 6. *Jurinea dolomea*, an important medicinal plant of Kashmir

Figure 7. The Core samples of *Pinus roxburghii* mounted in wooden frame box for dendrochronological study.

Figure 8. Core sample after sanding ready for further dendrochronological investigation.

Figure 9. Research team during data collection in Shounthar Valley, Neelum District

Figure 10. Students recording the DBH of a fuel wood tree in temperate forest ranges of AJK.